Web-based Hypermedia Courseware in Higher Education: A Proposed Framework

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Abstract

This thesis is concerned with hypermedia and learning, and in particular with the design and development factors that need to be considered for the creation of hypermedia-based courseware in higher education that uses the Web as a delivery platform.

One of the most commonly cited problems with educational hypermedia is related to the design and structure of the educational material. It appears that Web-based instructional authors have not had access to an instructional model, which has been empirically tested. However, there is a large body of knowledge in the field of instructional design from which one can draw suitable conclusions for the design process of Web-based educational hypermedia. The current research recommends that a precondition for effective Web-based courseware design in higher education is careful consideration of the traditional body of knowledge in the field of instructional design which should act as a foundation for future developments in the design process. In addition, the end-users' input should be sought as it can confirm the above and enhance further our understanding toward the implementation of this new medium in higher education.

Based on this recommendation, a framework is proposed in terms of its design, user input and evaluation for the development of Web-based courseware in higher education aimed at supporting the delivery of physical modules. The thesis describes how the different stages of the proposed framework were implemented through the development of two Web-based courseware applications aimed at supporting the delivery of two higher education modules taught in De Montfort University, U.K.

In order to test the validity of the proposed approach, that a Web-based courseware developed according to the experimental framework could effectively support the delivery of physical modules compared with conventional teaching methods, two empirical studies have been conducted. They were concerned with the summative evaluation of the two Web-based courseware applications, which were developed according to the proposed framework. The results from the evaluation of the two empirical studies indicated significant improvements in users' performance and satisfaction compared with conventional teaching methods. Thus, the proposed framework can indeed offer a solution for the development of Web-based courseware that aims to support the delivery of physical modules in higher education. Moreover, the experimental framework can also provide a detailed starting point and can be adapted for the design and development of Web-based courseware aimed at addressing distance learning or other forms of Web instruction.

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Author Declarations

1. During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification.

2. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

3. The PhD programme of which this thesis is part has consisted of:

3.1 Independent Study

3.2 Supervision tutorials

All the above were held in the School of Design and Manufacture, Faculty of Art and Design, De Montfort University, Leicester.

3.3 Attendance at relevant research conferences

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Chapter 1 Introduction

This thesis is concerned with hypermedia and learning, and in particular with the design and development factors that need to be considered for the creation of hypermedia-based courseware in higher education that uses the World Wide Web (Web) as a delivery platform. The research work presented in this thesis has been presented at the 'WebNet 97' international conference on the WWW, Internet, and Intranet (Georgiadou and Higgett, 1997). Part of this work has also been published in *Computers in Teaching Initiative, Art and Design Newsletter* (Georgiadou and Higgett, 1998). In addition, one of the Web-based courseware applications developed was shortlisted in the European Commissions' Multimedia Awards for 1997. This chapter includes an overview of the research work and a chapter by chapter guide to the structure of the thesis.

Courseware is a relatively recent appellation for Computer Based Learning, which refers to the use of computers for the delivery of instruction in an interactive mode. Cognitive conceptions that derive from modern learning theories, such as the Information Processing theory, stress that learning is an active, constructive, cumulative, self-regulated process in which the learner plays a critical role (Shuell, 1992, p. 21-25; Jonassen, 1988, p. 153). In other words a learner can learn effectively if s/he is engaged in learning activities. In addition, these activities should take into consideration elements like preceding knowledge, the context in which the learning material is presented and organised, and also the availability of specific internal frameworks with which to integrate the information.

Current discussions concerning effective learning in higher education emphasise that techniques associated with active and flexible/open learning should be used to help students achieve the goals of higher education. Active learning is the term used to emphasise the importance of ensuring that students engage actively in the learning process, rather than passively accept the work as a component of course requirements. The term flexible/open learning promotes a shift from formal whole-class didactic teaching towards individual or the group management of learning through the provision

by the teacher of structured resource materials (Committee of Scottish Universities Principals, 1992).

Higher education within the United Kingdom, as elsewhere in Europe, is growing at an unprecedented rate. As conventional institutions react to the pressure to increase student numbers without a commensurate increase in staff, increased reliance on resource-based learning can be expected (Entwistle, Thompson, and Tait, 1992). Hypermedia-based learning support systems offer great scope for the development of active and flexible learning environments, and thus for an increase in the quality and effectiveness of the learning experience. The characteristics of hypermedia systems that make them attractive for teaching and learning are their ability: to integrate varied formats and voluminous amounts of information; to be enabling rather than directive systems; and to facilitate interactions among people and machines as well as among groups of people (Marchionini, 1990).

Marshall McLuhan argued in the 1970's that "in the era of automation and electricity the globe becomes a community of continuous learning, a single campus in which everybody, irrespective of age is involved in learning a living" (McLuhan, 1970, p.41). Up to now the use of the conventional media have not managed to meet McLuhan's 'prophecy', but his argument may now become a reality, since information and communication technologies are merging and bringing about a 'new industrial revolution' based on information, in an emerging 'information society' (European Commission, 1994). Today there are claims that the desk top PC is 'a window on the world' and users horizons are no longer bounded by information and developments on the local campus (Bates, 1995). Technological advancements in digital media, the Internet and the World Wide Web (Web) have allowed terms such as 'virtual books', 'virtual libraries', and even 'virtual universities' to enter into common usage. The Web can be seen as the medium chosen to prepare and educate people for life in an information society.

There has been a lot of interest, recently, in hypermedia-based courseware that uses the Web as a delivery platform. Web-based hypermedia courseware is being introduced to education at an accelerating rate supported by major national and European Government funding. This is because the Web inherits all the characteristics of hypermedia systems

that make them attractive for teaching and learning and provides even more. The Web can integrate all existing media in a digital hypermedia format; it can provide the technology for synchronous and asynchronous communication between teachers and learners irrespective of time and location; it can be a content provider as it is the largest and more diverse information resource in the world today; and above all it is cross-platform. The fact that Web-based educational hypermedia can hold considerable promise as a revolutionary way to enhance learning, does not guarantee its success as an educational tool, however.

One of the most commonly cited problems with educational hypermedia is related to the design and structure of the educational material. The design of educational programs on the market is often ineffective from an educational standpoint, thus hypermedia programs do not satisfy the claims or potential of hypermedia (Bates, 1995; Preece, 1993; HEFCE 1996; Stratfold, 1994; McAteer and Shaw, 1995). Therefore, in keeping with the advances of technology, the recent explosion of Web-based instruction is currently demanding that designers take yet another look at the instructional design process. It appears that Web-based instructional authors have not had access to an accredited instructional model which has been empirically tested about its effectiveness regarding the design of Web-based educational hypermedia, because most of the studies in this area are exploratory since this medium is so new in education. However, there is a large body of knowledge in the field of instructional design from which one can draw suitable conclusions for the design process of Web-based educational hypermedia.

The current research recommends that a precondition for effective Web-based courseware design in higher education is careful consideration of the traditional body of knowledge in the field of instructional design which should act as a foundation for future developments in the design process. This body of knowledge includes theories of instruction and courseware design factors that concern hypermedia structure, learner control, feedback, interactivity, and screen design elements. In addition, the end-users' input should be sought as it can confirm the above and enhance further our understanding toward the implementation of this new medium in higher education.

Based on this recommendation, a framework is proposed in terms of its design, user input and evaluation for the development of Web-based courseware in higher education

aimed at supporting the delivery of physical modules. The following five stages describes the proposed framework.

Stage 1 Review of the area of instructional design in order to identify design and development considerations potentially applicable to the development of Web-based courseware that aims to support the delivery of physical modules in higher education.

Stage 2 Acquisition of end-users' input through a survey aimed at determining the users' preferences in terms of general Web-based educational design practices.

Stage 3 Development of prototype courseware based on the results from Stages 1 and 2.

Stage 4 Evaluation of prototype with end-users - Formative evaluation.

Stage 5 Revision based on evaluation results from Stage 4.

It is suggested that a Web-based courseware developed according to the proposed framework could effectively support the delivery of physical modules by promoting learning and providing significant improvements in users' performance and satisfaction in higher education compared with conventional teaching methods.

The validity of this approach needs to be tested empirically and this constitutes a principal element of this research. Two empirical studies were designed to accomplish this task. They were concerned with the summative evaluation of two Web-based courseware applications, which were developed according to the proposed framework on Interactive Digital Entertainment (IDE), for Level II, BA Honours Multimedia Design students at De Montfort University (DMU), U.K, and Programming and Software Engineering (PSE) for three different groups of postgraduate students. The first group was consisted of students studying MSc in 'Computer Aided Engineering' delivered by DMU in collaboration with the Fachhoshule Bielefeld, Germany. The second group consisted of British students studying MSc in 'Software Techniques in Image Processing' in De Montfort University, UK. Finally, Russian Ph.D. students studying in Moscow's Buaman Technical University, Russia in collaboration with De Montfort University, UK, were the third group.

The URLs for these two Web-based courseware applications are as follows:

IDE - http://severn.dmu.ac.uk/~nick/STILE/IDE/main.HTM

PSE - http://www.cms.dmu.ac.uk/~elisa/STILE/CAE/main.html

Since the evaluation of the empirical studies is intended to investigate both the users' performance and satisfaction with using the Web-based courseware, a multi-faceted approach has been employed. This approach is largely based upon a summative evaluation method suggested by Marchionini (1990), that addresses both the processes and the outcomes of learning. Summative evaluation, which is the most commonly used type of evaluation in instructional technology, is concerned with the finished product - i.e. courseware - and its comparative value with conventional methods of instruction.

The results from the evaluation of the two empirical studies indicate significant improvements in users' performance and satisfaction compared with conventional teaching methods. Thus, the proposed framework can indeed offer a solution for the development of Web-based courseware that aims to support the delivery of physical modules in higher education. In addition, the results indicate that the end-users input was very important for two main reasons. Firstly, it was a very significant 'ingredient' of the proposed framework, and secondly, it offered a set of interface design considerations/guidelines for Web-based courseware that aims to support the delivery of physical modules. These interface design considerations that have been derived from this study are documented in Chapter 6. Although the results from the current research are of interest in their own right, further research is needed to extend them. Suggestions for further research are documented in the final chapter of this thesis (Chapter 7).

The whole thesis consists of seven chapters and thirteen appendices. The following paragraphs provide a chapter by chapter guide to the structure of the thesis.

Chapter 2 serves as a review of the literature and existing research in the area of hypermedia and learning and shows where this research fits in this area. It starts with descriptive definitions of the terms multimedia, hypertext, and hypermedia. Then the issue of hypermedia models is discussed with particular emphasis on the World Wide Wed model. Next, the chapter explores the potential of hypermedia and learning

focusing mainly on hypermedia-based learning in higher education. Within this context, European and national initiatives are also discussed. Following this, the chapter examines the potential of the Web in higher education and moreover issues concerning basic features, advantages, and drawbacks of Web-based courses are discussed. Finally, the chapter identifies and examines the problem, with which this research is concerned.

Chapter 3 discusses the design of the current research. It starts by suggesting a way to solve the research problem examined in Chapter 2 by proposing a framework for the development of Web-based courseware aimed at supporting the delivery of physical modules in higher education. Next, it discusses the approach of the current research by determining the appropriate research methodology. In addition, methodologies for evaluating hypermedia-based learning are discussed with particular emphasis on the multi-faceted approach proposed by Gary Marchionini (1990). Within this context the techniques and procedures of data gathering and analysis are examined.

Chapter 4 serves as a review of research in educational multimedia and hypermedia features used for designing effective hypermedia-based courseware. It starts with a discussion on the influence of learning and instructional theories in instructional design, with particular emphasis on the Gagné-Briggs theory of instruction. Following this, the chapter looks at courseware design factors such as structure, learner control, feedback, interactivity, and finally screen design. Finally, specific factors that need to be considered in Web design are also discussed. The factors that are examined in this chapter, constitute the Stage 1 of the proposed framework, and will be considered in the design of the experimental Web-based applications, which is described in Chapter 5.

Chapter 5 describes how the Stages 2-5 of the proposed framework were implemented in two Web-based experimental courseware applications and also how the different instructional design factors identified in Stage 1 of the proposed framework were fulfilled in these two pieces of experimental courseware. It does this by giving two accounts. The first one concerns a preliminary survey conducted prior to the development of the prototype coursewares and describes the way that it was conducted and analyzed (Stage 2). The second one concerns with the design, development, and evaluation process of two experimental Web-based instructional applications that

constitute the prototype courseware applications (Stages 3,4,5), that will be used in the empirical studies. The account includes reasons for the selection of learning materials, authoring tools, the structure of the learning materials, the design of the user interfaces, and the production techniques.

Chapter 6 gives an account of the two empirical studies designed to test the validity of the proposed framework. The procedures followed, results obtained, and their implications are described in detail.

In Chapter 7, the thesis concludes, by summarising the main achievements of the current research, providing a critical evaluation of the research, and proposing ways to extend the findings from the current work through further research.

Chapter 2 Hypermedia and Learning: The Higher Education Case

2.1 Introduction

This chapter serves as a review of the literature and existing research in the area of hypermedia and learning and shows where this research fits in this area. It starts with definitions of the terms multimedia, hypertext, and hypermedia. Then, the issue of hypermedia models is discussed with particular emphasis on the World Wide Web model. Next, the chapter explores the potential of hypermedia and learning focusing mainly on hypermedia-based learning in higher education. Within this context, international and national initiatives are also discussed. Following this, the chapter examines the potential of the World Wide Web in higher education and moreover issues concerning basic features, advantages, and drawbacks of Web-based courses are discussed. Finally, the chapter looks into the specific problem with which this research is concerned.

2. 2 Multimedia, Hypertext, and Hypermedia

The terms of multimedia, hypertext, and hypermedia have been widely used during the last few years and often used synonymously and interchangeably. There exist no single set of definitions for these terms. Instead there are numerous working definitions emphasising different aspects of the same idea. The following paragraphs will provide descriptive definitions for each one of these terms.

Multimedia

Multimedia, as the word suggests is the combination of various media. Mills (1991) suggest that "multimedia is an umbrella term for the integration of different elements, such as text, video, still photographs and sound, in a single application" (quoted in McKerlie and Preece, 1992, p.115). Definitions of multimedia usually emphasise the idea that there are a number of different media involved; and that they should be 'integrated', 'combined', 'delivered', and 'presented', and that they should be 'interactive' and 'engaging' to use (Fischer & Mandl, 1990; Gygi, 1990; Keeler and Denning, 1991;

Anderson, 1989; Ito, 1989). McKerlie and Preece (1992) suggest that to some extent a range of general computer applications over the last decade have exhibited these characteristics. Text mixed with images and graphics is common, scroll bars animate text movement, and sounds are used to provide information and feedback. "But, multimedia is more than a collection of multiple media: it is a complex interaction of stimuli which are intended to achieve an effect" (p.115).

Hypertext

Ted Nelson, who coined the term 'hypertext' in the late sixties, states 'by hypertext I mean non-sequential writing' (Nelson, 1987). All traditional text, whether in printed or digital form is sequential, meaning that there is a single linear sequence defining the order in which the text is to be read. On the other hand hypertext is non-sequential; there is no single order that determines the sequence in which the text is to be read (Nielsen, 1995, p.1). There are many definitions of hypertext in the literature (Bolder, 1991; Landow, 1992; Nielsen, 1995; Conklin, 1987). The common elements to all these definitions are the notions of nodes and links. As shown in Figure 2.1, hypertext consists of interlinked pieces of text or other information. Each unit of information is called a node. Whatever the grain size of these nodes, each of them may have pointers to other units, and these pointers are called links. The number of links is normally not fixed in advance but will depend on the content of each node. Some nodes are related to many others and will therefore have many links, while other nodes serve only as destinations for links but have not outgoing links of their own (Nielsen, 1995, p.2).

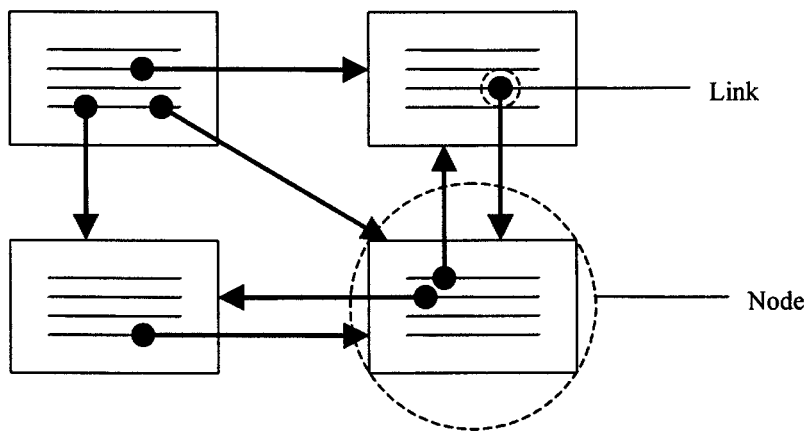


Figure 2.1 Schematic view of a hypertext with four nodes and seven links

Hypermedia

The term hypermedia emphasises the diversity of media that can be used to encode information in nodes. While the traditional definition of the term hypertext stresses that the system deals with plain text, hypermedia supports different media types in nodes. Smith and Weiss (1988) argues that technically, 'hypermedia' is a computer-based approach to information management in which data are stored in networks of nodes connected by links. Nodes can contain text, graphics, audio, video, source code, or other data and are meant to be viewed through an interactive browser and manipulated with an editor. Browsers retrieve information within nodes, while editors allow altering node content and link. From a user's perspective, hypermedia programs are knowledge bases in which every display is a menu to others. Colour coding, icons, cursor changes, and other screen design devices are used to indicate which display elements constitute links. An interface is provided that eases navigation and that usually has controls for moving among displays or to key parts of the knowledge base. Typically, tools are provided for direct information retrieval, such as key word searching and index. Users have full control over information presentation unless access to specific parts of the material is restrained for confidential or strategic reasons (Locatis *et al*, 1989, p.65). The term hypermedia is used to stress the multimedia aspect of a hypertext system (Nielsen, 1995, p.5). Therefore hypermedia is the union of multimedia and hypertext (Davies, 1997).

Frequently the terms hypermedia and multimedia are used interchangeably to describe a linked, non-linear knowledge structure with multiple data types - text, graphics, sound, animation, video. Bolter (1991) argues that a hypermedia display is still a text, a weaving together of elements treated symbolically. Shirk (1994) points out that information from sources referring to hypertext applies equally to hypermedia because although the initial term hypertext has now given way to its successor hypermedia 'we are still dealing with text, or at least textual concepts' (p. 79).

Throughout this thesis the term hypermedia is used to describe a linked, non-linear knowledge structure with multiple data types - text, graphics, sound, animation and video. However, when the thesis is referring to literature sources, then it maintains their use of terminology.

2.3 Hypermedia Models

A hypermedia system is a complex piece of software, consisting of several parts, which serve a very different purpose. In theory one can distinguish three levels of a hypermedia system (Campbell and Goodman, 1988):

- Presentation level: user interface
- Hypertext Abstract Machine Level: nodes and links
- Database Level: storage, shared data and network access

Until recently hypermedia systems were closed systems - material created in one system could not be transferred or integrated with material created in another system because of proprietary document formats and storage mechanisms (Fountain, Hall, Heath, Davis, and Hugh, 1990). Today, several hypermedia models exist, which have been designed to make systems open and also to integrate hypertext functionality into the desktop. As these models describe the possible elements in hypermedia systems, no implementation exists for most of these models. Only the Hypertext Abstract Machine (HAM) model and the Dexter model have been implemented partially (De Bra, 1997). The HAM model described by Campbell and Goodman (1988), is a general purpose, transaction-based, multi-user server for a hypertext storage system. The Dexter Hypertext Reference Model attempted to integrate the formal aspects found in different hypertext systems (Halasz and Schwartz, 1990). However, currently the most successful model in terms of existing applications is the World Wide Web model, which represents the hypermedia side of the Internet, introduced by Tim Berners-Lee in 1990.

2.3.1 Hypertext on the Internet: The World Wide Web Model

The Internet is the name for the interconnected set of computer networks around the world. It emerged in the late 1960's as a product of research, which aimed to connect an U.S. Defence Department Network, called the APRANET and various other radio and satellite networks. The APRANET (APRA stands for Advanced Research Projects Agency of Pentagon) was an experimental network designed to support military research about how to build networks that could withstand partial outages, like bomb attacks, and still function. The objective of the Internet was to develop communication protocols, which would allow network computers to communicate transparently across

multiple, linked, packet networks. This was called the Internetting project and the system of networks, which emerged from the research, was known as the Internet. The system of protocols, which has developed over the course of this research effort, became known as the TCP/IP Protocol Suite, after the two initial protocols developed, Transmission Control Protocol (TCP) and Internet Protocol (IP) (Netskills, 1997).

Since the first day that the Internet emerged, institutions, foundations, private firms, and individuals have provided connectivity to millions of computers on a large number of networks. The National Science Foundation's (NSF) benefaction was very important because with its networking efforts in the late 1980's Internet access became available to people outside the scientific and governmental area. In the late 1980's NSF created five supercomputer centres known as the Internet Backbone. Up to this point the world's fastest computers had only been available to weapons developers and a few researchers from very large corporations. By creating supercomputer centres, the NSF made these resources available for any scholarly research. The Internet increased in popularity because it can offer various ways of interpersonal synchronous and asynchronous communication, information access and retrieval. Basically it offers the ability for electronic mail (e-mail), discussion groups, real-time virtual conferencing, long-distance computing, and file transfers. These features of the Internet, which are currently supported by the Web, will be discussed later in this chapter in the context of education.

However, the most important factor that contributed to the growth and popularity of the Internet was the invention of the Web. Tim Berners-Lee initiated the Web project while he was working for European Center for High Energy Physics, known as CERN, in Geneva, Switzerland. The initial project proposal outlined a simple system of using networked hypertext to transmit documents and communicate among members in the high-energy physics community. By the end of 1990, the first piece of Web software was introduced on a NeXT machine. It had the capability to view and transmit hypertext documents to other people over the Internet, and came with the capacity to edit hypertext documents on the screen. The Web became widely accessible to those outside the scientific and academic communities with the development of the MOSAIC graphical interface in 1993, which allowed the transmission and display of in-lined

graphics together with text, by the National Centre for Supercomputing Applications at the University of Illinois at Urbane-Champaign (Nielsen, 1995, p.179).

2.3.1.1 World Wide Web Architecture

Web software is designed around distributed client-server architecture. A Web client or Web browser is a program, which can send requests for documents to any Web server. It is called a Web browser if it is intended for interactive use. The browser gives some means of viewing the content of nodes, and of navigating from one node to another. Navigation is called the process of moving from one node to another through the hypertext web by following links. Various features of a particular browser may facilitate navigation such as keeping a history of where the user has been. A Web server is a software program that, upon receipt of a request, sends the document requested back to the requesting client. Using a distributed architecture means that the client program may be running on a completely separate machine from that of the server, possibly in another room or in another country. Because the task of document storage is left to the server and the task of document presentation is left to the client, each program can concentrate on those duties and progress independently of each other (Berners-Lee, 1996).

Nielsen (1995) argues that the Web follows the three-level architecture for hypertext recommended by Campbell and Goodman (1988). The lowest level, the database level, consists of the Internet and all those computers around the world that choose to supply materials to others over the Web. These computers act as servers and in principle the user need not care where they are located, what type of hardware or software they use, or what internal storage mechanism they use for the data. All the servers provide their data to the client software in a standardised format called HyperText Markup Language (HTML) through a standard communication protocol called HyperText Transfer Protocol (HTTP). This combination of HTML and HTTP constitutes the hypertext abstract machine (middle level) and is the only point at which clients and server computers need to agree. The user can use a variety of software running on a variety of computers as long as the computers use HTTP and understand HTML files.

The Web browser running on the user's machine handles the presentation level of the model. There are many software packages that allow a user to browse the Web and to handle different user needs and capabilities (see also Glossary in Appendix XIII). They are available for almost every computer platform and operating system. They differ in how they deal with multimedia, which version of HTML they read and which special extensions they allow. The first browsers were text-based, such as Lynx. However, as mentioned above, in 1993, MOSAIC, the first Web browser employing a Graphical User Interface (GUI), was released. Marc Anderseen developed the idea of MOSAIC while he was an undergraduate student at the University of Illinois. As a distributed multimedia browser, MOSAIC provided a unified interface to the diverse protocols and data formats available on the Internet; text, pictures, video, and sounds could all be presented. In April 1994 Marc Anderseen and a partner founded Netscape Communication Corporation. They released Netscape Navigator, which is currently one of the premier Web browser programs, along with its competitor Internet Explorer from Microsoft (Davies, 1997).

There are cases when browsers have to use another program to handle file types that are not supported internally. These programs are called helper applications or plug-ins, and they can be specified in the configuration of the individual browsers and range from Quicktime and MPEG movies (file types for digital video applications) viewers to communication and other Internet applications. In order for the browser to activate these applications users need to have them available on their client computer. The applications vary from platform to platform and actually this is a major drawback because for example a video file of the type of .AVI (Video for Windows) cannot be viewed on a Unix platform. However, most of these applications are readily available on the Internet. Netscape Communications maintains a helpful listing of these helper applications and viewers and where to get them.

According to Tim Berners-Lee, the primary element of the Web architecture is the Universal Resource Identifiers (URIs). URIs known also as Uniform Resource Locators (URLs) implement a unique address schema for all items that can be reached in the Internet. They are strings that encode a certain protocol, network address, and the local location of an object on the Internet together with certain attributes to access the object.

URIs exists for Internet news services (NNTP Protocol), for File Transfer Protocol (FTP) archives, for databases, and for e-mail addresses (Berners-Lee, 1996).

The following paragraphs discuss in more detail the terms of HTTP and HTML mentioned earlier, which are fundamental in Web architecture.

HyperText Markup Language (HTML)

HTML is an application of ISO 8879:1986 Information Processing Text and Office Systems; Standard Generalised Markup Language (SGML). SGML is a system for defining structured document types and markup languages to represent instances of those document types. The term HTML refers to both the document type and the markup languages for representing instances of this document type. The HTML is a simple markup language used to create hypertext documents that are platform independent. HTML documents are SGML documents with generic semantics that are appropriate for representing information from a wide range of domains. HTML markup can represent hypertext news, mail, documentation, and hypermedia; menus of options; database query results; simple structured documents with in-lined graphics; and hypertext views of existing bodies of information. HTML has been in use by the Web global information initiative since 1990 (WWW Consortium, 1997).

HyperText Transfer Protocol (HTTP)

The HTTP is an application-level protocol, which facilitates the delivery of distributed, collaborative, hypermedia information systems. It is a generic, stateless, object oriented protocol which can be used for many tasks, such as name servers and distributed object management systems, through extension of its request methods (commands). A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred. HTTP stands at the very core of the Web. HTTP is the mechanism that allows the Web server and the client to communicate with each other. In case the returning data from the server to the client are text, images, sound file or movie, the Web server retrieves the data from permanent storage (e.g. hard disk) and transmits it back to the client. However, there is a case when the client's request can be data that is not directly available from the server, thus have to be retrieved from another program, called a gateway. These programs are called

gateways because they generally act as gateways between the Web and the server-side resources such as databases, feedback forms etc. (WWW Consortium, 1997).

In order to make this relationship work the server and the getaway programs must communicate with each other. The details of this interaction are specified by the Common Gateway Interface, known as CGI. CGI is a standard for interfacing external programs with information servers, such as Web servers. It defines the output it must return to the server in order to be understood. A CGI program is actually a third-party application developed in a language such as C, C++, Perl, Visual Basic or really any language supported by the operating system in which the server is running. However, the most common used is Perl (Practical Extraction and Report Language) programming language. According to Perl's author, Larry Wall, Perl is an interpreted language optimized for scanning arbitrary text files, extracting information from those files and printing reports based on that information. Perl uses sophisticated pattern matching techniques to scan large amount of data very quickly (Wall and Schwartz, 1991). Figure 2.2 illustrates the flow of data when a user accesses a CGI program. The solid lines shows the data flow using HTTP and CGI. HTTP transfers data from the client to the HTTP server and back again. The CGI mechanism control the flows of data from the server to the gateway program (shown as the triangle) and back again.

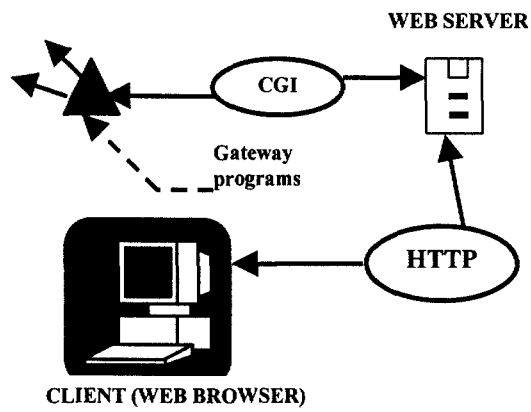


Figure 2.2: Flow of Data to Gateway Programs

2.4 Hypermedia and Learning

There are two quite different forms of teaching via a computer: pre-programmed computer-based learning or CBL, and computer-mediated communications or CMC. There are a number of terms used for pre-programmed computer-based learning, such as CBL (Computer-Based Learning), CAI (Computer-Assisted Instruction), CAL (Computer Aided Learning) etc. The term CBL will be used throughout this thesis to describe pre-programmed instruction. While there are subtle differences in approach between each of these terms, what each has in common is that the learner works through pre-designed materials, interacting by answering questions embedded within the materials and choosing options or 'routes' through the learning material (Bates, 1995, p.189). However, the latter property of CBL reflects the use of hypermedia technology, which was not available in early CBL materials due to the lack of the technology to support such operations. There are two basic educational features that distinguish CBL from CMC. The first is that in the case of CMC the learner can be in contact with other learners and teachers. The second is that remote databases can be accessed through electronic networks, and information can be extracted from a database and downloaded into the learner's or teacher's own computer, and may be stored for later use. Therefore, in CBL the interaction is *with* the computer, but in CMC the interaction is mostly *through* the computer to other people or sources of information (Bates, 1995, p.202). The Web due to its properties to deliver hypermedia together with synchronous and asynchronous communication can deliver courseware that involves both CBL and CMC.

2.4.1 Short History of Educational Hypermedia

Computers were first used in education and training in the 1950's. Much of the early work in CBL was done by researchers at IBM, who developed the first CBL author language and designed one of the first CBL programs used in public schools. Another pioneer in the field was Gordon Pask, whose adaptive teaching machines made use of computer technology to teach such skills as card punching and object tracking (Reiser, 1987, p.38).

Regarding the evolution of hypermedia and learning, key individuals include Vannevar Bush, Douglas Englebart, and Ted Nelson. Bush, President Franklin Roosvelt's science

advisor proposed in 1945 a scholar's workstation called 'memex', a hypothetical mechanical device that predated computers and that could use state-of-the-art photographic technology to manipulate, display, and interconnect information on microfiche (Bush, 1945). Though the system was never implemented, the concepts are still relevant to this day. Engelbart adapted Bush's ideas to the computer in the early sixties, creating a system called 'oNLine System' (NLS) which had hypertext-like features. The system was used to store all research papers, memos, and reports in a shared workplace that could be cross-referenced with each other (Engelbart, 1963). In 1968, he demonstrated NLS as a collaborative system among people shared geographically. While Engelbart was developing NLS, Nelson was implementing his vision of a 'docuverse' (document universe) where everything could be available to everyone. "Any user should be able to follow origins and links of materials across boundaries of documents, servers, networks and individual implementations. There should be a unified environment available to everyone providing access to this whole space" (Nelson, quoted in Balasubramanian, 1994). Nelson designed 'Xanadu' a repository publishing system intended to store a body of writings as an interconnected whole, with linkages, and to provide instantaneous access to any writings within that body. As mentioned in section 2.2 he was the first to refer to such systems as hypertext and later as hypermedia.

2.4.2 Educational Characteristics of Hypermedia Systems

Although hypertext has been discussed for more than fifty years, advances in hardware, software and human-computer interfaces have only recently created conditions where hypermedia systems are technically possible, thus generating great interest from all intellectual sectors. According to Marchionini (1988), there are three main characteristics of hypermedia systems that have great potential for learning and teaching.

First, hypermedia systems allows immense collections of information in a variety of media to be stored in extremely compact form and accessed easily and rapidly. Thus comprehensive and diverse materials can be assembled and delivered to learners. Moreover, these materials can be linked both explicitly and implicitly. Hypermedia authors can use explicit links to suggest paths and relationships through the information,

and learners can choose to follow them or not, in effect, creating their own interpretation of the content. Implicit links are links to support material, such as databases, dictionaries etc., and navigational aids such as graphics of the user's path. Hypermedia allows learners to apply these links as needed.

Second, hypermedia is an enabling rather than a directive environment, offering high levels of learner's control. Learners are allowed to decide the pace and sequencing of navigation and to construct their own knowledge by browsing hypermedia according to their individual abilities and objectives. Such an environment requires learners to constantly make decisions and evaluate progress, thus forcing them to apply high order thinking skills. Therefore, hypermedia offers possibilities for learners to learn not only what they want to learn, but also how to learn.

Third, hypermedia offers the potential to alter the roles of teachers and learners and the crucial interactions between them. "Good teachers always learn from their students, and hypermedia provides an opportunity to facilitate and formalise the human-human interaction that is central to effective teaching and learning" (Marchionini, 1988, p.9). The flexibility of hypermedia enables students to create unique tours and interpretations of the information in a hyperdocument and share these with fellow students and teachers. Hypermedia can facilitate this exchange by saving and replaying tours and allowing these tours to be studied and exchanged. The interactive nature of hypermedia can advance repetitive interaction between learners and teachers, thus affecting the nature of teacher/learner relationships.

The use of hypermedia in teaching and learning is not problems free. There are four main problems especially for learners: (a) disorientation, (b) distraction, (c) technological progress, and (d) human psychology and sociology (Marchionini, 1988). Disorientation is caused from the quantity of information to which a learner has access. Moreover, distraction is due to the high level of learner control that hypermedia systems provide. The problems associated with technological progress concern mostly the speed and memory requirements of hypermedia. To be effective, hypermedia systems must execute linking with very short response times. Therefore, technological advances in digital storage and networking are closely related with the effective use of hypermedia in education. As far as the 'human psychology and sociology' problem is concerned,

resistance to change is the primary consideration. People are accustomed to traditional learning styles, such as the traditional classroom instruction, and therefore, how learning is affected by the application of these new technologies is uncertain. However, learners must acquire a new type of literacy to benefit from the new opportunities for learning that hypermedia offers (Marchionini, 1990, p.356)

Authors of hypermedia instruction cannot help to ease the problems associated with technological progress and human psychology and sociology. However, they can employ hypermedia structuring strategies in order to help diminish or even eliminate the problems of disorientation and distraction in the learning process. Learner's control and structuring strategies are discussed in depth in Chapter 4.

Regarding evidence on the effectiveness of computer-based learning and in particular hypermedia-based learning the results of two meta-analytic studies are of particular interest. In 1980, Kulik, Kulik and Cohen integrated findings from 59 independent evaluations of computer-based college teaching and they conducted a meta-analysis on its effectiveness. This research was conducted during the time period 1967 through 1978. The meta-analysis showed that computer-based instruction made small but significant contributions to the course achievement of college students. 14 of the 54 (approximately 25%) comparisons reported statistically significant differences between teaching methods. Kulik *et al* (1980) concluded their research by pointing out that "developments in computer technology have been occurring so swiftly that no one can predict with confidence what the next year, much less the next decade, will bring to computer-based college teaching" (p. 540).

Recently CliffLiao (1997) conducted a meta-analysis on the effects of hypermedia versus traditional instruction on student's achievement on thirty-five different empirical studies that were published from 1986 to 1997. The results from this study suggest that the effects of using hypermedia in instruction are positive and greater than the traditional instruction. 18 of the 35 (approximately 51%) comparisons reported statistically significant differences between teaching methods. Despite the fact that the scale of these two meta-analytic studies is not the same, there is an obvious difference in the results reported. It can be argued that this difference is associated with the advancement of technology. Naturally, the studies published from 1986 to 1997 used

more advanced technology to deliver instruction than those published from 1967 to 1978. Therefore, Liao's study provides to the area of hypermedia evidence for positive outcomes from using technology. However, there is still a need to examine what makes hypermedia such an effective learning tool.

2.4.3 Reasons for Increased Learning Using Hypermedia

The similarities between the structure of multimedia and the information processing theory account for a large part of the success of learning with multimedia (Bagui, 1998). The information processing theory, which is currently the dominant learning theory (Anderson, 1995) describes how people take in the information and how people learn information (Preece, Rogers, Sharp, Benyon, Holland, and Carey 1994; Anderson, 1995). The basic idea of the information-processing approach is that information enters and exits the human mind through a series of order processing stages as shown in Figure 2.3. Cognition is viewed in terms of how the perceptual processors perceive information and how that information is attended to, processed and stored in memory. In stage 1 the information is encoded from the environment into some form of internal representation. In stage 2 the internal representation of the stimulus is compared with memorised representations that are stored in the brain. Stage 3 is concerned with deciding on a response to the encoded stimulus. When an appropriate match is made the process passes on to stage 4, which deals with the organisation of the response and the necessary action. The model assumes that information in unidirectional and sequential and that each of the stages takes a certain amount of time generally thought to depend on the complexity of the operations performed.

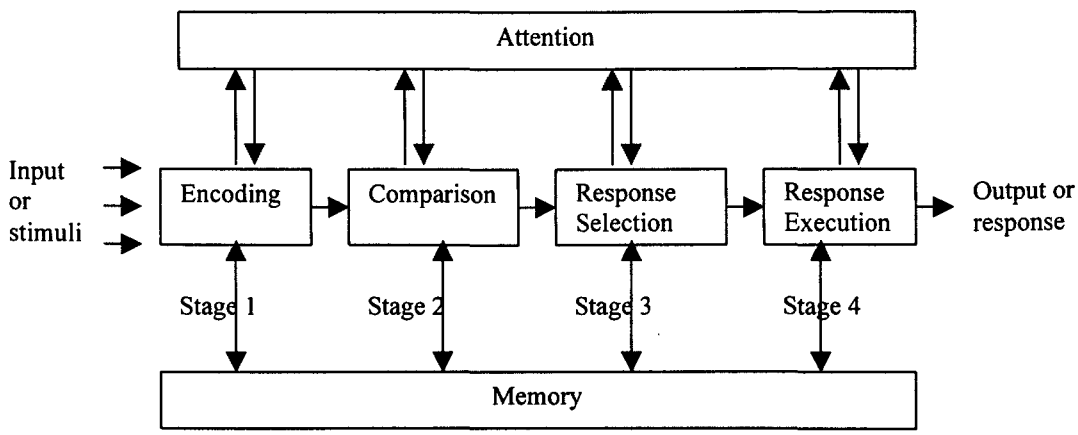


Figure 2.3 Human Information Processing Stages (adapted from Barber, 1988)

Three types of memory, known as the multi-store model of memory are identified in the information processing theory:

- The sensory store that holds information for a very brief period of time (a few tenths of a second). Only a small fraction of the information entering the sensory stores is attended to and selected for further processing in the short-term store.
- The short-term memory store or working memory that holds information for a short period of time (a few seconds). A characteristic of the short-term memory is that its capacity to hold information is limited in amount and time. At most the number of items we can remember at one time is about seven. This phenomenon, known as 'the magic number 7 ± 2' was identified by Miller in 1956. Information reaching the short-term memory store is actively processed and may then be transferred into a long-term memory store.
- The permanent long-term memory store. Information entering the long-term memory is assumed to be permanent (Preece *et al*, 1994).

The components of the multi-store model of memory make up the human knowledge base. If a person is able to retrieve a piece of information from his/her knowledge base, then it is argued that that person knows that piece of information, or has learned that piece of information. Thus, in the human brain most knowledge can be accessed by multiple routes. Multimedia also allows pieces of information to be accessed through multiple routes, taking advantage of the way that the human brain organises information. (Bagui, 1998).

Another reason for increased learning using hypermedia is the Dual Coding Theory (DCT), which is an aspect of the information processing theory, and was first suggested by Paivio in the 1960's. Much of the evidence for DCT came from research in human memory where it is often found that memory for pictorial material is superior to memory of verbal material. Researchers have also found that memory for verbal material is greatly enhanced if one can develop visual images corresponding to the material (see Anderson 1995:107). Clark and Craig (1991) argue that the DCT is perhaps the only theoretical basis for the interest in multimedia instruction. According to DCT (Paivio, 1971, 1986; Clark and Paivio, 1991) information is processed through

one or two generally independent channels. One channel processes verbal information, such as text or audio. The other channel processes non-verbal information, such as illustrations. Information can be processed through both channels. Information processing through both channels is called referential processing and has an additive effect on recall. Learning is better when information is referentially processed through two channels, than when is processed through only one channel. Referential processing may produce this additive effect because the learner creates more cognitive paths that can be followed to retrieve the information. In other words, DCT suggests that when information in visual and verbal forms is learned, each form is stored in a separate cognitive system, thus two storage systems for the same information accounted for a superior recall of information taken in by words and pictures. Since recall requires that we locate some items in memory, items with two processing locations might be remembered better than items with one location (Paivio, 1971, 1986; Clark and Paivio, 1991).

A third reason for increased learning using hypermedia is that hypermedia allow more interactivity than traditional classroom instruction (Najjar, 1996). Interactivity appears to have a strong positive effect on learning. Examinations of 75 learning studies (Bosco, 1986; Fletcher, 1989) found that people learn the material faster and have better attitudes towards learning the material when they learn in an interactive instructional environment. Najjar (1996) argues that "the learning advantages of computer-based multimedia instruction over traditional classroom lecture may be due to the increased interactivity of multimedia instruction rather the multimedia information itself" (p. 132).

2.5 Hypermedia Based Learning in Higher Education

Higher education within the United Kingdom, as elsewhere in Europe, is growing at an unprecedented rate. By the end of the decade, total student numbers should rise by over fifty per cent from today's figure. There is a growing demand for continuing education. This relates to the fact that modern industrial competitiveness depends on skill acquisition. There are also changes in career patterns emerging, with many people retraining at least twice during their working life. In 1990 237,000 mature students entered UK higher education and only 232,000 young students. (These figures exclude the Open University). The increase in mature students was 77 per cent compared with

1980 (Committee of Scottish University Principals, 1992). As conventional institutions react to the pressure to increase student numbers without a commensurate increase in teaching staff, increased reliance on resource-based learning can be expected (Entwistle *et al* 1992, p.59). Brown and Atkins (1988) argued that substantially fewer lecturers, supported by carefully designed course materials, could increase the effectiveness of teaching, particularly if various forms of computer-based learning are also provided.

In order to decide which methods of teaching can encourage learning and are cost-effective, there is a need to consider the nature of the learning that takes place in higher education. Students in higher education are required to acquire an extensive technical knowledge of their subject area, together with the associative skills involved in applying that knowledge either within a profession or an academic discipline. Moreover, students should develop additional skills, which are considered important by employees. These include communication skills - effective oral and written communication of ideas, together with supporting computer skills; problem-solving in realistic complex contexts, showing initiative and an awareness of practical constraints; and inter-personal skills in working together collaboratively in a team. Techniques associated with active and flexible/open learning have been used to help students achieve this goal. Active learning is the term used to emphasise the importance of ensuring that students engage actively in the learning process, rather than passively accept the work as a component of course requirements. Active learners seek out the information they need, judge their own progress, and are group-motivated. Flexible/open learning encourages similar forms of activity among students, but also this learning promotes a shift from formal whole-class didactic teaching towards individual or group management of learning through the provision by the teacher of structured resource materials (Committee of Scottish Universities Principals, 1992).

Entwistle *et al* (1992) has identified several factors that affect the level of academic performance; one of them is the 'teaching methods'. Teaching methods include three main components.

1. Quality and style of teaching in lectures and group work.
2. Practical work.
3. Provision and use made of learning resources.

Effective learning depends on students being able to follow up lectures and tutorials with their own independent study. Students also need to have access to appropriate learning resources and know how to use them effectively. Learning resources involve materials provided by the lecturer (handouts and reading lists), textbooks which students are expected to buy or borrow from a library, and other sources of information, for example video and audio tapes, slide presentations, and a variety of computer-based programs.

In 1991 the Committee of Scottish University Principals set up a Working Party to study potential approaches to the problem of teaching and learning in mass higher education. A major consideration of this study was the cost and benefits of innovative teaching methods and the use of technology.

> With the transformation of higher education into a system that is adapted to servicing the needs of much larger numbers comes the imperative to develop much greater flexibility. Distance and open learning methods - long practised by the Open University - free students from the constraints of time and place, and even allow for more individualised feedback to students that could be contemplated within the traditional university teaching systems. (Committee of Scottish University Principals, 1992, p.2)

Some of the benefits identified from the working party for computer-based and distance education and also relate to hypermedia-based learning as well are as follows:

- *Modified Traditional Systems* - Favourable changes in all the performance measures of traditional teaching systems could be achieved by a combined use of innovation and educational technology, particularly by the use of distance learning and computer based learning methods.
- *Access* - Intake and recruitment arrangements to a variety of courses could be greatly improved by creating self-paced supported learning courses giving a satisfactory preparation for a range of subjects requiring specific skills as prerequisites.
- *The shift from synchronous single-location learning support to asynchronous networked learning support* - The severe space and time constraints of traditional presentation methods using lectures and laboratories can be removed by a shift to

self-paced supported learning using a variety of possible support and delivery mechanisms.

- *The shift from passive learning to active learning* - Learning is an active process in which concepts are acquired, incorporated into appropriate schemas, and tested in action. Computer-based learning support systems offer great scope for the development of active learning environments, and thus for an increase in the quality and effectiveness of the learning experience.
- *The shift from static presentation to dynamic presentation* - Cost-effective methods of producing, transmitting and storing acceptable quality video and animation will greatly improve the presentation of a wide range of materials, and hence the quality of the learning support system.
- *The shift to multimedia* - The imaginative and skilful use of a wide range of media offers huge scope for imaginative teaching.
- *The shift from unidirectional presentation to interactive presentation* - Interactivity offers great scope for benefits in clarification, elaboration and consolidation, and is the key to the production of highly supportive learning environments. Great benefits in quality and effectiveness could be obtained, given a well-designed support system.
- *The shift from broadcast delivery to personal delivery* - The possibility, given skilful design, of developing learning support systems which tailor their response to an individual needs and performance is of great potential value in the battle to combine volume benefits with quality benefits. Properly developed, it could greatly increase the scope for self-paced learning and for access and remedial teaching, driven by an individual's motivation.

Some of the costs identified from the Committee of Scottish Universities Principals (1992) for computer-based learning which as with the benefits discussed relate to hypermedia-based learning are as follows.

- *Infrastructure costs* - These are the costs of purchasing and installing hardware and software, and of providing networks.
- *Courseware costs* - The costs of courseware will depend on its commercial exploitation. Students could be required to purchase disk-based courseware in the

same way as they are currently expected to buy books. However, as far as Web-based learning material is concerned, this is not exactly the case. At the moment there are plenty of teaching materials freely available on the Web, but also there are materials that are aimed primarily at distance education where the user needs to be enrolled in a course and pay tuition fees in order to have access to them. It can be argued that it is quite early to judge how the situation will evolve in the future because the Web as an educational tool is still in its early phase but is developing very quickly.

- *Research and Development costs* - Every large-scale growth in the use of technology needs a major programme of research and development. The research and development part is a very important component because the application of any innovative use of technology in education needs to address psychological and sociological issues. For instance, learners and teachers may need time to familiarise themselves with innovative ways of learning and teaching. In addition, some learners may perform better in conventional teaching and learning environments. Research and development costs may cut down if the industry is willing to invest in such a programme. This can be the case if it can be demonstrated that the research and development being conducted is likely to lead to wide exploitation.

From the above discussion the great potential of hypermedia-based learning in higher education becomes apparent. Well-designed hypermedia courseware can be a flexible learning environment where the students are actively engaged in the learning process. Therefore, the problem in maintaining and promoting the quality of provision in higher education within the given financial constraints can be solved with the development of hypermedia-based learning resources. Some evidence exists that the benefits can actually outweigh the costs. Beijderwellen (1990) found that for more than 50 students a year, an interactive video program on geology developed from scratch was more cost-effective for the institution than a summer school site visit. Also, Van der Brande (1993) reported that British Telecom used a CD-ROM system to train its operators to use computerised telephone exchanges. The cost of this system was 6 million ecus, compared to an estimated 60 million ecus for using traditional methods. In addition, the meta-analytic studies that were discussed earlier and the interest on educational

hypermedia shown from European and national initiatives as will be discussed in the next section, indicate that there is a great possibility that more evidence will come in the near future. Gill Tucker (1996), Dean of Learning and Teaching in Oxford Brookes University points out that,

> As the concept of a global information society becomes a reality we can realising (sic) that information technology can be both a tool for enhancing and supporting student learning as well as providing access to learning to a more diverse student body both on and off campus. We are, therefore, discovering how essential it is to integrate learning technology into our teaching and learning strategies. (p.3)

There are currently a number of national and European funding initiatives to pump prime the development of hypermedia educational resources. The following section discusses the most important of these initiatives. Particular emphasis is given to the European Union's policy concerning information society and learning.

2.5.1 Educational Hypermedia Initiatives within the European Union

It is now widely accepted that research and technological development are key factors for the competitiveness of the European Union, which in turn determines its future wealth and influence in the global economy (Bangemann, 1997). The European Union is heading towards the implementation of the 'Information Society' as the Bangemann Report (European Commission 1994a) suggests. Multimedia for research, education and training plays a critical role in the realisation of the 'Information Society'. Peter Bates (1995) on behalf of the European Commission points out:

> (Information and communication) technologies and the advances of digital electronics are now allowing the creation of *new multimedia telematic services* and applications which combine sound, image and text, and for which all means of communication – telephone, facsimile, television and computers – are used in a complementary way. The development of these new means of communication represents an element of increased competitiveness for enterprises and opens up new perspectives in terms of work organisation job creation and *learning opportunities*. The diffusion of these new technologies at all levels of economic and social life is thus gradually transforming our society into an "information society" (p.1). (italics added)

The European Union's *White Paper* (European Commission 1994, p.13) declares that "the dawning of a multimedia world (sound - text - image) represents a radical change

comparable with the first industrial revolution". The Bangemann Report (European Commission, 1994a) explains this statement further:

> Throughout the world, information and communication technologies are generating a new industrial revolution already as significant and far-reaching as those of the past. It is a revolution based on information, itself the expression of human knowledge. Technological progress now enables us to process, store, retrieve, and communicate information in whatever form it may take – oral, written or visual – unconstrained by distance, time and volume. This revolution adds huge new capacities to human intelligence and constitutes a resource, which changes the way we work together and the way we live together. (p.3)

As Europe enters the emerging global information society, new opportunities for transforming lifelong learning and continuing training are beginning to emerge. The convergence of information and communication technologies is enabling the creation of new multimedia telematic applications and services. In 1986 the European Commission started the first systematic work on technologies for education and training in the pilot projects which led to the exploratory Action on DELTA Programme (Developing European Learning through Technology Advance) in 1988 for the period of two years. The aims of this Action were to assess the potential market for using technology and telecommunications in education and training; and to test whether interest was of a sufficient level to carry out further European research in this area. More than 200 organisations were involved in 30 projects during this Action and the overall budget was 20 million ECU (European Commission, 1994b). This Exploratory Action was carried forward under the area of 'Telematics for Flexible and Distance Education' within the Third Framework Programme from 1991 to 1995 (Roselló, 1995). The aim of this Programme was to support the design and implementation of systems and services that will improve education and training provision in Europe by making them more efficient, more widely available and better able to meet the needs of individuals and industry. This Programme had a budget of 62 million ECU and funded a total of 30 research technology and development projects (European Commission, 1994b).

Following this, in 1994 the 'Telematics Applications Programme, 1994-1998' was initiated on the basis of the Union's Fourth Framework Programme. The Telematics Applications Programme is concerned with societal application research based on

communication and/or information technologies. It constitutes the focal point of actions supported by the European Commission in this field. With a budget of ECU 902 million, it occupies a pivotal role in both research and development related to such applications and Community policies involved in the establishment of the Information Society. Indeed, within the Telematics Applications Programme, 60% of the projects contribute to the recommendations of the 1994 Bangemann to the European Council 'Europe and the global Information Society'. The Programme (whose management is shared by Commission Directorates-General XIII-C XIII-E) is subdivided into four major fields and 12 sectors. One of these four fields is 'Telematics Applications for Knowledge' aimed at developing new tools and applications for improving access to and sharing of knowledge. Three sectors constitute this field: 'Libraries', 'Research', and 'Education and Training'. More than 60 projects were funded in this field throughout European institutions and industries (European Commission, 1997).

The Programmes mentioned above constitute the main European Union's initiatives in the field of educational hypermedia. However, there are other initiatives involved such as the 'Educational Software and Multimedia' Task Force and the IMPACT Interactive Multimedia (IMM) Projects (European Commission, 1996). These initiatives are aimed at investigating the use and effectiveness of educational multimedia software in homes, schools, universities and vocational training in order to provide suitable solutions through numerous projects that are carried out from European institutions and individuals. Another important Programme, which was launched on May 1996, is the INFO2000 at the instigation of Commissioner Bangemann. INFO2000 aims to stimulate the development of the European multimedia content industry and is a key element in Dr Bangemann's Information Society initiative (European Commission, 1996a). From this brief account the significant role of educational hypermedia in the realisation of the Information Society in Europe becomes apparent.

2.5.2 Educational Hypermedia Initiatives in the United Kingdom

In the United Kingdom many initiatives have been taken such as the establishment of Computers in Teaching Initiative (CTI) centres and the launch of the Teaching and Learning through Technology Programme (TLTP). The UK Universities Funding Council (UFC) launched TLTP in February 1992, when universities were invited to

submit bids to the £7.5 million per year initiative. The invitation to bid stated that 'the aim of the programme is to make teaching and learning more productive and efficient by harnessing modern technology'. The response to this invitation, which totalled 160 submissions, emphasised the urgent need across the sector to fund initiatives which would, in the long term, assist academic staff in meeting the new challenges of a changing higher education sector. From the 160 submissions, 43 projects were funded to a total cost of £22.5 million over three years. The new needs of the sector, demonstrated by the response to the first initiative, were recognised by the successor Councils to the UFC - Higher Education Funding Council for England (HEFCE), Scottish Higher Education Funding Council (SHEFC), Higher Education Funding Council for Wales (HEFCW), and the Department of Education in Northern Ireland (DENI). In April 1993, the above funding bodies agreed to commit funds to a second Phase of TLTP. The response to the second invitation resulted in 367 submissions. A total of £3.75 million was made available to fund a further 33 projects under the second Phase of TLTP. The total funding for TLTP up to 1996 is seventy five million pounds, making TLTP the largest learning technology initiative ever undertaken within UK higher education. Since it came into existence the TLTP has been an essential agent of change in the area of learning technology (TLTP, 1996). The projects funded produced hypermedia-based learning material, which were CD-ROM-based and Web-based. In October 1997, the HEFCE and DENI invited bids for funding under the third Phase of TLTP. Funding in Phase 3 will be primarily for projects to encourage the use of new technology-based and learning materials (HEFCE, 1997).

2.6 Potential of the World Wide Web in Education

Nowadays the most popular platforms for delivering educational hypermedia are CD-ROMs, and the Web. CD-ROM stands for Compact Disk Read Only Memory. Read only means that the user can only read information from them and not write information back to them. Although CD-ROM technology has many advantages such as large storage capacity; portability (large amounts of data can easily be transported); durability (well suited to long-term archiving of large amounts of data); the ability to search reasonably quickly through large amounts of data, they have three main disadvantages. CD-ROMs are problematic as a global distribution medium because they lack the main

ingredient of person-to-person interaction, they are difficult and costly to update, and in principle they are not cross-platform. The Web, which is the cutting edge of global education delivery, overcomes these disadvantages. Through helper applications and internal mechanisms the Web can connect a learner to almost any part of the Internet. Because of this the Web shares the advantages and disadvantages of the rest of the Internet. McManu's (1995) description of the Internet fits the Web equally well.

> The Internet can deliver video, but not as quickly as videotape, television, or CD-ROM. It can carry real time personal interaction, but not as well as telephone or video conferencing. It can display textual information, but not as useful as a book or magazine. Why then will the Internet ever be used? The Net has two real advantages over other media. It combines advantages of other media so that it conveys video and sound better than a book, is more interactive than videotape and, unlike CD-ROM, it can link people from around the world cheaply. The second advantage, and the one that is often overlooked when discussing the Internet as delivery system, is that it can also be a content provider. The Internet is arguably, the largest and more diverse information resource in the world today. It is possible to incorporate the wealth of information available on the Net in your design. For instance if you are designing a module on renaissance art history, you can include links to the Vatican Library and the Louvre, as well as the Art History exhibit of the Australian National University, just to name a few. This sort of immediate access to information and resources can not be found with any other medium. (p.12)

The next paragraphs will discuss in detail the features of the Web with potential for education and the technology that supports them.

2.6.1 Features of the Web with Potential for Education

HTML delivers hypermedia documents in the Web. Since the first day that HTML was created it has evolved, new features have been added such as defined 'hot spots' in images, more flexible layout styles, and formatted tables. Moreover, Dynamic HTML (DHTML) documents are interactive HTML documents, such as feedback forms that are created on the fly from the Web browser upon a user's request.

An exciting area is the integration of new Internet technologies into the Web. The Web offers a range of communication channels, both asynchronous and synchronous. Electronic mail (e-mail) and bulletin boards are the most common forms of

asynchronous communication. E-mail involves mainly transferring text from one computer to another over the Internet and makes it possible to communicate with virtually any other user connected in the Internet, anywhere in the world. Moreover, e-mail technology supports the transfer of any type of file when these files are attached to the original message. Although e-mail provides transmission of files is not recommended for large files. Instead the File Transfer Protocol (FTP) can be used. FTP allows fast transmission of any file regardless its type and size over the Internet. The bulletin board is an electronic location where users can leave messages for other users. It also allows limited conferencing between users when accessing the bulletin board at the same time.

Synchronous communication channels include Internet Relay Chats (IRC), Multiple User Dungeons (MUDs), and computer teleconferencing. IRC are real-time group discussions and MUDs, which are essentially an IRC in a particular subject, provide users with the ability to interact with each other in real time. MUDs are multi-user interactive role-playing games on the Internet. MUD technology can be used in education to implement text-based virtual forums and virtual seminars where students and teachers can meet in real time and exchange ideas. However, more popular in education are MOOs, which are object-oriented MUDs since they have sophisticated built-in programming language that allow individual users to extend the environment by 'building' or creating new objects. Curtis and Nichols (1993) describe a MOO as a network-accessible, multi-user, programmable, interactive system well suited to the construction of text-based adventure games, conferencing systems, and other collaborative software. Its most common use, however, is as a multi-participant, text-based virtual reality. Participants give coded text-based commands that are interpreted as appropriate. Such commands may cause changes in the virtual reality, such as the location of a character, or may simply report on the current state of that reality, such as the appearance of some object. The database contains representations of all of the objects in the virtual reality, including the MOO programs that the server executes to give those objects their specific behaviours. In an educational context the ability of MOOs to allow users to create new objects can permit the student to become an active participant in the learning experience. In addition, MOO's provide a strong sense of 'place', possibly bringing back some of the social interchange of 'campus' life' that is lost

in distance education. A MOO server can also be configured to act as an HTTP server. This means that a Web browser can be used to look at locations, rooms, people, artefacts, etc. in the MOO. These objects can have hypertext URL's attached and therefore be used to structure information on the Web (Hobbes and Taylor, 1996).

Another synchronous communication technology being integrated into the Web is the CUSeeMe. CUSeeMe is a teleconferencing program, which allows users to see and hear each other by converting the data from a video camera into an Internet compatible format. Functionality such as this combined with the Web's built-in audio-visual capabilities suggests new possibilities for group-based on-line education.

The shared whiteboard is also a real-time tool supported by the Web. Internet whiteboard applications allow two people to view a shared drawing space. In addition to graphics, writing on the board can be used for communication, though whiteboard applications are usually combined with other Internet communication systems, such as the CUSeeMe teleconferencing technology.

Another influence likely to affect the Web in a major way is HotJava, a Web browser developed by Sun Microsystems that can execute programs (known as applets) written in the Java programming language and be included (like images) in HTML pages. The Java language is the first to present a comprehensive solution to the challenges of programming on the Internet, providing an object-oriented programming language optimised for the creation of distributed, executable applications and offering portability, security, advanced networking and reliability without compromising performance. Because Java is compiled into machine independent bytecodes, applications written in Java can migrate transparently over the Internet, accessible by anyone using the HotJava browser or any other Java enabled browser. Netscape Navigator now offers Java support enabling it to download Java applets to run on a wide variety of client systems. Java has been available since April 1995 for developers using the Sun Solaris or SunOS platforms. More recently the availability of the language has been extended to other varieties of UNIX, Microsoft's Windows NT and Windows 95 operating systems. Further, an equivalent of Java was developed by Microsoft Corporations and is called ActiveX.

Another good example of how the Web technology is being advanced is real media. Real media is digitised audio and/or video that have been compressed into a format that a server can break down into packets and then broadcast across a network to a Web client. The client then reassembles the data packets into the correct order and plays back the audio and/or video in real time without breaks or frustrating download delays that have hitherto presented an obstacle to informational, recreational and creative use of audio and/or video.

Finally, one of the more recent developments of the Web is the establishment of the Virtual Reality Modelling Language (VRML) as a standard method for describing three-dimensional virtual scenes on the Web. Although VRML was a static description language during its initial phase, it is currently being extended to support interactive virtual environments and behaviour of virtual world entities. Its originator, Mark Pesce (1996) defines it as "a language for describing multi-user interactive simulations - virtual worlds networked via the global Internet and hyperlinked with the Web". Like HTML, the 3D worlds that VRML provides can be hyperlinked to other resources on the Web. VRML can be thought as a 3D equivalent of HTML, providing a three-dimensional interface to theWeb. VRML could make navigating through on-line museums, libraries, marketplaces, and every other space as common as interacting with textual information (Vacca, 1995, p.28).

Summarising, the Web is providing a number of opportunities for teachers and students. Resources can be accessed which might otherwise have been unavailable, as it is currently the largest and most diverse information resource in the world with cross-platform portability. Teaching programs presented in a clear, attractive, and practical manner can be accessed and used by students as part of their modules or as distance learning courses. Students and teachers can communicate synchronously and asynchronously, thus fulfilling the essential component for interpersonal interaction in the teaching and learning process. Therefore the Web can be seen as a piece of instructional technology because it can meet the requirements of the instructional technology, as they have been defined by 'Commission on Instructional Technology' and also 'Definition and Terminology Committee of the Association for Educational

Communication and Technology'. Instructional technology according to the 'Commission on Instructional Technology' (1970) can be defined in two ways:

> (I)t means the media born of the communication revolution which can be used for instructional purposes alongside the teacher, textbook and the blackboard. The pieces that make up instructional technology include television, films, overhead projectors, computers, and other items of 'hardware' and 'software'. (p.21)

Beyond this way of defining instructional technology, another major concept associated with the field of the instructional technology is the notion of the individualised instruction. The 'Definition and Terminology Committee of the Association for Educational Communication and Technology' (1972) points out:

> The educational technology approach has been directed towards expanding the range of resources used for learning, emphasising the individual learner and his unique needs, and using a systematic approach to the development of learning resources. (p. 36)

The Web has the potential to deliver individualised instruction. Through hypermedia presentations can give the learners the ability to tailor the learning process to their individual needs.

2.7 World Wide Web-based courses in Higher Education

Currently there are a large number of on-line courses on the Web, covering a wide range of topics similar to those that academic and training institutions offer. The nature of these courses is varied from higher education courses, to training courses. Within higher education two types of on-line courses have been identified. The first type is concerned with the delivery of support material for physical modules such as lecture notes and syllabus for on campus students. The second type is concerned with the delivery of primary learning resources aimed to support off campus students in distance learning. Distance learning Web-based courses are offered from conventional institutions with physical location, such as the Open University, U.K, as well as from virtual universities like 'Learning On Line University' (LOLU) (http://www.lolu.org/) and 'Athena University' (http://www.athena.edu/).

LOLU claims that is an online school with courses featuring lectures, live chats throughout the school population, continuing class discussion in online forums, course

glossaries, optional assignments, inter-student e-mail, self-scoring tests, and other educational features in an exceptionally robust and user friendly setting where everything is Web-based. The courses it offers run for ten weeks and the fees are $50 per course. Further, Athena University is administered by the Virtual Online University Services International (VOUSI). VOUSI claims that it offers a novel and effective approach to academic excellence, professional development, and life-long learning. "Where the conventional distance education program leaves one isolated, our electronic campus allows one-to-one collaboration, debate and interaction between fellow students and instructors by way of a distinctly innovative model for distance education" (http://www.vousi.com/). Athena shares VOUSI's mission to provide a quality liberal arts education to students in a more cost-effective and accessible manner. To accomplish this mission, Athena has established a virtual education environment which, can be accessed from anywhere on the globe at any time by exploiting present telecommunication technology. Athena campus is constructed from a MOO, incorporating features and objects specifically built to provide a comprehensive educational environment. It offers many online courses included an accredited Master degree in Business Administration.

Despite the fact that some of the existing on-line courses are still in experimental stages due to the novelty of the medium, there is still a respectable number of courses that have been running for the last couple of years and their providers claim that they have a satisfying number of students. For instance, in the academic year 1998/99, 5,100 students have been enrolled to the 'Object Oriented Approach', an introductory computing course provided by the UK Open University. A Web-based database from the University of Texas, U.S., called 'The World Lecture Hall' (http://www.utexas. edu/world/ lecture/) contains links to pages created by faculties worldwide who are using the Web to deliver class materials. It offers an alphabetical index with 73 different areas of study from accounting to zoology, and links to Web-based courses in each of the area. In addition, they offer translation service from or into English, Spanish, French, German, and Portuguese, and a facility to add new materials in this database.

Another fact that indicates the significance of Web based courses and predisposes for their future proliferation is that Internet software companies are offering services for the development of Web-based courses. Examples of such services are the 'CourseInfo' (http://courseinfo.com), the 'Chalk' (http://chalk.ifactory.com), and the 'CyberExam'. (http://www.vlearning.com). These companies offer methods by which instructors can easily place course materials online by creating an Internet Web site. The software is designed by the instructor who wants to provide a new facet of interaction with students but does not have the time to learn complex authoring languages. The providers of these services claim that they supply tools for creating and maintaining a Web site, which are extremely easy to use, yet perform many complex functions such as online collaborative classroom activities as well as off-line interactions, including asynchronous self-paced assignments, discussion groups, etc. Moreover, new software types have appeared aimed at providing authoring tools for creating Internet-based training such as the 'ToolBook II Assistant' from Asymetrix (http://www. asymetrix.com).

2.7.1 Basic Features of Web-based Courses

In order to identify the basic features involved in Web-based courses a sample of ten such courses were examined. However, the following courses were examined in more detail:

- 'Unix Systems Programming' course offered by the School of Computing, Curtin University of Technology, Western Australia. This Web based course provides support material for on campus students. (http://www.cs.curtin.edu.au/units/usp251/notes/contents1.html)
- 'An Object Oriented Approach' course offered by the Open University, UK. (http://www.open.ac.uk)
- 'Introduction to Art' course provided by the City University, USA. This Web based course also provides support material for on campus students. (http://www. caso.com/iu/city.html)

The following nine basic features were identified within Web-based courses. The first six features are included to a lesser or greater degree in all Web-based courses. However, the last three features in this list are used almost exclusively in Web-based courses aimed at distance learning.

1. *Presentation of class materials* - The course's syllabus and items that would otherwise appear on a classroom overhead projector such as lecture notes, slides etc. are presented in hypermedia format. There are also links to other Web resources that apply to the course curriculum.
2. *On-line Databases/Libraries* - The students have access to on-line databases where data relevant to their course are stored in digital format. In addition, students can access on-line libraries, browse electronic book catalogues and make reservations.
3. *Electronic mail (email)* - Email is the primary form of communication for all the types of courses, where messages, questions and comments can been exchanged between students and instructors.
4. *File Transfer Protocol (FTP)* - FTP is used for downloading large size files from Internet resources or the institution itself to the user's computer so they can been processed later by the user off line.
5. *Bulletin boards* - Bulletin boards are used to post messages to students and tutors. Unlike chat session, bulletin boards do not require the sender to be logged in at the same time as other participants; it is asynchronous communication. Participants can check back to see new postings by other members on the topic they have suggested.
6. *Quizzes and exercises* - Students undertake a set of instantly self-scoring tests which provide feedback on their performance, and they may submitted to the tutor via email for further assessment if needed.
7. *MOOs* - They are used to create open discussion areas, known also as 'chat rooms' to facilitate one to one or group, real time formal or informal discussions in subject areas. In the case of distance education courses MOOs are used for real time lectures and conferences, and also as a facility to incorporate features and objects specifically built to provide an educational environment.
8. *Performance Tracking Report* - Students receive feedback and performance tracking report from their tutor via email.
9. *On-line exams*. This feature is mainly used in distance learning courses, where exams are taken in a way similar as the campus based courses.

The benefits identified for computer-based and distance learning in the previous section of this chapter 'Hypermedia-based Learning in Higher Education' equally apply to Web-

based courses. In addition, the features of the Web examined in the 'Potential of the World Wide Web on Education' section suggested the power of the Web in education. Therefore in this stage only an outline of the main advantages of Web-based courses will be presented next.

- Global access to courses and relevant information irrespective of time and location.
- Access to a large, expandable resource base covering a broad range of material including software.
- The ability to update course material easily.
- Easy downloading of paper-based teaching resources.
- The Web facilitates a flexible approach to learning, including group, distance, and collaborative learning. Moreover, it facilitates synchronous and asynchronous interpersonal interactions.
- Appealing presentation of course materials through hypermedia technology.

However, there are some particular drawbacks in Web-based courses associated with the costs identified for computer-based and distance learning in the 'Hypermedia and Learning' section of this chapter that worth consideration. These are as follows.

- An important drawback of on-line courses is the lack of physical communication among participants. Most people are used to working in an environment that affords physical personal interaction with peers and they may find it difficult to respond effectively in electronic communication. An important factor that contributes to this disadvantage is the absence of the body language and facial expression when text-based discussion takes place in an electronic environment. Moreover, students are depriving the experience of the student way of life.
- Another possible trade off is that students will find using the technology an added learning curve and will need time to become confident in using the Web and its services. There is also the possibility of low levels of student participation in the course. It can be seen that participation varies considerably, and undoubtedly may be influenced by the design of the course. In the case of a second level undergraduate course 'DT2000: An Introduction to Information Technology' delivered by the British Open University in the first year of the course only 26 per

cent of students were contributors to the course (Bates, 1995, p.214). Furthermore without good design and moderating skills, it is very easy for online discussions to descend into low level chat or low levels of response from students.

- Other barrier(s) to Web-based courses may be the psychological disorders that may result to the participants such as information overload and addiction to the nature of on-line communication. As far as the nature of the courses is concerned the use of poor teaching strategies can be a major drawback. This can occur when computer programmers rather than academic subject experts lead the course development team.
- Finally, technical problems may be an obstacle to some Web-based courses. Some courses may require high performance computers in order for the user to 'run' effectively some of the hypermedia applications available. Furthermore, the connection to the Internet may be 'slow' when the network is too busy; resulting in slow downloads of information and unpleasant navigation throughout the materials presented.

In order for online courses to be undertaken effectively by students and overcome the barriers that are involved, there is a number of issues that need to be considered. For instance, before the student undertakes a Web-based course, training and familiarisation with the technology is recommended. This can be done by the student either participating in an Internet fundamental course, available from most institutions, or get familiar with the Web on his/her own by browsing Web pages, exchanging e-mail, downloading information, participating in news groups and on-line discussions etc. It is also essential that the students familiarise themselves with the reading and writing of electronic documents. This particular issue is examined further in Chapter 7.

As far as the institutions are concerned, technical and design factors must be considered in order for Web-based courses to be effective and successful. Regarding the technical aspect of Web-based courses there is a need for standardisation of the facilities available. That means that the educational software should be designed to be cross platform and compatible with the average performance hardware. The standardisation and integration of the available Internet software and plug-ins will also facilitate the efficient and effective use of Web-based courses.

2.8 Research Problem

The factors concerned with the effective design and structure of the computer-based educational material form the main research problem of this thesis. The author herself comes from an educational and design background and has a natural interest on how these two areas interact. The course providers, i.e. institutions must ensure that the design of educational material takes into consideration instructional design issues including instructional theories and issues concerning the user interface design so that the design is both effective and appealing to the user.

Currently, possibly as a result of the novelty of the medium, in many cases producers and authors of educational hypermedia do not pay the requisite attention to the authoring of the end product. The majority of educational hypermedia gives the impression that a high percentage of these applications have been produced quickly, and not by a group of educationists and instructional technologists, but by a skilled user of an authoring program. Reigeluth and Curtis argued in 1987 that "the failure of so many instructional programs and materials has often been the result of an emphasis solely on content, with little regard for principles of instructional design to produce effective, efficient, and appealing instruction" (p. 202). To a certain extent this is the case at the moment. Evidence suggests that a great deal of hypermedia-based material is very poorly designed from an educational standpoint, thus hypermedia programs do not satisfy the claims or potential of hypermedia (Bates, 1995; McAteer and Shaw, 1995; Stratfold, 1994). Preece points out, that "if such sophisticated systems (hypermedia) are not well designed, they will create psychological problems for users, such as memory overload and divided attention, or they will fail to suit the variety of ways that people work together or alone" (Preece, 1993, p.135). In addition, in a recent report of the HEFCE regarding the evaluation of the TLTP, it is argued that a number of the funded projects demonstrated a degree of naivete as regards the complexity of the educational tasks, which they faced. "In only a small minority of cases can we say that projects had taken account of pedagogic issues in any systematic way: often existing research concerning the use of technology in higher education even in the relevant discipline was not used" (HEFCE, 1996).

2.8.1 Efforts to Tackle the Problem

The University's of Glasgow's TILT project, Teaching with Independent Learning Technologies, is a TLTP project that was funded to show how teaching and learning can be made more productive and efficient throughout a single higher education institution, especially by demonstrating how information technology may support more independent learning (Arnold, Barr, Donnelly, Duffy, Gray, Morton, Neil, Sclater, 1995). However, the project was mainly concerned with CD-ROM based courseware and not with Web-based courseware. Therefore the issues emerged from this study are worth consideration but they cannot automatically apply to Web-based courseware.

Fritts and Krawchuk (1997) suggested an instructional design framework, which is based on Edmonds, Branch, and Mukherjee study (1994). Edmond *et al* by comparing various instructional design models identified what they consider to be the fundamental components of the instructional design process. These components include (a) a situational assessment, including an analysis of the learner and content, (b) development of instructional goals, objectives, and strategies, (d) design of the media and the materials, (d) implementation of pilot instruction, and (e) summative and formative evaluation. However, Fritts and Krawchuk (1997) research is of an exploratory nature and there is no empirical evidence that this framework can be effectively applied.

James (1997) has also made an attempt to tackle this research problem by suggesting a design methodology for a Web-based learning environment. However, there is no underlying instructional theory to this proposed methodology, which is mostly concerned with the presentation level of Web-based courseware and the structuring of several nodes. Similarly to the framework that Fritts and Krawchuk (1997) suggested there is no empirical evidence regarding this methodology's effectiveness.

As shown Web-based instructional authors do not have access to an instructional model, which has been empirically tested about its effectiveness regarding the design of Web-based educational hypermedia, because most of the studies in this area are exploratory since this medium is so new in education. In the meantime, Web-based hypermedia courseware is being introduced to education at an accelerating rate supported by major national and European Government funding. In addition, specialised commercial

authoring tools and services offer great possibilities for educators to take advantage and produce Web-based instructional material for themselves. Therefore, the recent explosion of Web-based instruction is currently demanding more research into the area of the instructional design process.

This research aims to address this need by suggesting the use of knowledge sources in the field of instructional design and the end-users' own input as the basis for the design of effective Web-based instructional material. This approach is suggested because there is a large body of knowledge in the field of instructional design from which one can draw suitable conclusions about the design process of Web-based educational hypermedia, because after all Web-based courseware is a piece of instructional software. This body of knowledge includes studies on learning and instructional theories as well as courseware design factors i.e. structure, learner control, feedback, interactivity, and screen design. However, this suggestion needs to be confirmed in order to show that the existing knowledge in the area can indeed be used for Web-based educational designs. End-users are considered appropriate to confirm this suggestion because as Tessmer suggests (1993) 'innovations succeed or fail by their users' acceptance' (p. 115).

2.9 Summary

Having examined the potential of hypermedia for learning and especially Web-based hypermedia in higher education, it is suggested that Web-based courses have an important role to play within higher education and learning. However, there is still a need for research in this area for two main reasons. The first reason is the novelty of the medium, and as the Committee of Scottish Universities Principals (1992) suggested every large-scale growth in the use of technology needs research and development. The second reason is that enough evidence exists that there is a need to examine design issues that are involved in the development of Web-based courses in order to make their application more effective and appealing to the learner. Therefore, in keeping with the advances of technology, the recent explosion of Web-based instruction is currently demanding that designers take yet another look at overall design methodology; in particular the instructional design process. Beyond the two definitions given for instructional technology in 'The Potential of the World Wide Web on Education' section

of this chapter there is a third one from the *Commission on Instructional Technology* (1970) that makes this point more clear:

> Instructional technology is a systematic way of designing, carrying out and evaluate the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication, and employing a combination of human and non-human resources to bring about more effective instruction. (p. 21)

A methodological approach to the research problem is the subject of the next chapter. This approach suggests that in examining Web-based instructional design issues, the traditional body of knowledge in the field of instructional design should be carefully considered together with and the end-users' own input as the basis for the design of effective Web-based instructional material. Based on this suggestion, a framework for the development of Web-based courseware in higher education is proposed in terms of its design, user input and evaluation.

Chapter 3 Research Design

3.1 Introduction

This chapter discusses the design of the current research. It starts by suggesting a way to solve the research problem examined in Chapter 2, by proposing a framework for the development of Web-based courseware aimed at supporting the delivery of physical modules in higher education. Next, it discusses the approach of the current research by determining the appropriate research methodology. In addition, methodologies for evaluating hypermedia-based learning are discussed with particular emphasis on the multi-faceted approach proposed by Gary Marchionini (1990). Within this context the techniques and procedures of data gathering and analysis are examined.

3.2 Proposed Framework

The proposed framework for the development of Web-based courseware in higher education is based on the suggestion that in examining Web-based instructional design issues, the body of knowledge in the field of instructional design should be carefully considered together with and the end-users' own input for the design of effective Web-based instructional material. The following five stages describes the proposed framework.

Stage 1	Review of the area of instructional design in order to identify design and development considerations potentially applicable to the development of Web-based courseware that aims to support the delivery of physical modules in higher education.
Stage 2	Acquisition of end-users' input through a survey aimed at determining the users' preferences in terms of general Web-based educational design practices.
Stage 3	Development of prototype courseware based on the results from Stages 1 and 2.
Stage 4	Evaluation of prototype with end-users - Formative evaluation.
Stage 5	Revision based on evaluation results from Stage 4.

Although each stage is presented separately, several activities in stages 4 and 5 occurred simultaneously because of the strong interrelationship between evaluation and revision.

3.3 Approach

In particular, the current research suggests that a Web-based courseware developed according to the proposed framework could effectively support the delivery of physical modules, by promoting learning and providing significant improvements in users' performance and satisfaction in higher education compared with conventional teaching methods.

The validity of this approach needed to be tested empirically and this constituted the principal element of this research. Two empirical studies were designed to accomplish this task. They were concerned with the evaluation of two Web-based educational applications developed according to the proposed framework: Interactive Digital Entertainment, for Level II, BA Honours Multimedia Design students at De Montfort University, U.K, and Programming and Software Engineering for three different groups of postgraduate students. The first group consisted of students studying MSc in 'Computer Aided Engineering' (CAE) delivered by DMU in collaboration with the Fachhoshule Bielefeld, Germany. The second group consisted of British students studying MSc in 'Software Techniques in Image Processing' in De Montfort University, UK. Finally, the third group consisted of Russian Ph.D. students studying in Moscow's Buaman Technical University, Russia in collaboration with De Montfort University, UK. In order to evaluate the effectiveness of the Web-based courseware applications, thus the validity of the proposed framework, a summative evaluation was conducted.

3.4 Experimental Methodology: Observation of Deliberate Intervention

Since this study is an attempt to develop a new approach to the design of Web-based courseware that could effectively support the delivery of physical modules in higher education an experimental methodology appears to be the most appropriate one to adopt. Allison, O'Sullivan, Owen, Rice, Rothwell, and Saunders (1996) point out,

> In essence an experiment is when the researcher introduces some new elements into a situation to observe the effects, if any, which that intervention produces. The purpose of experimental research is to identify

> causal connections. In any experiment, some of the relevant variables are controlled or held constant, whereas the other relevant variables are manipulated (....) The key variables in experimental research are of two kinds - the *independent variable* and the *dependent variable.* The dependent variable is the phenomenon that appears, disappears or changes as the independent variable is applied. (p. 17-18)

Therefore, in the current research the level of performance and satisfaction of the higher education students' that undertake the particular modules designed, is the dependent variable and the teaching method is the independent variable.

In general, in experimental research design the subjects being studied are divided into two matched groups: the *experimental group*, which is exposed to the experimental treatment, and the *control group*, which does not receive the experimental treatment. Before the administration of the experimental treatment, both groups are tested regarding the relevant variables through a *pre-test.* A *post-test* is used to test both groups after the treatment is given to the *experimental group.* The results of the pre-tests and post-tests for both groups are compared in order for the effects of the treatment on the experimental group to be assessed (Allison *et al*, 1996, p.17).

Remenyi and Williams (1995, p.192), have pointed out that the most powerful experimental methodology is the 'Observation of Deliberate Intervention', which involves imposing a controlled and deliberate change on a system and observing the effects that it has on other variables. The most important stages in this approach are as follows:

1. The *Experimental Design* stage, where the researcher identifies some key issues such as the form that the intervention will take; what data will be collected before, during, and after the intervention; what sort of control group/s are required; and how a sample may be chosen to represent the whole population.
2. The *ex-ante* stage, which is concerned with the measurement of the variables and the collection of data concerning the performance of an organisation before the deliberate intervention.
3. The *Deliberate Intervention* stage.
4. The *ex-post* stage which is concerned with the measurement of the variables and the collection of data concerning the performance of an organisation after the deliberate intervention.

5. The *Testing and Analysis* stage, which is concerned with the analysis and the final testing of the data, collected in previous stages.

The current research has adopted the 'Observation of Deliberate Intervention' as the methodological approach. Before discussing how each one of the stages included in this approach was implemented in the current research, it is important to examine the notions pre-test, post-test, attitude and acceptance questionnaire, interview and debriefing session that are constantly used throughout this thesis.

Pre-tests are usually performance tests that are used to determine how much learners already know with respect to the intended instructional objectives. Pre-tests help in measuring the learning gain from instruction, the difference between what objectives learners knew before instruction and those they knew after it. The use of a pre-test will determine if the learning succeeds because of the instruction or because learners knew it before the instruction. *Post-tests* are again performance tests, usually with the same content as the pre-tests, and are used to determine whether learners have actually achieved the goals and objectives of the instruction. Without a post-test there can be no measure of the learning gains from pre-test to post-test (Tessmer, 1993).

Attitude and acceptance questionnaires are important when learners' feelings or inclinations are part of the goals of the instruction. For example, learner satisfaction or willingness to use the instruction can be important goals for self-instructional learning material (Tessmer, 1993). In general, the items involved in research questionnaires can be *fixed alternative* or *open-ended.* The word item is used in preference to question because the request for information is often not phrased as a question (Allison *et al,* 1996). In fixed alternative items, the respondent is required to choose from two or more predetermined alternatives such as true/false or agree/disagree. Often a scale format, which allows the respondent to register degrees of agreement or disagreement in an item, is used in such type. The main advantages of this type of items are: they produce greater uniformity and inferentially greater reliability because respondents are forced to select one of the responses available, and also such items are easily coded for statistical computational analysis. The fact that they offer fixed alternatives may be seen as disadvantage when none of the alternatives given appear to match the respondent's view. This may result in inappropriate, inaccurate or misleading responses. A possible

solution to ease this problem is to allow the respondent to state 'undecided'. *Open-ended* items on the other hand, give the respondents more space to take the initiative in expressing their opinions or feelings to a given question without this being forced into categories or options. A major drawback of such type of items is that it is often difficult to record adequately the responses and to code or to attach numerical value to them (Allison *et al*, 1996).

Interviews grant the flexibility to delve into respondents' reasoning about the program. The appeal issues of personal relevance, credibility and acceptability sometimes require longer answers and more clarification than questionnaires allow. In education, usually semi-structured interviews are used. In this case although the subjects are prompted with questions, the main aim is to get their subjective reactions to the software and the evaluation experience. Interviews can also have the form of *debriefing sessions*. This technique is commonly used to close evaluation processes (after any tests given) with general questions that prompt the learner to express what she or he liked, disliked, found interesting, or would change in the evaluated application (Flag, 1992). The next section discusses how each one of the stages included in the 'Observation of Deliberate Intervention' was implemented in the current research.

3.4.1 Experimental Design

Due to the nature of the current research, the *Experimental Design* stage includes more considerations than those identified by Remenyi and Williams (1995). As mentioned, the Web-based courseware applications are designed according to the proposed framework. Therefore, the basic consideration of this stage is the development of the proposed framework. The identification of the design and development considerations, which constitute the Stage 1 of the proposed methodology, derived from the literature review in the area of instructional design. The term literature refers to books, articles from journals, reports from initiatives and projects, electronic documents from Web-based resources and databases. However for ease of reference the general term literature will be used throughout this thesis.

The preliminary end-users' input -Stage 2- was obtained and analysed through a survey. Finally the evaluation of the prototype courseware with end-users -Stage 4-

was achieved through a series of steps involved in the formative evaluation of the Web-based courseware applications. The following sections discuss in detail how each of these stages was implemented.

3.4.1.1 Survey

The conduct of the survey was the first step in the acquisition of the end-users' input. The subjects of this survey were both the undergraduate and postgraduate students who were studying either Interactive Digital Entertainment or Programming and Software Engineering respectively and agreed to participate in the research presented in this thesis. A self-completion questionnaire was used, aimed at providing data about users' preferences on general practices in terms of educational Web design. The areas covered by this questionnaire concerned media considerations, navigation issues and involvement of the end-users in the design. The items included in this questionnaire were fixed alternative, with five-point scale format from 'Strongly agree' to 'Strongly disagree' including a mid-point, and open-ended items. Subjects' responses to the scaled fixed alternative items were easily transformed into quantitative data for computerised statistical analysis. Content analysis was employed to analyse the results from the open-ended items by measuring the frequency of similar words or phrases on the answers provided. According to Weber (1986) the central idea in content analysis is that the many words of the text are classified into much fewer content categories. Each category may consist of one, several or many words. Words, phrases, or other units of text classified in the same category are presumed to have similar meanings. Based on the results from this survey and the design and development consideration found in instructional design literature a prototype was designed for each of the Web-based courseware applications. The next step involved the formative evaluation of the two pieces of courseware.

3.4.1.2 Formative Evaluation

According to Tessmer (1993) formative evaluation is the judgement of the strengths and weaknesses of instruction in its developing stages, for the purpose of revising the instruction to improve its effectiveness and appeal. The evaluation is conducted by collecting data about the instruction from a variety of sources, using a variety of data

gathering methods and tools. There are four classically recognised types of formative evaluation, which have these general characteristics:

1. Expert review - experts review the instruction with or without the evaluator present. The experts can be content experts, technical experts, designers or instructors.
2. One-to-one evaluation - one learner at a time reviews the instruction with the evaluator and comments upon it.
3. Small group - the evaluator tries out the instruction with a group of learners and records their performance and comments.
4. Field test - the evaluator observes the instruction being tried out in the learning environment for which it was intended, with a group of learners.

In this research, the formative evaluation of the courseware applications consisted of one-to-one evaluation, field test, and expert review. The small group evaluation was omitted because of time constraints. The rest of this subsection discusses how the different techniques for data gathering were used in each of the types of formative evaluation.

In the one-to-one evaluation an audio recording of the combination of semi-structured interview and debriefing session was used. In semi-structured interview although the subjects were prompted with questions, the main aim was to get their subjective reactions to the clarity, completeness and ease of use of the Web-based courseware. The debriefing session was used to conclude the evaluation with general questions about the instruction and the design of the Web-based courseware and to prompt subjects' suggestions for the improvement of the courseware. The one-to-one evaluation was repeated three times for each courseware in order to achieve designs that reflected the concerns and comments across the sample. This strategy was adopted because the sample in both cases was multicultural and in particular for the Interactive Digital Entertainment case the age group was not homogenous. The subjects were selected carefully in order to represent the sample: an overseas student, a mature student and a British student for the Interactive Digital Entertainment, and a German, a Russian and a British student for the Programming and Software Engineering. The recorded comments were transcribed and analysed through content analysis.

In the field test pre-tests, post-tests included attitude and acceptance questionnaires, and debriefing sessions were used. Pre-tests and post-tests having the same content in the form of fixed alternative and open ended items were used to measure the learning gains from the instruction. Statistical methods were used to examine the reliability of the results from the pre-tests and the post-tests. The attitude and acceptance questionnaire was designed to elicit subjects' attitudes towards the use of the courseware (e.g. I felt challenged by the instruction) and towards the specific interface design elements identified in the one-to-one evaluation (e.g. Do you find it helpful that external links and communication channels are opened in a second browser?). The items included in this questionnaire were fixed alternative with five-point scale form, from 'Strongly agree' to 'Strongly disagree' including a mid-point, and open-ended items. The analysis of the responses was similar to the one described in the *Survey* section above.

Finally, in the expert review an attitude and acceptance questionnaire aimed at determining the reactions of content experts with lecturing experience in the area towards the Web-based courseware, and a debriefing session were used. The items included in this questionnaire were both five-scale and open-ended, and concerned the attitudes towards the medium being used and the strategy being employed. In addition, it included revisionary items to determine if the content expert would somehow change the instruction to make it more effective or usable. The design of the Web-based courseware applications was revised twice: once after the one-to-one evaluation, and again after the field test (Stages 4 and 5). No revision suggestions were documented in the expert review for both courseware applications. The next paragraph discusses the rest of the considerations that needed to be addressed in the 'Experimental Design' stage of the adopted methodology.

Obviously, the form that the intervention will take is Web-based courseware, and as far as the required control group/s is concerned there were two: an intervention group, which used the Web-based courseware in place of a lecture, and the control group, which had the lecture in the classroom. However, a problem occurred in Programming and Software Engineering study: in not having an adequate number of subjects and suitable circumstances to form a control and an intervention group. The approach

taken to overcome this problem is discussed in Chapter 6. Regarding the sample chosen to represent the whole population the study had to rely on volunteers because not all the students were willing to participate.

Finally, after the final revisions on the courseware applications' design (Stage 5) summative evaluation was employed in order to collect the data before and after the intervention, thus to test the validity of the approach. Summative evaluation is a method commonly applied in instructional technology, and as the intervention used in the current study is instructional software, it was the most appropriate one.

3.4.1.3 Summative Evaluation

Summative evaluation may be defined as the design, collection and interpretation of data and information for a given set of instructional materials for the purpose of determining the value or worth of these materials usually comparing it with other forms of instruction of the same material (Dick and Carey, 1990; Draper, Brow, Edgerton, Henderson, Mcateer, Smith, and Watt, 1994; Tessmer, 1993). Since the evaluation of the empirical studies is intended to investigate both the users' performance and satisfaction by using the Web-based courseware a multi-faceted approach has been employed. This approach is largely based upon a summative evaluation method suggested by Marchionini (1990), that addresses both the processes and the outcomes of learning.

Multifaceted approach

Marchionini argues that the interactivity of multimedia and hypermedia provides learners with access to vast amount of information in varied forms, control over the process of learning, and the potential for collaboration with the system and other people. Such empowerment of learners forces evaluators of learning to adopt a broad-based set of methods and criteria to accommodate 'self-directed' learning. He suggests a 'multi-faceted' approach to the evaluation of hypermedia based learning that address both the processes of learning and the outcomes of learning. As data collection techniques, Marchionini suggests all the techniques described in the instructional system design literature such as questionnaires, interviews, think aloud protocols, and

performance tests. Regarding data analysis methods, he suggests both quantitative and qualitative analysis.

Learning Outcomes

Performance tests or assignments are typically used to judge the quality and the quantity of learning. For well-defined learning tasks, like knowledge acquisition, or motor skill development, teacher-made tests or standardised tests are considered valid and reliable indicators of learning. One advantage of performance scores is that they are typically interval or ratio values (or can be transformed as such) so that powerful inferential statistical analysis can be employed to make generalisations about uniform impact "Performance tests provide the best measures of learning outcomes and all summative evaluations should strive to include such measures in their research toolkits" (Marchionini 1990, p.362).

Learning Processes

According to Marchionini (1990, p. 365) empirical evidence is the hallmark of scientific inquiry, and behavioural observations are obvious methods for conducting inquiry about human learning with technology. An important assumption underlying the use of such methods is that human behaviour reflects cognitive processing. Observations may be random or systematic, brief or longitudinal, formal or informal. Data can be collected by one or multiple observers who make mental, written, audio-taped, or video-taped notes. The way that the multifaceted approach was used in the ex-ante, ex-post and analysis and testing stages of the current research will now be discussed.

3.4.2 Ex-ante, Deliberate Intervention, Ex-post, Analysis and Testing

In this research performance tests were used to determine the learning outcomes, prior to and after the intervention. In detail, pre-tests with multiple choice and open-ended items in printed form were used to determine learning outcomes prior to the intervention (ex-ante stage). Post-tests and delayed post-tests were used to determine learning outcomes after the intervention (ex-post stage). Delayed post-tests were used because even if students show that they learned a lot in an immediate post-test, it may

soon decay. Another reason for the application of the delayed post-tests is that recent evidence show that sometimes major benefits occurs only after a delay (Draper *et al* 1994:10). The statistical methods that were used to examine the reliability of the conclusions drawn from the performance tests are discussed in Chapter 6.

In the case of Web-based learning the most important aspect of learning processes is how the learners interact with the Web-based courseware. In order to investigate subjects' interaction with the courseware attitude and acceptance questionnaires with both fixed alternative and open-ended items and debriefing sessions were used. The data for the control and the intervention group were collected at the same time and they have both been analysed using quantitative and qualitative techniques. Table 3.1, shows the multifaceted toolkit adopted for this research and used in the summative evaluation, which includes performance tests, attitude questionnaires and interviews.

Evaluated Objects	Data Collection Method	Data Types
Learning Outcomes	Performance Tests (pre-tests, post-tests, delayed post-tests)	Quantitative
Learning Processes	Attitude Questionnaires Debriefing Sessions	Qualitative/Quantitative Qualitative

Figure 3.1 A multi-faceted evaluation research toolkit

It has to be mentioned that in order to determine the items included in the attitude questionnaires that were concerned with the use of the courseware, in both formative and summative evaluation, the usability of the Web-based courseware was considered. Usability is one of the key criteria used in software evaluation. It is the software quality most apparent to the end-users of a system. The value of usability is very clearly illustrated in the following quote. "When we come to make serious use of a product, its usability for the tasks we wish to perform is central in shaping our opinion of its worth. If the product fails to help us to perform those tasks efficiently, effectively and with satisfaction, then we will be likely to form a poor opinion of it" (Macleod, 1992, p.4). Usability is usually associated with five parameters (Nielsen, 1990):

1) Easy to learn - The user can quickly get some work done with the system.

2) Efficient to use - Once the user has learnt the system, a high level of productivity is possible.
3) Easy to remember - The casual user is able to return to using the system after some period of not having used it, without having to learn everything all over.
4) Few errors - Users do not make many errors during the use of the system or if they do so they can easily recover them.
5) Pleasant to use - Users are subjectively satisfied by using the system; they like it.

The items included in the attitude questionnaires were concerned with the three of these parameters: easy to learn, efficient to use, and pleasant to use. The evaluation of the rest of the five parameters involved in usability requires repetitive evaluation sessions and possibly analysis of the navigation patterns of the users. Due to time constraints and the unwillingness of subjects to participate in long and repetitive evaluation sessions, the current research did not touch upon these two parameters. However, their evaluation is considered in further research in Chapter 7.

3.5 Summary

This chapter has outlined the methodology adopted for the current research. Thus, in order to proceed with testing the validity of the suggested approach, the development of the proposed framework is required. The next chapter will be concerned with Stage 1 of the framework, that is the identification of the design and development considerations for Web-based courseware creation.

Chapter 4 Instructional Design Considerations

4.1 Introduction

This chapter serves as a review of research in educational multimedia and hypermedia features used for designing effective hypermedia-based courseware. It starts with a discussion on the influence of learning and instructional theories in instructional design, with particular emphasis on the Gagné-Briggs theory of instruction. Following this, the chapter looks at courseware design factors such as structure, learner control, feedback, interactivity, and finally screen design (visual elements: colour, text, graphics, video, and animation) and audio elements. Finally, specific factors that need to be considered in Web design are also discussed. The factors that are examined in this chapter, constitute the Stage 1 of the proposed framework, and will be considered in the design of the experimental Web-based applications, which is described in Chapter 5.

4.2 Learning Theories

Courseware is a relatively recent appellation for Computer Based Learning, which refers to the use of computers for the delivery of instruction in an interactive mode. Reigeluth (1987) defines courseware as "computer software which is designed to create some sort of instructional environment for the purpose of facilitating learning" (p. xi). All the instructional theories are based on learning theories as they attempt to bridge the gap between theory and research in the basic processes of learning and the applied aspects of instruction in schools (Hilgard and Bower, 1975, p. 606). Wingfield (1979) defines learning as "a relatively permanent change in behaviour, or knowledge brought about by practice or experience" (p. 3). Cognitive psychologists from the past and present have recognised many varieties of learning and they have drawn conclusions about how people learn based on different theoretical and empirical approaches. There is no single theory of learning, rather a number of attempts to understand the many varieties of learning. Hence, because it is difficult to measure learning directly, people tend to measure the products of learning. "Learning itself is an internal event, which like the wind, is invisible to the eye, and can only be judged by its effects" (Wingfield 1979, p. 13). It is outside the remit of this research to introduce and explain in detail all

the existing learning theories. Yet, some basic information on the major learning theories is provided in Table 4.1.

Primary Division Of Learning Theories	Major Theories	Major Theorists	Approach
EMPIRICISM (associationism) A major thesis of empiricism is that learning occurs through contiguous association of events and ideas. Is the view that experience is the only source of knowledge. Special emphasis is given to sensory experience although some allowance is made too for knowledge derived from intellectual reflection regarding relations among a number of experiences.	**Behaviourism** (1910's)	Edwin R. Gurthie John B. Watson	**Behaviourism** which dominated American psychology in the fist half of the century, held that cognitive psychology was to be entirely concerned with external behaviour and was not to try to analyse the workings of the mind that underlay this behaviour.
	Stimulus-Response Or Neobehaviourism (1910-20's)	Edward L. Thorndike	Learning for **S-R** associationists involves primarily the formation of mechanical connections of some sort between stimuli and responses. Everything a learner does whether it is thought or action is explained in terms of responses following stimuli or stimuli following responses. Stimuli are features of the environment, which act on an organism to cause its response. Responses are reactions of an organism to stimulation.
RATIONALISM (Cognitive Theories) Rationalism is the general philosophical position that reason is the prime source of knowledge, that reason alone rather than authority or spiritual revelation or intuition, or sense data is the only valid basis for knowledge, belief, and action. Understanding, the comprehension of knowledge from reason, should be the aim of empirical as well as philosophical investigation.	**Gestalt-field** (1920's)	Max Werheimer Kurt Koffka Wolfgang Köhler	Learning for **Gestalt-field** theorists, is a process of gaining and changing insights, outlooks or thought patterns. This theory sees a person, his/her environment, his/her interaction with the environment all occurring at once; this is the meaning of field.
	Information Processing (1960's)	Saul Sternberg	**Information Processing** theory attempts to analyse cognition into a set of steps in which an abstract entity called information is processed. This approach characterises humans as information processors, considering that everything that is sensed (sight, hearing, touch, smell, and taste) is information that the mind processes.

Table 4.1 Learning Theories (Sources: Hilgard and Bower, 1981; Anderson, 1995)

Considerations from Learning Theories Useful in Educational Practice

Sternberg (1984) argues that despite the fact that in their majority the learning theories are based on different approaches to explain the learning process they describe at least three functions of the process, which are as follows.

(a) The information must be collected and filtered from spurious environmental stimuli.
(b) Knowledge can be accumulated in an orderly, sequential and hierarchical manner, or in other words learning of a particular concept only occurs if the concepts that are prerequisites to the new concept have been acquired.
(c) The disparate pieces of new information must be combined and organised.

Shuell (1992) argues that for many decades those learning theories, which fall under the category of empiricism, such as behavioural theory, viewed learning as something that happens to an individual 'from the outside in'. The learner encounters a stimulus, makes a response, and the consequences of this response determine whether there is an increase or decrease in the likelihood that the learner will repeat the response. "A corollary of the model is the belief that knowledge is an entity that can be passed, more or less intact, from one individual to another" (Shuell, 1992, p. 22). However, cognitive theory, e.g. Information Processing theory, that began to displace behavioural theory during the 1970's stresses that on the contrary learning occurs from the 'inside out' rather than the other way around (Shuell, 1992).

Cognitive theory emphasises the activity of the learner in acquiring, processing and structuring information (Fosnot, 1984). Learner activity is based on various processes such as perception, thinking, memory and the representation of knowledge (Shuell, 1986). The importance of the learner's environment has not been excluded, but the emphasis has shifted from the pre-eminence of external factors to the pre-eminence of internal cognitive factors. These cognitive conceptions stress that learning is an active, constructive, cumulative, self-regulated process in which the learner plays a critical role (Shuell, 1992, p. 21-25; Jonassen, 1988, p. 153). In other words a learner can learn effectively if s/he is engaged in learning activities. In addition, these activities should take into consideration elements like preceding knowledge, the context in which the

learning material is presented and organised, and also the availability of specific internal frameworks with which to integrate the information.

Hilgard and Bower (1975) in *Theories of Learning* summarised some principles that derive from the primary division of learning theories, i.e. empiricism and rationalism, which can potentially be useful in educational practice. However they argue that the generalisations that they present are mere summarisation of empirical relationships that hold rather widely, and many of them are not stated with sufficient precision to be considered laws of learning.

The more important principles emphasised within empiricism (behaviourism) are the following.

- The learner should be *active* rather than a passive listener or viewer.
- *Repetition* is important in acquiring skills, and in bringing enough 'overlearning' to guarantee retention
- *Reinforcement* is important; that is, repetition should be under arrangements in which desirable or correct responses are rewarded.
- *Generalisation* and *discrimination* suggest the importance of practice in varied contexts, so that learning will become appropriate to a wider range of stimuli.

Similarly, the principles emphasised within rationalism (cognitive theories) are as follows.

- The *organisation of knowledge* should be an essential concern of the teacher or educational planner and may depend on the developmental level of the learner. Thus the progression from simple to complex is not from arbitrary meaningless parts to meaningless wholes, but is from simplified wholes to more complex wholes. The part-whole problem is therefore an organisational problem, and cannot be dealt separately apart from a theory of how complexity is patterned.
- *Learning with understanding* is more permanent and more transferable than rote learning or learning by formula.
- *Cognitive feedback* confirms correct knowledge and corrects faulty learning.

- *Goal-setting* by the learner is important as motivation for learning and his/her successes and failures are determiners of how s/he sets future goals. (Hilgard and Bower, 1975, p. 607-609).

Hypermedia-based courseware has the potential to integrate all the above principles that can be derived from both the major divisions of learning theories. Using hypermedia the learner can be actively engaged in the educational process; can navigate through the presented material in any direction, so that repetition is allowed; can receive reinforcement through feedback. Also, due to the fact that the educational material can be presented in many different ways within the same programme, different contexts can be used taking into account the cultural and individual differences of the learner.

4.3 Instructional Design Theories

In his presidential address to the American Psychological Association in 1899, John Dewey called for the development of a 'linking science' between learning theory and educational practice. Ralph Tyler has also stated the need for such a body of knowledge. He has described instructional design as playing a sort of middleman role (Tyler, 1978). "Instructional design is the linking science - a body of knowledge that prescribes instructional actions to optimise desired instructional outcomes, such as achievement and effect" (Reigeluth, 1983, p. 5). Therefore the purpose of the field of instruction is to provide educators and trainers 'with prescriptions for making their instruction more effective and appealing' (Reigeluth, 1987, p. 1).

Currently there is no major theory determining hypermedia educational design in particular, but there are several instructional theories from which useful conclusions can be drawn. Charles Reigeluth in his books *Instructional Design Theories and Models: An Overview of their Current Status* (1983), and *Instructional Theories in Action* (1987) provides an excellent overview of instructional design and the description and application of several such theories. Another valuable updated source can be found in The Theory Into Practice Database, created by Creg Kearsley (1997) which contains information on fifty major theories of learning and instruction.

After studying these theories it was decided to adopt and examine in detail Gagné's theory of instruction for three main reasons. Firstly, Gagné's theory of instruction is the only theory that prescribes different methods of instruction for different learning situations. In this particular research, that aims to produce hypermedia-based learning material that supports the delivery of physical courses in higher education, Gagné's theory is the most suitable one because it allows a match between the instructional objectives of the physical course to be made with those of the hypermedia-based instruction. Secondly, Gagné is referenced in almost all the literature that concerns instructional design. D. Laurillard described him as the undisputed father of the field of instructional technology "whose book *The Conditions of Learning* first published in 1965 and now in its fourth edition forms the precursor to all current work" (Laurillard, 1993, p. 72). Thirdly, Gagné's theory has developed through time following the evolution of learning theories. Since 1965 when Gagné first wrote The Conditions of Learning the theory shifted from a grounding in behavioural psychology to using Information Processing theory, which is currently one of the dominant theories in cognitive psychology, as its empirical base. In 1987 Gagné in *Instructional Technology: Foundations*, acknowledges that notable advances have been made in the understanding of human learning by psychologists who promote the information processing model as a framework for the investigation of learning processes.

> The adoption of this model by learning psychologists represents a paradigm shift away from an early theoretical position based on stimulus-response associations. The modern view of cognitive processing makes it possible to consider learning as a multistage process involving feature perception, short term storage, rehearsal, semantic encoding, long term storage and retrieval, as primary kinds of cognitive operations. In consequence, this view conceives instruction as comprising events external to the learner that are designed, each in its own way, to support internal learning processes. (Gagné, 1987, p. 4)

Steinberg (1991) argues that Gagné's events of instruction which are based on his events of learning were derived 'directly from information-processing theories of instruction' (p. 38). As already discussed, the information processing theory account for a large part of the success in learning with hypermedia (Bagui, 1998).

A result of the continuous evolution of Gagné's theory is that this theory takes into account the use of new communication media in education. It has to be noted that the

current status of Gagné 's theory is a result of his collaboration with Leslie Briggs, and is known today as the Gagné-Briggs theory of instruction. In 1987 Briggs died and since then Walter Wager who worked closely with Briggs for several years in the teaching of instructional design principles continues his work. Reigeluth (1987) points out that the Gagné-Briggs theory was the first major attempt to integrate a wide range of knowledge about learning and instruction - 'its impact on the field has been immense' (p. 11).

However, if the Web-based courseware applications were not aimed primarily at supporting the delivery of the physical modules and to promote mainly factual learning but were aimed at promoting more advanced knowledge in the particular content area, then Cognitive Flexibility Theory should also be considered. Spiro and Jehng (1990) argued that two important things happen as one moves from the initial introduction to a content area to more advanced stages of knowledge acquisition in that area. First, the conceptual content tends to become more complex and the basis of its application more 'ill-structured'; and second, the goals of learning and the criteria by which learning is assessed shift from introductory level familiarity with concepts to the mastery of important aspects of complexity. The Cognitive Flexibility Theory suggests a metaphor "of the criss-crossed landscape with its suggestion of a nonlinear and multidimensional traversal of a complex subject matter" (Spiro, Feltovich, Jacobson, and Coulson, 1991, p. 67). In other words the theory emphasises the need for repeated presentations of the same material in rearranged instructional sequences and from different conceptual perspectives in order to accommodate learner's individual differences.

However, due to the nature of the current investigation it was not felt necessary to overcomplicate the structure of the Web-based courseware applications for two reasons. First, the applications developed aimed mainly at supporting the delivery of the physical modules and therefore the nature and the depth of such a study did not necessitate such complex patterns of movement through the courseware. Second, there was less need for a complex navigational system thus allowing students to become familiar with the Web-based environment quickly. The latter was a specific request gained from consultation from prospective users through the preliminary survey documented in the next chapter. From this the opinion was formed that the less concentration required from the student

for navigation the more concentration would be available for the presented material. Nevertheless, Cognitive Flexibility Theory should be considered for projects aimed at providing self-study materials that are not supported by physical tutorials. For more information on how this theory was implemented in interactive hypermedia programs the reader can examine an account by Fitzerald, Wilson, and Semrau (1997).

4.3.1 Gagné-Briggs Theory of Instruction

According to Gagné-Briggs theory of instruction (Gagné and Briggs 1979; Gagné, Briggs, and Wager 1988) the most important issue in designing instruction is to decide how to sequence the learning materials. Ausubel (1968) argues that the sequence in which learning occurs influences the stability of cognitive structures and therefore influences long-term retention and transfer. The theory recommends a 'top-down' approach to designing an instructional sequence. The process of designing an instructional sequence should start by identifying and sequencing more general goals and objectives, and progress by levelling down to increasingly specific objectives. After the identification of the objectives that state the performance expected after the course is completed, the major course units should be identified. These units "define the performance expected on clusters of objectives having a common purpose in the organisation of the total course" (Gagné and Briggs, 1979, p. 137). Further, there is a need to identify the target objectives for each unit, and then to sequence the units in the most appropriate sequence. Sequencing is done largely on the basis of expert opinion and intuition. Performance objectives, which are the specific learning outcomes expected, derive from target objectives. The performance objectives, which make up a lesson, similarly to the sequencing of units, are sequenced on the basis of expert consensus. Finally, the performance objectives are broken down into enabling objectives, each of which may have several, subordinate objectives. The enabling objectives "support the learning of performance objectives either because they are essential prerequisites skills required to learn target objectives, or because they facilitate such learning" (Gagné and Briggs, 1979, p.137).

Another important step in designing instruction is the identification of the expected type of learned capability. The Gagné-Briggs theory of instruction identifies five categories of learned capabilities and it suggests different methods of instruction for each one of

them. Moreover, it identifies nine events of instruction that should usually comprise the instruction intended to develop any desired capability.

The Categories of Learned Capabilities

For the prospects of designing instruction Gagné outlines five categories of human learned capabilities or learning outcomes, each of which requires different instructional prescriptions. These are as follows:

1. Verbal information - Instruction is often designed to convey systematically organised ideas in various discourse forms such as description, exposition and narrative. This kind of learned knowledge is verbal information.
2. Intellectual skills - As the name implies this kind of learning outcome enables the learner to do something that requires cognitive processing. Several varieties of intellectual skills are usually distinguished:
   a. Discrimination - This kind of intellectual skill is considered to be acquired when a learner is able to discriminate between stimuli that differ along one or more physical dimensions.
   b. Concrete concepts - When they have learned a concrete concept, learners are able to identify instances of an object property, of an object, of an event, or of a spatial direction.
   c. Defined concepts - This kind of intellectual skill is considered to be acquired when a learner is able to demonstrate the application of the rule that defines the concept.
   d. Rules - A rule is a cognitively understood relation between concepts.
   e. High-order rules (problem solving) - When learners encounter problems to be solved, they make use of previously learned rules. Usually, some combining of these rules occurs in the course of solving the problem, resulting in a more complex or high-order rule.
3. Cognitive strategies - These are skills by means of which learners exercise control over their own learning processes and thinking.
4. Attitudes - Internal states that influence the personal action choices a learner makes. Instruction can readily be designed to establish new attitudes or to modify existing ones.

5. Motor skills - Productive actions involving movement controlled by the muscles are refined in timing and smoothness by the learning that occurs during practice. The result of such learning is a motor skill. (Gagné, 1985; Gagné, Briggs and Wager, 1988; Gagné and Wager, 1988).

The intellectual skills have been divided into five subcategories because the learning of any one intellectual skill depends on the prior learning of one or more simpler intellectual skills. In order to learn to solve problems by using two or more rules, a learner must have already learn to use the various component rules. Because a rule relates two or more concepts, the learning of those concepts is an essential prerequisite for the learning of the rule. Similarly, defined concepts often have concrete concepts as critical attributes, and concrete concepts cannot be learned unless their common characteristics can be discriminated (Gagné and Briggs 1979, pp.137-141). Identifying the category of learned capability into which the desired learning fits is important because Gagné and Briggs prescribe different methods of instruction for each category of learned capability.

The Events of Instruction

The information processing theory of learning describes the manner in which the act of learning involves a number of internal processes each of which transform information affecting the learner, and brings about a change in state that advances learning (Estes, 1978; Klatzky, 1980). Gagné (1985) argues that those internal processes are enhanced by means of a specific order of instructional methods he calls 'the events of instruction'. The events of instruction establish the internal and external 'conditions of learning' essential for the various types of learning outcomes to be learned. In order to be more effective the events of instruction, must be differentially designed for each type of learning outcome. Table 4.2 provides a brief description of the function served by each internal process and suggests the general nature of external events that may be used to influence (i.e. enhance) each of the processes.

Internal Learning Process	External Instructional Events
1. Alerting the leaner to receive stimulation	1. Gaining attention
2. Acquiring an expectancy of the results of learning	2. Informing learner of lesson objectives
3. Retrieval of items in long-term memory to the working memory	3. Stimulating recall of prior learning
4. Selective perception of the patterns that enter into learning	4. Presenting stimuli with distinctive features
5. Semantic encoding of presented material, to attain a form of long-term storage and ready retrieval	5. Providing learning guidance
6. Responding with a performance that verifies learning	6. Eliciting performance
7. Reinforcement, by means of which the results of learning are established	7. Providing feedback
8. Providing cues that are used in recall	8. Assessing performance
9. Generalising performance to new situations	9. Enhancing retention and learning transfer

Table 4.2 Internal Processes of Learning, their Function, and the Types of External Events that may support them (adapted from Wager and Gagné, 1988, p. 43)

The next section describes in more detail the nine different events of instruction with some examples relevant to the use of CBL (Gagné, 1985; Gagné, Briggs and Wager, 1989; Wager and Gagné 1988).

1. *Gaining attention.* Environmental components can act on the learner by directing his/her attention to certain stimuli or aspects of stimulus objects and events. Various kinds of events are employed to gain learner's attention. In computer based learning the initial operating instructions should be presented on the screen including some displays that change second by second i.e. a button that is a link to another piece of information.

2. *Informing learner of the objective(s).* In any given instructional process there is a need for a decision about the nature of the change in behaviour, that is, what the learner will achieve at the end of the process. Only if this is done will it be possible to infer what kind of learning situation needs to be established to bring about this change. "When learners comprehend the objective of instruction, they will acquire an expectancy that normally persists throughout the time learning is taking place and that will be confirmed by the feedback given when learning is complete" (Gagné, 1985, p. 247). In computer-based learning what the student will accomplish once

s/he has completed the instruction should be stated in simple terms in some part of the program.

3. *Stimulating recall of prior learning.* Before engaging in the instruction the learner is asked to recall some things previously learned. What is to be recalled should be naturally related to the new learning. A way to accomplish this in CBL is to refer learners to other parts of the presented material by utilising hyperlinks, or to structure the instruction in such a way where each section of the material is linked with previous prerequisite sections. Moreover, carefully designed computer screens can encourage the dual coding of information in order to stimulate recall.

4. *Presenting the stimulus material.* Every type of learning requires a stimulus, and usually these stimuli must be located within the learning environment, outside the learner using objects already in the learner's environment, or by means of pictures, printed books or oral communication. Any stimulus must have its distinctive features clearly delineated, for example in CBL the important features of diagrams or charts should be highlighted; headings or bold or italic print should be used in text.

5. *Providing learning guidance.* This instructional function is necessary in order to give hints and suggestions to the learner in order to make the stimulus as meaningful as possible. For example a step-by-step guide of the CBL application's use, or a graphical map of the application's structure can provide learners with guidance.

6. *Eliciting the performance.* Here the learner is required to demonstrate the newly learned behaviour to show whether or not the learned capability has been stored in long term memory. A way to facilitate this event in CBL is to provide on-line tests for learner's self-assessment.

7. *Providing feedback.* Here the student is informed of the degree of correctness of his or her performance. It can be student initiated and immediate, or be provided by the instructor possibly after some delay. In CBL immediate feedback on the learner's self-assessment can facilitate this event.

8. *Assessing the performance.* To ensure that the learner has learned the new capability, it is necessary to require additional instances of the performance. Most frequently testing the students, asking them questions, or asking them to solve problems does this, in CBL these tests can be on-line.

9. *Enhancing retention and transfer.* The occurrence of transfer seems to be a matter of permitting the student to 'think about' and 'apply' the knowledge s/he has acquired. Exercises that promote the application of the acquired knowledge can achieve this.

The nine events of instruction need to be considered in every case as potential ways of providing external support to internal learning processes. However, there are conditions in the learners and in the learning situation that modify the particular ways in which these events are delivered. For example, learners who approach computer-based learning materials with eagerness may not need to have their state of alertness additionally stimulated - their attention has already been gained. Whether or not learners need to be informed of the lesson's objectives in some comprehensive manner may depend on whether they already know what the goal of learning is - perhaps in the case that it is one in a series having a common or general objective. However, a computer-based learning display does not always need to include every one of these events. The designer may decide to omit one or more of the events, either because of particular characteristics of the targeted learners or of the learning task (Gagné and Wager, 1988, p. 43-44).

Authoring Courseware according to Gagné-Briggs Theory of Instruction

Authoring refers to the process of designing screen displays and preparing specifications to the programmer for the development of a computer-based learning program based on what role the program is expected to serve in the learning process. As mentioned earlier, different type of learning outcomes require different instructional conditions to facilitate acquisition. In addition, the Gagné-Briggs theory of instruction acknowledges that the required conditions for learning can be put into effect in different ways and to different degrees by each medium. Thus, some media are much more broadly acceptable for instructional purposes than other. Gagné and Reiser (1983)

define instructional media as 'the physical means by which an instructional message is communicated' (p. 5). Therefore, one of the essential decisions that must be made in instructional design is what medium to employ as a vehicle for the communication and stimulation that make up instruction. Gagné (1985) argues that various combinations of media acquire supplementary capabilities for instruction, and thus become much more useful than the individual media that compose them. Moreover, Gagné, Briggs and Wager (1988, p. 203) have stated that the computer is a particularly useful and versatile instructional medium. It can display both print and diagrammatic pictures on a screen and accept learner responses via a keyboard, joystick, or other control devices. By suitable design, computer-based instruction can be truly interactive, providing adaptive, informative feedback to the learners in accordance to their responses. Because of this feature, computer-based learning is particularly well suited for the learning of intellectual skills.

Gagné's argument about the use of media for instructional purposes is very important concerning educational hypermedia because it stresses that the combination of multiple media are much more effective for instructional purposes than the individual media that compose them. The Gagné-Briggs theory of instruction will be discussed again in the next chapter, which describes the design of the two experimental Web-based courseware applications. In that chapter the expected learning outcomes will be examined in the light of the five domains of learning outcomes and their subordinate types suggested by Gagné from the viewpoint of what to include in the events of instruction in order to facilitate the particular kind of learning outcomes intended.

4.4 Courseware Design Factors

Courseware design factors refers to factors that are documented in instructional design literature in general and in particular in hypermedia design, that are concerned with hypermedia structure, learner control, feedback, interactivity, and screen design elements.

4.4.1 The Structure of Hypermedia-based Courseware

This issue is concerned with how to organise and structure instructional information in the hypermedia knowledge base. As mentioned in Chapter 2, hypermedia extends the

non-linear representation and access of the electronic representation of text, i.e. hypertext, to graphics, sound, animation and other forms of information transfer. The two key features of any hypermedia application are nodes and links. There are several ways to organise and structure the nodes within a hypermedia application. Jonassen describes three types of hypermedia structures, which are unstructured hypermedia or node-link type, the structured hypermedia or network type, and the hierarchical type (Jonassen, 1986; Jonassen and Grabinger, 1990).

Unstructured hypermedia is a random node-link hypermedia in which only referential links are used. This type of hypermedia provides random access directly from any node to any other node that is linked to it as shown in Figure 4.1. Two nodes are linked because one node contains a reference to the information in the other. The user jumps immediately to any topics within the hypermedia by pointing at the item.

Structured hypermedia or network type implies an explicit organisation or arrangement of nodes and associative links. Structured hypermedia consists of sets of nodes, each set accessible from any other set as shown in Figure 4.2. The node sets can be structured in any number of ways, such as node-link, hierarchical, network, depending on the nature of the processing the designer wants to elicit from the user. The structure of each node set with the various options available within each set needs to be conveyed on every screen. Another method for structuring the node sets is to combine related concepts, tie them together in an introductory block, and then permit access within the set only to concepts contained within the set. The network structure would be most appropriate when the instructor wants to permit the users to advance, review, see examples, repeat the unit, or escape the set to explore another set.

In the hierarchical structure the information is organised in such a way that general concepts are broken down into more detailed concepts which are instantiated by individual events or objects as illustrated in Figure 4.3. The user of the hypermedia application with such a kind of structure is required to move up and down through the hierarchy in order to access related concepts and explore subordinate and superordinate relationships. However, there is a starting point in the structure - normally the first one displayed to users - which usually is a node that represents the most general concept.

Jonassen and Granbinger (1990) recommend that information models can be either deductively or inductively developed. The deductive or top-down approach in designing the information model requires starting with a content's structure or expert's knowledge structure. Many subject matter domains have well prescribed content structures, so that the arrangement of ideas in the content domains determines the structure. This approach lies in the assumption "that learning is the process of replicating the expert's knowledge structure in the learner's knowledge structure. However learning should be facilitated by hypermedia that replicates the expert's knowledge in the structure of the hypermedia and explicitly conveys that structure" (Jonassen and Granbinger, 1990 p. 22). The inductive or bottom-up approach to hypertext design is based on observations on how users navigate through unstructured hypertext and how they assimilate information from hypertext.

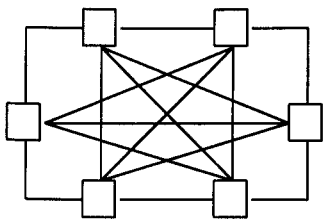


Figure 4.1 Node-link Structure

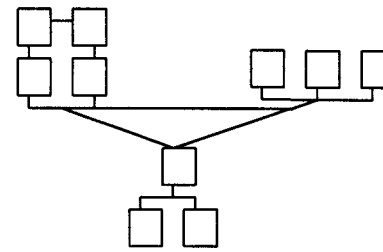


Figure 4.2 Network Structure

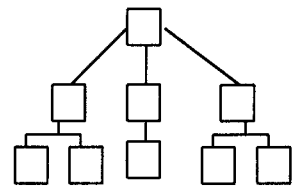


Figure 4.3 Hierarchical Structure

Jonassen (1986) argues that the three levels of hypertext he described "are not intended to represent an exhaustive list of hypertext designs, nor should they be accepted as absolute arguments" (p. 289). However, the author believes that the hypertext levels that Jonassen outlines are a suitable starting point for the structuring of hypermedia educational applications. Educational hypermedia need to be structured carefully

because "the less structured the hypertext is, the less likely users are to integrate what they have learned into their own knowledge structures" (Jonassen, 1992, p. 125).

The rationale for Jonassen's argument lies on the notion of 'web teaching' suggested by Norman (1976). Norman argued that complex materials must be presented in a way that allows the student to develop some framework for relating the pieces of information to each other, and then covers the material again, perhaps in more depth, enlarging and enriching the framework of knowledge already acquired (Norman, 1976, p.8). As mentioned earlier Gagné and Briggs (1979) recommend a 'top-down' approach to designing an instructional sequence where sequencing is done largely on the basis of expert opinion and intuition. In addition they suggest that the learning of any one intellectual skill depend on the prior learning of one or more simple intellectual skills. Therefore, based on the similarities of these two approaches, it is argued that the hypermedia structures suggested by Jonassen can be used for structuring material for the learned capability of intellectual skills suggested by the Gagné-Briggs theory of instruction.

4.4.2 Learner Control

The issue of learner control is primary to the design of interactive instruction. Learner control allows students to tailor their instructional experiences to suit personal needs and interests (Kinzie and Berdel, 1990). Laurillard (1987) suggests that learners should be given more control over the content, their access to the content and their interaction with the content; she points out that,

> There is no well-established reason to suppose that a program designer, whether teacher, researcher or programmer, knows better than the student how they should learn. Therefore when we are designing materials for a media that is capable of providing an unusual degree of individualisation via student control, it seems perverse not to take advantage of it. (p. 4)

Hypermedia and multimedia allow a great deal of learner control. The student not only has control over the depth, order and selection of material, but being interactive it allows an extra dimension in user control - there can actually be a discourse between the learner and the interactive system (Stratfold, 1994). However, there are dangers in surrendering too much control to the user. Research suggests that low-ability students,

especially those lacking understanding of the basic concepts of the information being presented fail to make effective use of the extra information and they get confused when control depends on a wide range of options (Gray, 1989; Litchfield, 1993). The high level of learner control may result in disorientation and distraction. Marchionini (1988) argues that "although self-directed learning is a worthy general goal of education, freedom to learn is not a sufficient condition to assure effective learning. Freedom can be confusing because it increases decision-making load" (p. 10).

However, teachers and designers should consider how to maximise the effective use of user control in hypermedia systems and shape the quantity of learner control into quality learner control experiences. The amount and type of learner control is dependent on several variables such as learner characteristics, content, and the nature of the learning task (Poncelet and Proctor, 1993). Learner characteristics include variables such as age and cognitive capabilities. Content that must be mastered often requires more program control, compared to content with no qualified mastery levels. Familiar learning tasks are best presented with more learner control than totally unfamiliar tasks. Ross and Morrison (1989, p. 28) have suggested a general list of situations where learner control is more appropriate than program control. Some elements of this list are as follows.

- Learners are older and mature.
- Learners are more capable.
- Content is familiar.
- Advisement is provided to assist learners in making decisions.
- Learner control is used consistently within a lesson.
- Learner control is combined with formative evaluation to identify and base revised designs on paths used by effective learners.

Summarising, learner control allows students to follow their own paths and adapt their own learning strategies. However, there are dangers giving the user complete control, without assistance in deciding which parts are relevant and which are the most productive paths to follow. A situation where the more control is given to the student, the more feedback about their decisions is given as well could be a solution (McAteer and Shaw, 1995). To achieve this the learner control issues should be intertwined with interactivity and feedback. As McKerlie and Preece (1992) suggest "control over the

work environment is influenced by the tools provided to interact with and within that environment" (p. 122).

4.4.3 Interactivity and Feedback

The most significant and unique feature of hypermedia, compared to other more 'conventional' media that have been used as educational tools in the past, lies with the increased element of interactivity between the user and the instructional material. Moreover, when computer-mediated communication is embedded in hypermedia courseware, the interaction is extended even further to facilitate 'interaction *through* the computer as well as *with* the computer' providing a powerful framework of inter-personal communication at a distance (Bates, 1995, p. 213). The term interactive, as Laurillard (1993) suggests, has been used "to differentiate computer-based learning from other methods by virtue of the computer's capability to be programmed to change its behaviour according to the learner's input" (p. 268). Reigeluth (1987) argues that "interactivity in instruction comprises the nature of the activity performed by the technology and the learner as well as the ability of the technology to adapt the events of instruction in order to make that interaction more meaningful" (p. 197).

Romiszowski (1993) suggests that interactivity can occur between teacher and learner, learner and learner, and learner and a computer-based system. To answer the question 'what is the nature of interactivity?' Romiszowski (1993) compares interactivity as it may be experienced within a multimedia program with interactivity as it is experienced on a day-to-day basis in human interactions or conversations. Through this comparison he identifies four types of interaction that can take place between human and computer.

In the first type the instructor gives a practical demonstration and explanation of key points to be remembered in the execution of a given task. The learner is expected to follow the demonstration and explain the key points back to the instructor. The instructor gives feedback to correct the learner's responses where the learner's performance is below expectation. This account of human interaction is related with the methodology commonly used in linear programmed instruction. In the second type, which is analogous to the branching model upon which most computer-assisted instruction is based, the instructor corrects the learner and also demonstrates alternative

examples to overcome specific learning difficulties experienced by the learner. Branching programs are based on the assumption that the learner's response could be used to control the material to be shown next to him/her. In the third type, which is analogous to the student-led search of a hypermedia package, the learner presents questions to the instructor who supplies the answers. In the fourth and last type, which is analogous to the ideal intelligent tutoring system, the instructor takes the conversation beyond the learner's initial request to probe the cognitive structure that the student has formed. This form of dialogue has often been refered to as 'Socratic'. These four types of interaction that Romiszowski describes relate to the 'depth of processing' or the quality of thinking that is demanded of the student. Therefore, interaction should vary according to the complexity of the learning tasks.

Orr, Golas, and Gao (1994) advise that it is important to design as much meaningful interactivity as possible into instructional software. In addition, they suggest a number of guidelines for increasing interactivity in instructional programs as listed below.

- Provide opportunities for interaction at least every three or four screens.
- Chunk the content into small segments and build in questions, reviews, and summaries for each segment.
- Ask as many questions as possible without interrupting the continuity of the instructional flow. Ask students to apply what they have learnt rather than memorise and repeat answers.
- Use rhetorical questions during instruction to get students to think about the content.
- Consider designs where the learner is not presented with information in a linear format, but rather discovers information through active exploration in the program.

One of the nine events of instruction suggested by Gagné is 'providing feedback' to establish reinforcement of appropriate performance and prevent further inappropriate performance. Poncelet and Proctor (1993) point out that feedback is the information given to the learner by the courseware, about the appropriateness of the learner's response. There are several factors that can determine the effectiveness of feedback such as the type and frequency of feedback given and the delay between the feedback and the instruction (Jonassen and Hannum, 1987). Feedback is closely related with the

issue of interaction as action without feedback is completely unproductive for a learner (Laurillard, 1993).

Laurillard (1993) identifies two types of feedback, 'intrinsic' and 'extrinsic'. 'Intrinsic' feedback is what is given as a natural consequence of an action. To illustrate the concept of 'intrinsic' feedback Laurillard uses examples of a child's actions while playing with water as the physical world responds to the child's actions of filling, pouring, etc. On the other hand 'extrinsic' feedback does not occur within a situation but as an external comment on it: right or wrong. She suggests that extrinsic feedback is not a necessary consequence of the action, and therefore is not expressed in the world of the action itself, but at the level of the description of the action. In computer-based instruction, however, the 'intrinsic' feedback relates to navigation and interactivity with the instructional program, and the 'extrinsic' feedback relates to the feedback on user's performance.

Schimmel (1988, p. 184) identifies three types of extrinsic feedback: (a) Confirmation feedback that simply confirms whether a learner's answer is correct or incorrect; (b) Correct response feedback that presents the correct answer; (c) Explanatory feedback, such as a step-by-step solution to an incorrectly answered question. Many actions require more extended 'extrinsic' feedback than confirmation feedback. Simple answers such as right or wrong can not provide any information about how learners should correct their performance. A more helpful form of extrinsic feedback would give the learner information about how to adapt and correct their performance, such as correct response and explanation feedback.

Locatis, Letournau, and Banvard (1989), suggest that generally, the amount of navigational assistance needed is a function of the size of the knowledge base, the usefulness of navigational aids already part of the authoring software, and the types of links the software allows. Shneiderman and Kearsley (1989) suggest that navigation may be facilitated when users can:

- Back up a node at a time.
- Review their paths through a knowledge base and immediately re-access any previous node.

- Search for information with key words or indexes.
- Use maps and tables of contents to see the overall structure of the knowledge base.
- Get 'fish eye' views indicating the names or contents of nodes neighbouring the one currently displayed.

Tessmer, Jonassen and Caverly (1989, p. 198) have stated that good courseware, in addition to the delivery of text and graphics to appropriate areas of the screen should promote good interactivity by facilitating access through navigation to some or all of the following options.

- Help key to get procedural information.
- Answer key for answering a question.
- Glossary key for seeing the definition of any term.
- Objective key for reviewing the course objective being worked on.
- Content map key for seeing a list of learner commands or options available to the learner.
- Overview of introduction key for reviewing the introduction to the unit.
- Menu key for exiting the lesson and returning to the menu.
- Exit key for exiting the course.
- Summary key for seeing the summary or conclusions of the lesson.
- Review key for reviewing parts of the lesson.
- Comment key for recording a learner comment about the lesson.
- Examples key for seeing examples of an idea.
- Previous frame or next frame for moving forward or backward in a lesson.
- Next lesson key for accessing the next lesson in a sequence.

Several general guidelines exist for the use of performance feedback (Jonaseen and Hannum, 1987; Orr *et al*, 1994). Some of these are summarised below.

- Provide feedback immediately after a learner's response.
- Feedback may be given after each response or after a group of responses to similar questions when previously learned material is being reviewed.

- Vary the placement of feedback according to the level of objectives. Provide feedback after each response for the learning of lower level objectives, and at the end of the session for the higher level ones.
- Provide feedback to verify the correctness. For incorrect responses, give the student information about how to correct their responses, or give a hint and ask the student to try again.
- If possible, allow students to print out their feedback.

Interactive hypermedia distinguishes itself from older multiple-media formats such as video by enabling the individual to interact with and control the flow of information with the computer. A well-designed hypermedia courseware may be a rewarding environment for learning when it provides many instances for meaningful interaction as well as feedback, which is information about the appropriateness of the learner's response that is given to the learner by the courseware.

4.5 Screen Design

The focus of this section is on how to present different screen elements such as text, colour, graphics etc., or in other words how to present stimulating information that will motivate the learner and assist him/her in retaining and recalling the information. This is clearly stated by two of Gagné's (1985) model of instructional events as discussed in the 'Instructional Theories' section of this chapter: (a) gaining attention, (b) stimulating recall.

There are many psychological factors to consider when designing hypermedia learning systems. Preece (1993) based on the Information Processing theory of learning suggests that the human psychological limitations include:

Memory load: For example how many different control icons is it reasonable to expect learners to remember at any one time - that is to hold in short-term memory. How can users be helped to navigate through hyperspace?
Perception: For example, what colours provide the best readability and what size of text or graphics is optimal?

Attention: For example, how can the users' attention be drawn to information that is relevant to any particular time where there is a lot of different information on the screen?

All these limitations should be taken into account in effective hypermedia courseware design. Well-designed screens should allow for maximum learning from the materials while providing the learner with appropriate control of the learning process (Milheim and Lavix, 1992). Therefore careful consideration of screen design factors is essential for the design of effective instructional applications. Screen design, which is an important part of Human Computer Interaction, is a particularly complex area of interactive hypermedia, which can be easily broken down into many sub-dimensions related to text, graphics, colour, and other visual aspects of interactive multimedia programs. Reeves and Harmon (1994) define screen design as a "dimension ranging from substantial violations of principles of screen design to general adherence to principles of screen design" (p. 491). They recognise two problems with screen design. First, screen design principles have not kept up with the rapidly changing nature of interactive multimedia technology. Second, creative designers may sometimes intentionally violate screen design principles to focus the user's attention. Nevertheless, they argue that enough knowledge exists about the principles of screen design and should be taken into account for effective educational multimedia designs.

Clarke (1992) points out that the design of effective computer based learning material involves the author in making many screen design decisions. "The author must combine graphics, text and colour into a structure that will develop dialogue with the learner in the form of information, questions, responses and feedback. The dialogue produced by the material will aim to assist the user to learn the information displayed" (Clarke, 1992, p. 6). Several researchers have produced guidelines based on psychological theory and practical experience to aid the author of computer based learning materials with screen design decisions. However they all stressed that their guidelines need to be applied in the light of content, type of learner and environment in which the material will be used (Preece et al, 1994, p. 499).

The following section is an attempt to summarise screen design guidelines proposed by Apple's Human Interface Guidelines (1987), Wagner (1988), Faiola and Deblois (1988),

Tufte (1990), Clarke (1992), Cox and Walker (1993), Morris, Owen and Fraser (1994), Preece et al (1994), McAteer and Shaw (1995). Some of these sources, such as Clarke (1992) and McAteer and Shaw (1995), are recent attempts to integrate research on screen design under the context of computer-based learning. Clarke (1992) points out that "the main guidelines (researchers) can produce for the screen designer are at best only partial and at worst speculative. The research evidence does not provide a comprehensive picture and there are many gaps to be filled" (p. 29). However, the design principal researchers produce are worth consideration but should be used with caution; in applying any of these guidelines the designer should always consider the function they are seeking to fulfil, the learning objectives, and the characteristics of the learners (Clarke, 1992, p. 30, 45).

4.5.1 Use of Space

- In western cultures, people tend to scan a display from top left to bottom right in the same way as a printed text is read. In addition the top of the screen represents the 'beginning' of a document and the bottom of the screen represents the end of the document.
- The eye will naturally move to a larger image before a smaller; to a moving object before a static one; to a non-symmetrical object before a symmetrical one; to a bright colour before a dull colour; to a colour before black and white.
- Areas demanding action are better placed near the centre of the user's attention.
- Avoid the temptation to make screens too busy. The simple design is a good design. A full screen can make difficult demands on the concentration of the user because of the psychological limitations of memory load, attention and perception discussed earlier in this chapter. Low-density screens, which have a relatively large amount of white space compared to the actual information are preferable.

4.5.2 Text

- The use of typeface should be consistent throughout the programme.
- Readability suggests for continuous reading that the use of serif is the most appropriate, with a character size of around twelve points and line spacing of one

and half lines. However, often sans-serif fonts work better on a computer screen than serif fonts.

- Headings and bullets could be in sans serif, the next size up from body text in a different style or colour from the main body of text.
- Large quantities of text are difficult to read and understand on a computer screen. Line lengths of about eight to ten words appear to be the optimum and 30 to 35 characters width.
- When a large amount of text is to be displayed it is preferable to split it meaningfully into several screens.
- Right justification of text should be avoided.
- Flashing text is difficult to read, but is appropriate for information that is quite vital that the reader should not miss it.
- Text enclosed within a box is not as easily read or comprehended as plain text.

4.5.3 Colour

- Short term memory is limited to between five to nine colours.
- Shape as well as colour should be used to overcome colour blindness.
- Text and background colours should be chosen carefully. The choice of colours for text should aim to maximise the contrast between the text colour and the background because the degree of readability of text on a screen increases with the contrast between the background and the text. Therefore, the use of black text on a white background, and vice versa is an optimal choice. Also, the choice of yellow on a dark background appears to meet with the approval of users.
- The number of different colours on any screen should be between three and six. Use of excessive amounts of colour does not serve to direct attention and no improvement of learning will be observed.
- Colour is a powerful means of highlighting information compared to the use of shapes for highlighting.
- Consistency in the functional use of colour is important.

4 5.4 Graphics

The use of pictures can certainly be an effective addition to text, helping learners to understand and remember what they read. This is valid only if the right picture is in the right place for the right reasons. Guidelines for the use of graphics in screen design are as follows.

- A high contrast between graphics image and background should be retained.
- Pictures not covered by the information in the text will not enhance learning in instructional situations.
- Pictures can help learners to understand and remember.
- Diagrams and maps are only useful if the information contained in them is used meaningfully.
- The illustration should be placed near the text, which it supports.

4.5.5 Animation

- Movement alerts attention, therefore animation will be the centre of the users attention, so if another event of importance is occurring on screen it may be ignored.
- Movement should be employed to reinforce connections and relationships
- When the animation contains vital information it is important to provide an option to repeat the sequence.
- More than one animation at a time in the same screen would result in confusion.

4.5.6 Video

- Video should be used to demonstrate devices in motion or to present 'real life situations'.
- The use of video for imparting abstract concepts and philosophies should be avoided.
- Video is least effective when simply used to show a speaker, and is less effective than the use of sound alone.
- Segments of video are better kept short and their purpose in the programme well considered.
- Guidelines for graphics and animation are also applied to video.

4.5.7 Three Dimensional (3D) Graphics - Virtual Reality

In the screen design literature there is no specific information on how three-dimensional graphics and virtual reality can be best presented in accordance with other screen design elements such as text. Some guidelines exist for three-dimensional interfaces exclusively (Brooks, 1988), but not for two-dimensional interfaces which include 3D elements. It can be argued that similarly to video, the guidelines for graphics and animation may also applied to three-dimensional graphics and virtual reality elements. This can be a solution but it is not the best possible approach especially when interactive 3D graphics and virtual reality environments can be relatively easily constructed and disseminated across the Internet with Virtual Reality Modelling Language (VRML). VRML is a very powerful tool and its application demands special research as will be discussed in Chapter 7 so that its potential to educational environments can be exploited.

4.5.8 Audio

Although audio is not visual information, it is examined as screen design element because it is an important part of the computer interface.

- When information is aural - language learning programs, music - the use of sound is vital.
- Sound can be used to gain attention and to reinforce information, which is also being presented graphically.
- Sound can provide feelings of immediacy and can add to the user's involvement with the program.
- In a program sound should be an option rather than a necessity.

4.6 Design for the World Wide Web

All the information presented above for the design and development of hypermedia courseware can be applied to Web-based hypermedia applications. However, the Web has some particular interface characteristics. One example is the use of fonts. It was mentioned in the 'text' section above that readability suggests the use of serif for continuous reading as most appropriate, but often sans-serif font work better on a computer screen than serif fonts. In the case of the Web this particular guideline is not

of such importance because font usage in current browsers depends on customised user preference settings, therefore the user can decide what type and size of font is suitable for him/her. Another example has to do with navigation. Shneiderman and Kearsley (1989) have suggested that navigation might be facilitated when users can back up a node at a time. Web browsers with graphical user interface provide back and forward buttons to facilitate navigation. Moreover, browsers give visual feedback to users regarding how much progress through a process has occurred and confirms that input has been received when a user is trying to access a link.

Recently attempts were made to offer 'good practices' for Web authors from the Advisory Group on Computer Graphics, which is an initiative of the Joint Information Systems Committee of the Higher Education Funding Council in England through the Support Initiative for Multimedia Applications (SIMA) (Isaacs, 1996; Davis and Tessier 1996). Moreover, the Yale Centre for Advanced Instructional Media developed a 'WWW Style Manual' aiming to provide information and guidelines for the design of WWW pages based on research on multimedia software design (Lynch, 1995). Most of these 'good practices' and guidelines have already been discussed in the previous paragraphs as they are based on previous research on screen design. However, it is worth identifying the 'good practices' documented in the 'WWW Style Manual' and the SIMA literature, which refers strictly to the design of Web-based applications. These are as follows:

- Speed and the time users have to wait for a system to respond are critical factors in interface design. To achieve an adequate level of response the author of a Web site should avoid the use of large graphics, which always load more slowly, and consider smaller graphics along with typographic styling to achieve the visual impact.
- A Web document without local links is a dead end and therefore if users hit a dead end in a site they never see the rest of the document. A good practice to avoid dead ends is to provide links in the document to the main page or to submenus within the pages.
- The width of the default browser should always be considered when designing inline graphics in order to ensure that users with the most common monitor sizes will not have to scroll horizontally to see the full extend of the graphic.

- A body of data, which belongs together, should be presented consistently. This gives an impression of wholeness, and helps to define the character and style of a Web site. A way of achieving this is by incorporating elements that occur in every page.
- A Web site should provide flexibility. This can be achieved through the provision of links on every page to give the user access to other parts of the body of information; the next and previous sections if the structure is sequential; and a search facility when it is provided.
- Alternatives to images should be provided to ensure portability and flexibility, so that those users with text-only browsers can access meaningful information in place of a graphic.

4.7 Summary

This chapter has discussed the design and development factors in the production of hypermedia based courseware. A range of resources is available in the literature regarding these factors. In this chapter an attempt has been made to bring together many of the available sources of information so that all the different factors meriting consideration in the production of a Web-based courseware may be integrated. The next chapter describes how the Stages 2-5 of the proposed framework were implemented in two Web-based experimental courseware applications and also how the different instructional design factors identified in this present stage were fulfilled in these two experimental courseware applications.

Chapter 5 Experimental Web-based Courseware Applications

5.1 Introduction

This chapter describes how the Stages 2-5 of the proposed framework were implemented in the development of two Web-based experimental courseware applications and also how the different instructional design factors identified in Stage 1 were fulfilled in these two applications. It does this by giving two accounts. The first one concerns the survey conducted prior to the development of the prototype courseware applications and describes the way that it was conducted and analyzed (Stage 2). The second one concerns the design, development, and evaluation process of the two experimental Web-based instructional applications (Stages 3,4,5) that will be used in the empirical studies. The learning materials contained in them are concerned with the area of Interactive Digital Entertainment (refer to as IDE), and Programming and Software Engineering (refer to as PSE), higher education modules, undergraduate and postgraduate respectively, taught at De Montfort University, U.K. The account includes reasons for the selection of learning materials, authoring tools, the structure of the learning materials, the design of the user interfaces, and the production techniques. It must be emphasized that the aim was to produce and evaluate Web-based courseware applications that would facilitate the development of the proposed framework and not to develop complete instructional applications.

5.2 Stage 2 of the Proposed Framework: Preliminary Survey

Prior to the development of the two experimental Web-based courseware applications (prototypes) an investigation was carried out in order to determine the end-users' preference in terms of general Web-based educational design practices.

Participants

Thirty-six adult subjects, age 21-30 years old, took part in this investigation. The subjects were both the undergraduate and postgraduate students who studied Interactive Digital Entertainment and Programming and Software Engineering

respectively and agreed to participate in the research presented in this thesis. 29 of the subjects were male and only 7 were female. They were mainly British but also Germans, Russians, Spanish, Greek and Malaysian. 44% of the subjects were highly computer literate, 53% had an average computer literacy and only 3% low. Moreover, the subjects were very receptive regarding the use of new technologies (see Table II.1 in Appendix II).

Instrument

The instrument used in this investigation was a self-completion questionnaire (see Appendix I). The questionnaire consisted of twenty seven items, both open-ended and five-point scaled items with a mid-point, and it was divided into four sections: (a) Multimedia Systems in General, (b) Multimedia System Users, (c) Media Elements, and (d) Multimedia Design and End-Users.

The first section, multimedia systems in general, was concerned with the use of the Web for courseware delivery in higher education. The purpose of this section was to seek the subjects' opinion towards a multimedia application, and also to distinguish the most important problems that the subjects encountered within such applications in general. In particular, subjects' preferences towards a Web-based educational application were investigated. The term multimedia was used throughout this questionnaire instead of hypermedia and the term educational multimedia application instead of courseware because people are more familiar with the former terms as the pilot questionnaire proved. The items included in this section are as follows:

A1. What applications do you see multimedia being specifically suited to?
A2. What features distinguish a multimedia application from a more traditional one?
A3. Of the multimedia applications you have seen and used, what problems did you find with them?
A4. What are the main advantages on using the Web for courseware delivery in higher education?
A5. What are the main disadvantages (if any) on using the Web for courseware delivery in higher education?
A6. If you were to be in charge of the development of a new multimedia application for courseware delivery on the Web what features would you insist on seeing in it? .

The second section was concerned with subjects' 'needs and wants' within a multimedia environment. The scaled items included are as follows.

B1. Multimedia users must be able to follow different routes in an application according to their prior knowledge.
B2. Multimedia users must be able to add personal notes and bookmarks.
B3. Multimedia users must be able to print textual and graphical information.
B4. Multimedia users must be able to copy information to other application.

The third section was concerned with subjects' preferences over media elements, their attitude towards hypertext and other interface issues. The scaled items included are as follows.

C1. The spoken word must replace written text whenever possible.
C2. Text is the most important media element.
C3. Any spoken words must also be available as text.
C4. Hypertext links distract the learner from the main issue.
C5. Hypertext must be available in any multimedia package.
C6. The facility to locate information by keywords is essential.
C7. Graphics must occupy more space on the screen than written text.
C8. A diagram/graphic map of the structure of the multimedia application is essential.
C9. The navigation tools must be constantly on view.
C10. Which of the following options you identify as appropriate for the navigation tools to be displayed? (The following options are illustrated: top, bottom, left-hand side, no preference)
C11. A communication channel, like a bulletin board, and a 'chat' room is an essential feature of any Web-based multimedia application.

The fourth section of the questionnaire was concerned with the involvement of the end-users in the design and development of Web-based educational multimedia application. The items involved in this section are as follows.

D1. It is useful to involve end-users during the design process.
D2. It is useful to involve end-users during all stages of the production process.
D3. End-users opinions are worth seeking.
D4. A multimedia application should be designed according to the end-users' needs.
D5. For what types of learning is an educational multimedia application useful?
D6. For what types of learning is not so useful?

5.2.1 Results

Section 1

A content analysis was performed in order to analyse the data obtained from the open-ended items in the first section (see Table II.1.1 in Appendix II). The majority of subjects felt that a multimedia application is mostly suited to the areas of education, entertainment and information dissemination. They also felt that the features that distinguish a multimedia application from a more traditional one are interactivity,

combination of multiple media, freedom of exploration, accessibility and communication.

Furthermore, the data gathered from this section revealed many different parameters, which should be included or avoided in the design of the Web-based courseware applications in order to promote and maintain users' satisfaction. The most common problems with multimedia applications were identified as an unclear and illogical structure, slow downloading times, and lack of support for the less experienced user. Regarding subjects' preferences towards a Web-based educational application the following set of data was obtained. Subjects felt that the main advantages of using the Web for courseware delivery in higher education compared to traditional teaching methods were as follows.

- Independence of time and location.
- Range and quantity of updated information.
- Mix of multiple media.
- Communication between students and tutors through electronic channels.
- Students can study at their own pace, and can get 24-hour access to lecture information instead of relying on the traditional lectures and making notes.
- Receive feedback without embarrassment.

Subjects' stated that the main disadvantages of the medium were as follows.

- Slow speed of on-line access.
- Lack of physical contact and communication.
- Limited accessibility only to those who have the technology required.
- Unanswered questions/Lack of discussion.
- Lack of teamwork experience.
- Rich media's quality (video, audio) is limited.

Moreover subjects' felt that the features they would insist on seeing in a Web-based educational application were in order of preference as follows.

- Clear and simple structure to speed up process
- Visuals (Graphics, Video, Animation)

- On-screen instructions/help
- Communication channels
- Search facility
- Flexibility according to users' needs
- Navigation map
- Sound
- Feedback

Section 2

In order to analyse the responses of the five-point scaled items selected values were assigned to each of the answers, where the value 0 was assigned to the mid-point as shown in Table 5.1. These values were chosen so that when the total score from all the thirty six subjects in each item is positive (*total score>0*), this indicates on balance, a tendency towards agreement on the item. When the total score is negative (*total score<=0)* this indicates a tendency towards disagreement on the item. Obviously, when the total score moves towards the highest value the agreement or the disagreement becomes stronger. In this particular survey those values were 72 and -72 respectively as the number of the subjects participated was 36.

Strongly agree	**2**
Agree	**1**
Not sure/No preference	**0**
Disagree	**-1**
Strongly disagree	**-2**

Table 5.1 Numerical values to the five-point scale

The responses from the second section which, was concerned with subjects' needs within a multimedia environment demonstrated that the majority of the subjects needed to be able to:

- follow different routes in an application according to their prior knowledge.
- add personal notes and bookmarks.

- print textual and graphical information.
- copy information to other applications.

Table 5.2 demonstrates the degree of agreement by displaying the total value of the subjects' responses to the scaled items of the second section. The items in Table 5.2, as well as in all the tables included in this chapter and also in Chapter 6, are presented in brief for ease of reference (see Table II.2 in Appendix II).

	Total	**(72)**	**(-72)**
B1. Different routes according to prior knowledge	**34**	Strongly agree	Strongly disagree
B2 Add personal notes and bookmarks	**39**	Strongly agree	Strongly disagree
B3. Print textual and graphical information	**56**	Strongly agree	Strongly disagree
B4. Copy information to other applications	**51**	Strongly agree	Strongly disagree

Table 5.2 Preliminary Survey - Subjects' responses to the scaled items of the second section

Section 3

Subjects' responses on the third section which was concerned with subjects' preferences regarding media elements, their attitude towards hypertext and other interface issues, indicated that text was considered to be the most important medium and should outweigh graphics on the screen and any spoken word must be available as text as well. Further, subjects felt that hypertext must be available in any multimedia application and did not distract the learner from the main issues. With regards to interface issues, the majority felt that any Web-based educational application should include a graphical map illustrating the structure of the application and this could also be a navigation tool constantly on view to speed up the information retrieval process.

However, subjects' responses on the item C10, which was concerned with the appropriate area on the screen where the navigation tools should be displayed, were inconclusive; none of the proposed approaches was favoured in particular (see Table II.4.1 in Appendix II). However, it was assumed that the users equally accepted all three of the approaches (top, bottom, and left-hand side). Therefore, as will be discussed later in this chapter in the first prototype courseware (Interactive Digital Entertainment) the navigation tool was displayed at the top of the screen, while in the second courseware

(Programming and Software Engineering), was displayed on the left-hand side area of the screen.

Furthermore, subjects felt that a facility to locate information by keywords and communication channels, like virtual bulletin boards and virtual open discussion areas are important. Table 5.3 demonstrates the degree of agreement by displaying the total value on subjects' responses to the scaled items of the third section (see Tables II.3 and II.4, in Appendix II).

	Total	**(72)**	**(-72)**
C1. Spoken word must replace text	**-11**	Strongly agree	Strongly disagree
C2. Text is the most important medium	**27**	Strongly agree	Strongly disagree
C3. Spoken words also available as text	**30**	Strongly agree	Strongly disagree
C4. Hypertext links distract the user	**-4**	Strongly agree	Strongly disagree
C5. Hypertext must be available	**16**	Strongly agree	Strongly disagree
C6. Locate info by keywords	**43**	Strongly agree	Strongly disagree
C7. More graphics than text	**-5**	Strongly agree	Strongly disagree
C8. A structure map is essential	**19**	Strongly agree	Strongly disagree
C9. Navigation tools constantly on view	**29**	Strongly agree	Strongly disagree
C11. Communication channels are essential	**27**	Strongly agree	Strongly disagree

Table 5.3 Preliminary Survey - Subjects' responses to the scaled items of the third section

Section 4

Subjects' responses to the fourth section of the questionnaire which was concerned with the involvement of the end-users in the design and development of Web-based educational multimedia application, indicated that the majority of the subjects agreed that a multimedia application should be designed according to end-users needs. Moreover, end-users should be involved during all stages of the design and production process. Table 5.4 displays the degree of agreement by displaying the total value on subjects' responses to the scaled items of the fourth section (see Tables II.5 in Appendix II).

	Total	(72)	(-72)
D1. Involve end-users in design process	40	Strongly agree	Strongly disagree
D2. Involve end-users in production	28	Strongly agree	Strongly disagree
D3. End-users opinions are worth seeking	47	Strongly agree	Strongly disagree
D4. Design based on end-users needs	48	Strongly agree	Strongly disagree

Table 5.4 Preliminary Survey - Subjects' responses to the scaled items of the fourth section

This section also included two open-ended items that were concerned with subjects' opinions on what types of courses a Web-based educational multimedia application is or is not applicable. A content analysis of the subjects' responses (see Table II.6 in Appendix II) showed that the majority of the subjects felt that the Web could be used for every area of study but in particular for theoretical subjects and computer-based subjects such as Computer Assisted Design or programming. They also felt that the Web could not be used for subjects that require physical activity, for artistic/creative subjects and for discussion courses. On the whole, the areas where subjects demonstrated the highest degree of agreement, thus deemed by the author as the most important to consider for the design and development of the prototype courseware applications, (Stage 3 of the proposed framework) are as follows.

A Web-based courseware should,

- Have a clear and simple structure to speed up the learning process.
- Provide the means for learners to study at their own pace independent of time and location.
- Include communication channels and keyword search facilities.
- Allow users to print textual and graphical information.
- Provide navigation tools constantly on view.
- Be designed according to end-users' needs.
- Be designed with the consideration that text is the most important medium and complex graphics and video should be used sparingly at this stage of technological development, because current bandwidth limitations results in unacceptable download times for multimedia rich elements which frustrate the learning process.

It has to be mentioned that a correlation of the responses with the different cultures and genders of the subjects was considered. However, because this study had to rely on volunteers it must be noted that the sample was statistically biased in gender and culture since the majority of the subjects were British males, and therefore any inferences made on the results must be made with care. This area of study (gender, and culture) was identified for further research in Chapter 7 because it is important to examine what people from different genders and cultures think about the use of Web-based courseware.

The study is now in a position to address the third stage of the proposed framework, as stages 1 and 2 have been addressed in Chapter 4 and the above survey respectively.

5.3 Stage 3 - Prototype Courseware Applications: Learning Materials

Two experimental Web-based courseware applications were developed through the course of this study. The learning material contained in them and the reason for their selection will be discussed in detail in the following subsections.

5.3.1 Courseware One: Interactive Digital Entertainment

The learning materials contained in the first courseware were concerned with the area of Interactive Digital Entertainment. This is taught as a second year fifteen-credit module on the BA (Hons) Multimedia Design course at De Montfort University, UK. The module is concerned with the design of entertainment applications that are both interactive and digital in nature. Therefore, it examines the development of applications for both personal computers and dedicated game consoles using cartridges, CD ROMs and the Internet. It also considers the nature of applications for future digital entertainment platforms and devices. The physical module consists of a series of 12 one-hour lectures, 2-hour practical workshops and group tutorials. Assessment is based on an individual critical evaluation exercise and a group design project.

The courseware's primary aim was to support the delivery of the physical module throughout the provision of lecture's content and also to supply related information for on-campus students. No support for the practical workshops was considered, as this side of the module is not taught in the physical module but rather supported by

practical tutorials. The learning materials were not adapted from any course book, but were authored for this particular courseware. The author of the learning material was the lecturer who normally delivered the module in the classroom. Strenuous efforts were made by him to give a detailed account of the content and avoid leaving any ambiguities, so that a student could find most of the answers to his/her questions in the lecture content. A secondary aim was also involved in the development of the courseware, which was to provide an alternative to the physical lectures for students who were unable to be present in the classroom due to illness or conflicts with their timetable.

The specific objectives of the Web-based courseware were adapted from the existing Teaching and Learning Plan for the physical module and extended in terms of the results from the above described survey and factors discussed in Chapter 4 as follows:

The courseware should provide:

1. The aims and the objectives of the module.
2. The teaching and learning strategies employed.
3. Assessment details.
4. Reading list.
5. An extensive account of the module's content which will include the entire lecture notes and specific visual examples on interactive digital entertainment products.
6. Keyword search facility
7. Communication channels.

Further, the courseware should be:

8. Highly flexible allowing work at a pace and depth set by the learner.
9. Entertaining, informative and challenging.
10. Extendable.
11. Educationally sound.

More specifically, objectives 1-5 were included in the existing Teaching and Learning Plan for the physical module; 6-9 were derived from the results obtained from the survey described above; objectives 10-11 agreed by the author of the learning material and the investigator on the basis of Stage 1.

5.3.2 Courseware Two: Programming and Software Engineering

The learning materials contained in the second Web-based experimental courseware were adapted from the lecture notes on a postgraduate module in Programming and Software Engineering. The module itself consists of a series of 15 two-hour lectures. Programming and Software Engineering is an important course for all engineers who wish to be trained in FORTRAN-77 and C Programming Languages. It offers a programming approach to software engineering, which gives an emphasis to the development of practical programming skills. Therefore the Web-based courseware in addition to the lecture notes needed to provide a wide range of programming examples with solutions and test procedures. This module is part of the educational programme of the three groups of students mentioned previously in section 3.3, Chapter 3. The development of the Web-based courseware was aimed at supporting the delivery of the physical module throughout the provision of the module's learning material and also to supply related information for these three groups of students, potentially allowing the constraints of distance, time and location associated with traditional educational techniques to be removed.

The objectives of the Web-based courseware were formulated on the same basis as those discussed for the IDE courseware as follows.

The courseware should provide:

1. The aims and the objectives of the course.
2. The students' handbook with information on teaching and learning strategies, assessment details, staff information, useful contacts, facilities provided in the university, a reading list and other useful information.
3. An extensive account of the course's content, which includes the entire lecture notes, specific visual diagrams on programming exercises, and programming examples.
4. Search facilities.
5. Communication channels.

Further, the courseware should be:

6. Designed for two types of users: (a) for advanced students wishing to refer to material for research and development, and (b) for new students requiring a

structured approach in learning Programming and Software Engineering. The sequence of the learning materials in this case was based on experience of the author of the material.

7. Highly flexible worked at a pace and depth set by the learner.
8. Informative and challenging.
9. Extendable.
10. Educationally sound.

The two modules mentioned above were chosen as the experimental learning material for the following reasons. Firstly, collaboration with the content providers was essential throughout the design and development process of the prototypes because they were the experts on the subject content and had experience in delivering the course through conventional lecturing methods. In view of that experience, they were also in a position to provide the learning objectives, and to know those areas of the module that would need special consideration and in which areas students tended to need more support, and could therefore provide suitable additional material. Secondly, the development of the experimental courseware applications was a long and demanding process in terms of time, and therefore it was difficult to find lecturers that were willing to participate in such a study.

Nevertheless, the lecturer of the 'Programming and Software Engineering' course was willing to participate because he felt that a Web-based courseware could be an important support to the delivery of the module. As already mentioned this module is part of the educational programme of three groups of postgraduate students that are located in three different countries.

Moreover, funding was available from the Higher Education Funding Council for England (HEFCE) Teaching and Learning Technology Programme (TLTP) Students and Teachers' Integrated Learning Environment (STILE) project, to develop a Web-based courseware in order to support the delivery of the IDE module. A multimedia designer was employed to aid the accomplishment of this task. In addition, the lecturer of this particular module was the director of studies for the presented research and therefore was most willing to participate.

5.4 Hypermedia Authoring Tools

In implementing the two experimental Web-based courseware applications HyperText Markup Language (HTML) was used as the primary authoring language. Common Getaway Interface (CGI) programs and Perl programming language was used to output dynamic information in real time when needed (i.e. search engine, bulletin board etc.). CGI programs and Perl was used instead of other means of outputting dynamic information such as Java, because CGI and Perl were the most reliable and common way of doing this in the time of the two pieces of courseware's development, and still are in some respect. Due to these reasons, many programmers have placed their CGI and Perl programs on the Web so that people who do not have a programmer's background can download and modify these programs according to their needs. This was exactly the case in the current research, as the author does not have a programmer's background.

5.5 Experimental Design of Courseware Applications

In this section, the implementation of Stages 3, 4, and 5 of the proposed framework is discussed. Stage 3 is concerned with the development of prototype courseware applications according to the results from Stages 1 and 2. Stage 4 is concerned with the evaluation of the prototypes with the end-users (formative evaluation). Finally, Stage 5 of the proposed framework is concerned with revisions on the design based on evaluation results from Stage 4. The different techniques for data gathering that were used in formative evaluation, and the way they were used is discussed in detail in Chapter 3. Therefore, this section will concentrate mostly on the actual results of the formative evaluation.

However, before discussing how each of these stages were implemented in the current research it is important to examine the expected learning outcomes of the current courseware applications in terms of the Gagné-Briggs theory of instruction, because it is the underlying instructional theory of this research.

The expected learning outcomes from the two Web-based courseware applications fall under the category of intellectual skills. Students by studying the learning material included in the two pieces of courseware are expected to be able to learn to discriminate

between concepts and apply their knowledge of different concepts and rules to problem solving and critical evaluation assessments in the physical modules. The next paragraph describes in more detail the nine different events of instruction for intellectual skills as the expected learning outcome (Gagné and Briggs 1979; Gagné, Briggs, and Wager, 1988).

1. *Gaining attention.* Introduce stimulus change.
2. *Informing learner of the objective(s).* Provide description of the performance to be expected.
3. *Stimulating recall of prior learning.* Stimulate recall of subordinate concepts and rules.
4. *Presenting the stimulus material.* Present examples of concept or rule.
5. *Providing learning guidance.* Provision of cues to proper combining sequence.
6. *Eliciting the performance.* Ask learner to apply rule or concept to new examples
7. *Providing feedback.* Confirm correctness of rule or concept application.
8. *Assessing the performance.* Learner demonstrates application of concept or rules.
9. *Enhancing retention and transfer.* Provide spaces reviews including a variety of examples.

In order to generate effective pieces of courseware the prototypes were tested against Gagné's nine events of instruction at every stage of their development during the formative evaluation. For example, the feedback system was not considered of primary importance in the initial design because the aim of the courseware applications was to support the delivery of the physical modules and not to replace them. Therefore it was considered that the necessary feedback on students' action would be given in the classroom from the tutor and not through the courseware applications. However, the formative evaluation showed that students wanted a feedback mechanism within the courseware applications as well. The fulfillment of the nine events of instruction will be discussed later in the chapter for each one of the courseware applications. The following sections will describe in detail how stages 3, 4, and 5 of the framework were implemented in each of the two prototype courseware applications.

5. 6 Interactive Digital Entertainment

5.6.1 Stage 3 of the Proposed Framework: Development of Prototype Courseware

The structure of the courseware was not entirely user lead but partly tutor lead in terms of information the student is required to know. Therefore it was structured according to the 'network structure' hypertext type suggested by Jonassen (1986, 1990) under the assumption that learning is the process of replicating the expert's knowledge structure in the learner's knowledge structure (see Chapter 4). It was arranged into the following six main sections: *Introduction/Aims and Objectives, Teaching and Learning Strategy, Reading List, Assessment, Teaching Plan,* and *News*.

As discussed in Chapter 4 one method to achieve the network structure is to combine related concepts, tie them together in an introductory block, and then permit access within the set only to concepts contained within the set. Another method is to make a set available from any other set by displaying a navigation toolbar on each screen that would present each of the options. A combination of these two methods was used to structure the information within the IDE courseware - all the sections were accessible from an introductory block and from each section as well. This is clearly illustrated in Figure 5.1. The solid lines in this figure show the links to and from the introductory block and the dashed lines shows the links between the different sections. In order not to make the Figure 5.1 very complicated only the links from the 'Strategy' section are shown as an example. However, all the other sections were linked accordingly.

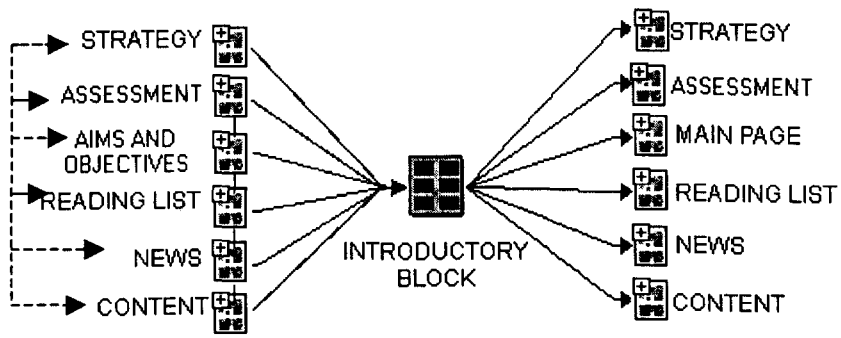


Figure 5.1 The structure of the IDE Web-based courseware

Firstly, all the different sections of the courseware were tied together in an introductory block, which was the basic navigation menu in the entry page as shown in Figure 5.2. Computer game characters were designed to represent each section in order to give a 'game-like' style to the courseware to match the learning material of Interactive Digital Entertainment. Each player was then given a name related to the 'role' they played: TARGET for aims and objectives, RISK for strategy, PHILLIN for content, HARVARD for reading list, JUDJE for assessment, and JORNO for news. The user simply used the introductory block illustrated by the *'player select'* graphic on the entry page to access the different sections of the courseware, in other words the different node sets. If the instructor wanted to add a new section, a new game character could be developed. In this way the courseware could be easily extended.

Figure 5.2 IDE courseware, Introductory block - 'Player Select' graphic

Moreover a version of the *'player select'* navigation graphic was constantly on view in all sections of the courseware in order to make the other sets/sections available from any set/section. This was different from the original graphic in terms that when a section was selected the game character connected with this section was displayed in a bigger size at one of the top corners of the screen. The other characters were then displayed at a smaller scale on the opposite corner as illustrated in Figure 5.3. The pages that contained the lectures also permitted access to the different sections of the courseware through a condensed version of the introductory block. In detail, the screen in these pages was divided in two frames as shown in Figure 5.4. The narrow frame at

the top of the screen included a map of the alternative sets along with an escape mode i.e. the button 'IDE MAIN' that takes the user to the entry page. The bottom large frame i.e. the main frame includes the text of the lecture and a set of relevant visual examples. There were also links - internal and external - at the end of each lecture page as well as throughout the lecture content, to other useful information and resources that were then displayed in the main window.

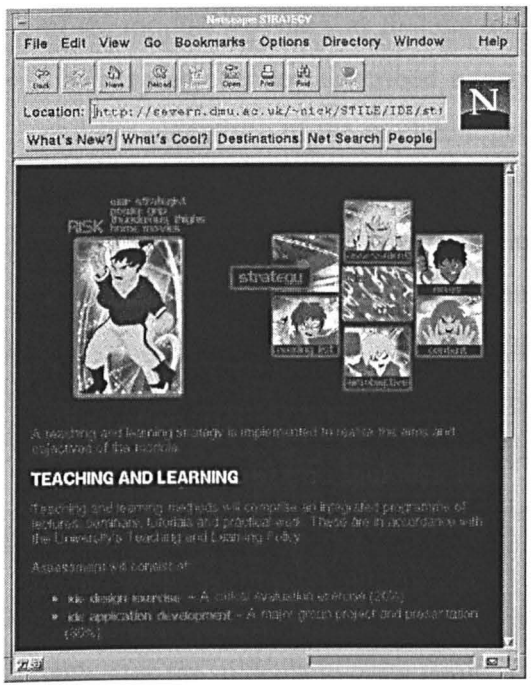


Figure 5.3 IDE, A version of the introductory block

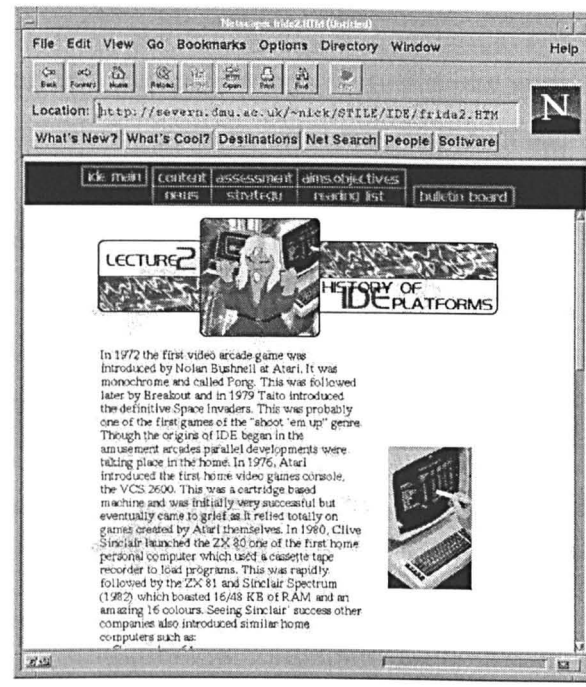


Figure 5.4 IDE, Layout of the lecture's page

The sequencing of the course's units/lectures was based on the opinion of the author of the material and is basically hierarchical. Moreover, the hierarchy of the learning outcomes included in the intellectual skills suggested by the Gagné-Briggs theory of instruction was considered in the sequencing of the lectures. The first lectures in this hierarchy provided general knowledge on the field of IDE such as terminology, history of IDE platforms (discriminations and concrete concepts). As the sequence progressed more defined concepts and rules were involved in the lectures so that learners could gradually proceed to high order rules, thus being able to evaluate and critically examine IDE platforms in order to suggest potential ways to advance the field. However, no individual lecture's objectives were included in every single lecture

because the whole series of lectures had a common objective, addressed by the 'Aims and Objectives' section of the courseware.

As well as information describing the module, this courseware based on the objectives described earlier in this chapter, also included details of support materials, the assignments, lecture notes, a search engine, and a bulletin board. In more detail:

- The **aims and objectives** section identified the specific strategic aims and objectives of the module and the way that the module would achieve them.
- The **strategy** section described a teaching and learning strategy to realise the aims and the objectives of the module together with the learning outcomes, exercises and projects.
- The **content** section presented the module syllabus and the teaching plan including the twelve specific lectures' content and also description of the practical exercises.
- The **assessment** section discussed the module's exercises and assignments, the grading system, submission and reassessment details.
- The **news** section contained information on physical tutorials and lecture's time, as well as information about the on-line tutorials and other events that might occur throughout the semester.
- The **reading list** section contained a list of useful resources like books, journals and web sites for students to draw upon.

Supplementary to the above areas there were:

- A **search engine** which, was an application that allows students to locate information throughout the lecture content files using keywords.
- A **bulletin board** which allowed limited conferencing between students when accessing the bulletin board at the same time, or as a place where students can leave messages - asynchronous communication.
- A link to tutor's **e-mail**.

The main information, that was the text and the graphics about the different sections were presented on a black background with light green and yellow fonts of easily readable size (12 points), in accordance with screen design guidelines on text and colour as discussed in Chapter 4, in order to imitate a computer's traditional game

environment. In contrast, the lecture units, the bulletin board and the search engine were all presented on a light graphical background, white in the case of the bulletin board and the search engine, with black colour fonts of easily readable size (12 points) as well in accordance with the above mentioned guidelines (Chapter 4). A white background was used for the bulletin board and the search engine in order to achieve the highest possible contrast between background and foreground, so that students with limited experience on Web-based applications could easily identify the function of these two tools. Moreover, the text was justified on the right hand side of the page with 1.5 line spacing, following the default styling of the Web browsers currently available.

Colour was used consistently throughout the courseware, and the graphics included were described by information in the text. Audio was not used because as the courseware was aiming to support on campus students, speakers were not available in the computer labs. Issues on feedback and interactivity will be discussed later in this chapter, after the formative evaluation section that follows, because subjects' input was very important in deciding how these issues will be applied.

5.6.2 Stage 4 of the Proposed Framework: Formative Evaluation of Prototype

One-to-one Evaluation

The first phase of Stage 4 consisted of one-to-one evaluation sessions between the author and the learner in order to review the initial design and comment upon the clarity, completeness and ease of use of the courseware. In order to achieve designs that reflected the concerns and comments across the whole sample this phase was repeated three times because the body of the end-users' was not homogeneous in terms of age and nationality.

A content analysis (see Table IV.1 in Appendix IV) of the comments showed that subjects were satisfied with the choice of the typeface and the colour both in the background of the main pages and the text. They were also content with the 'game-like' character of the courseware, and the fact that there was always a navigation tool on view. In addition they stated that the amount of hyperlinks was satisfactory and that they would prefer if there were no hyperlinks at the end of each lecture unit because this allowed them to concentrate on the lecture content without feeling tempted to visit other

sites. Moreover they stated that the bulletin board and the e-mail facility were more than adequate in order for students and tutors to communicate within the campus. However, they felt that if the courseware was to be used for distance learning, then more communication channels would be needed such as computer conferencing and chat rooms.

Subjects' dissatisfaction and suggestions for improving the design have been summarised into the following points.

- A set of keywords and a brief summary of what the lecture covers was needed, so that students could know roughly the content of each lecture.
- More visual examples were required to attract and maintain user's attention.
- A help file for novice users was needed that would explain how the courseware should be used.
- Loading of external links, communication channels and search engine should be in a secondary window within the same browser so that user could alternate between a number of windows at the same time and always have something to refer back to.
- Use of different graphical backgrounds should be employed in each lecture page so that the users could easily distinguish when a link is part of another lecture; thus they do not feel that the instruction is too intense.
- External links should not be displayed at the end of a lecture's page because users could become tempted to visit them and not concentrate fully on the lecture's content.

However, all subjects stated that any modifications of the courseware should take into account the downloading times, which could be very long with rich media elements such as audio or video. All the subjects' suggestions were considered and implemented in the revision of the courseware. Figure 5.5 illustrates the lecture page after the addition of the set of keywords and the summary and also presents how an external link is displayed in a secondary browser. The reasons why all suggestions were implemented are as follows. First, some of the subjects' suggestions (keywords, summary, help file) confirmed what was already discussed in Stage 1 for increasing interactivity in Chapter 4, section 4.4.3, and were also identified by the subjects in the preliminary survey. Second, because the medium is so new in education all

suggestions must be considered at this stage. Moreover, the validity of the suggestions that address interface design issues will be examined in the field evaluation that follows.

In addition to the changes made based on the suggestions that were concerned with the presentation of the information a new feature was added in the application: a help file with site description and navigation tips.

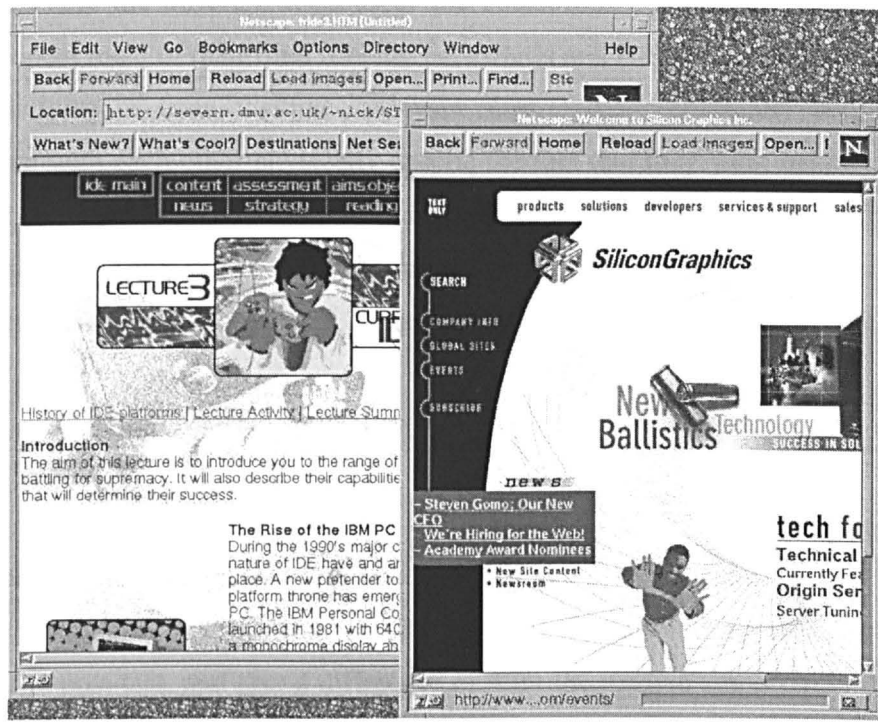


Figure 5.5 IDE Courseware - The lecture page with an external link after the amendments

Field Test

Ten volunteer subjects, aged 19-27, who were studying IDE took part in the field test. They were all British nationals and had an average computer literacy (see Table IV.2 in Appendix IV). Lecture number three on 'Current IDE Platforms' was used as the example learning material. The aim of this lecture was to introduce students to a range of IDE platforms. It described the platforms' capabilities and some of the possible factors that will determine their success. The Web-based lecture consisted of the lecture notes and a set of relevant graphics. At subjects' disposal were all the features

of the IDE courseware and subjects were instructed to use and evaluate them as well. Two instruments were used in the field test: a pre-test, and a post-test, which also included an attitude and acceptance questionnaire (see Appendix III). In addition a debriefing session followed the completion of the attitude and acceptance questionnaire.

Subjects were observed throughout the whole time they worked with the courseware. In general, subjects concentrated on the lecture's content after they had spent some time looking around the different sections of the courseware. However, three out of ten subjects spent most of their time flicking backwards and forwards between the external links windows or even visiting irrelevant sites. Also, constantly subjects were interacting with each other physically despite the fact that they were instructed not to, and as a consequence unfortunately none of the subjects used the bulletin board or the e-mail facility. Table 5.5 presents the means of the pre-test and post-test performance scores on a scale of one to ten.

	Pre-test	Post-test
Performance Means	3.4	7.2

Table 5.5 IDE, Field Test. Performance means on pre-test and post-test

The results of the performance test indicated that subjects' performance was increased after the instruction. A difference of 3.8 was observed between the means of the pre-test and the post-test, and also a difference of 4 on the median respectively (see Table IV.3.1 in Appendix IV). Moreover, a Pearson correlation coefficient test yielded r=0.78 (see Table IV.3.2 in Appendix IV). Statistically, the closest the value of r is to 1 the more positive the correlation is, on the contrary, as r tends towards -1 the more negative the correlation is. However, the r=0.78 that was yielded in the present situation showed that subjects' prior knowledge scores correlated positively and consistently with their performance in the post test. Subjects with higher prior knowledge scores, demonstrated a better performance in the post-test, than subjects with lower prior knowledge scores.

The post-test attitude questionnaire was consisted of fifteen items; ten of them were five-point scaled items (Q1, Q2, Q3, Q4, Q5, Q7, Q8, Q12, Q13, Q14); four of them

were five-point scaled items with a comment option (Q6, Q9, Q10, Q11); and one of them was open-ended item (Q15) as listed below:

1. I understood the directions on (a) How to use the instructional material, (b) What section to look at next (c) How to operate the application.
2. The application is easy to use by every learner.
3. The purpose of the lecture was clear.
4. The information in the lecture was clearly presented.
5. I now have a better understanding of this area.
6. I felt challenged by the instruction.
7. I want to use it again.
8. Should more examples be used?
9. Is there any place where a visual or graphic could help clarify what was being said?
10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding them?
11. Are some lacking details in general?
12. Do you find helpful that the external links, the communication channels and the search engine are opened in a second browser?
13. Do you think that graphical backgrounds within each lecture should be consistent but different from other lecture's background?
14. Do you think that the fact that there are no links to further information at the end of each lecture's page help you to concentrate more to the lecture's content?
15. If you were to be in charge of the development of these particular multimedia lectures what features would you insist on seeing in it and why?

Table 5.6 demonstrates the total value of the responses to the scaled items based on the selected values presented in Table 5.1 (see Tables IV.4.1, IV.4.2, IV.4.3, and IV.4.4 in Appendix IV). As ten subjects were participated in the field evaluation the highest value of agreement and disagreement is 20 and -20 respectively.

In general, these results indicated that the majority of the subjects felt that the Web-based lecture was clear and easy to understand and after studying it they had a better understanding of the area studied. In addition they felt challenged by the instruction and they stated that they wanted to use the application again. A tendency towards disagreement was observed in the items "Are some lacking details in general?" and "Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding them?". Nevertheless, the responses of the subjects in the scaled items Q8 and Q9, in the comment sections of items Q9 and Q11 and also in the open-ended item Q15, indicated that they needed more visual examples to explain further the concepts presented and also they needed a print/save option (see Table IV.4.5 in Appendix IV). It goes without saying that these results

appeared to be contradictory. On the one hand the majority of the subjects felt that the courseware did not lack any details, but on the other hand the results indicated that they needed more visual examples to explain the concepts presented further. However, this contradiction was clarified in the debriefing session.

	Total	(20)	(-20)
1. I know how to work with the application	15	Strongly agree	Strongly disagree
2. Any learner can use the application easily	15	Strongly agree	Strongly disagree
3. The purpose of the lecture was clear	12	Strongly agree	Strongly disagree
4. The info was clearly presented	13	Strongly agree	Strongly disagree
5. Better understanding of the area.	13	Strongly agree	Strongly disagree
6. I feel challenged by the instruction	9	Strongly agree	Strongly disagree
7. I want to use it again	11	Strongly agree	Strongly disagree
8. I need more examples	5	Strongly agree	Strongly disagree
9. Need more visuals to clarify concepts	12	Strongly agree	Strongly disagree
10. Need more explanation	-3	Strongly agree	Strongly disagree
11. In general, there are some lacking details	-2	Strongly agree	Strongly disagree
12. External link opened in a second browser	18	Strongly agree	Strongly agree
13. Different graphical backgrounds	12	Strongly agree	Strongly agree
14. No links at the end of the lecture's page	13	Strongly agree	Strongly agree

Table 5.6 IDE, Field Evaluation Post-test. Total value of responses to the scaled items

In the debriefing session subjects aired that it would be useful if the courseware could provide more visual examples because the medium is ideal to present visuals of IDE applications. However, they were still concerned about the unacceptable delays that would occur if the courseware was too rich in visuals. They also suggested that they needed feedback at the end of each lecture, so that they could be sure that they really understood the concepts presented. Additionally, the students felt that the human element to clarify points and discuss subjects further was essential. Moreover, it was agreed that the physical interaction with their classmates and teachers was irreplaceable. Bulletin boards and e-mail could help to decrease the feeling of 'working alone' but it was felt that they could not be a substitute for the physical presence and interaction. However, subjects stated that this attitude might be a result of their unfamiliarity with

Web-based lectures. They also stated that this was the main reason they did not try out the communication channels included in the courseware.

Regarding the suggestions from the one-to-one evaluation that were implemented in this version of the prototype, subjects demonstrated a great degree of appreciation. Therefore the revisions made based on subjects' suggestions from the one-to-one evaluation were confirmed. As far as the need for print/save option identified by the subjects, the Web software facilitates such an option. However, the fact that this was identified as a need indicated that some of the subjects were unaware of this property of the Web. Therefore, an explanation of how the save/print option embedded in the Web software works was added in the contents of the help file.

Expert Evaluation

One lecturer in Multimedia Design was willing to review the courseware and comment upon its clarity, its completeness, and its ease of use and effectiveness. The techniques for the data gathering in this method were a self-completion questionnaire (see Appendix III) and a debriefing session. The comments made are summarised in the following points.

- The content was current, accurate and in certain extent complete. IDE is dealing with new technologies, and therefore new content can be added while the technology progresses.
- The courseware was very clearly structured and thus students could use it without help.
- The content expert felt that the courseware was a very good attempt to confront new technologies. He would recommend it to his students because he believed that it could provide savings in students' learning time. Students would find this approach interesting mainly because it would allow them to re-read the course information in their own time. He also felt that such an application could also produce savings in staff teaching time in specific areas such as factual learning and also savings in university's resources for instance cutting down the budget for printed lecture notes.

- It should be used to support existing teaching methods and all modules should provide similar support.

However he felt that the current limitations of the technology (e.g slow downloading times, the need for powerful computers) may result in students studying entirely at home experiencing difficulty in using it. However, he pointed out that "the content and ideas are solid and despite such problems it uses a range of new developments that when fulfilled will be a strong challenge to traditional methods".

5.6.3 Stage 5 of the Proposed Framework: Revisions based on Stage 4

No improvements were suggested by the content expert and the revision of the courseware was based only on subjects' suggestions. The revisions suggested by the subjects in the one-to-one evaluation have already been discussed. Therefore, only the revisions made based on the results from the field evaluation will be discussed here. Following subjects suggestions the following additional improvements were implemented to the courseware:

- More examples in the form of visuals and graphics, but within the limits acceptable for fast downloading.
- On-line assignments providing immediate feedback using multiple-choice questions related to lecture content, for each lecture as shown in Figure 5.6.

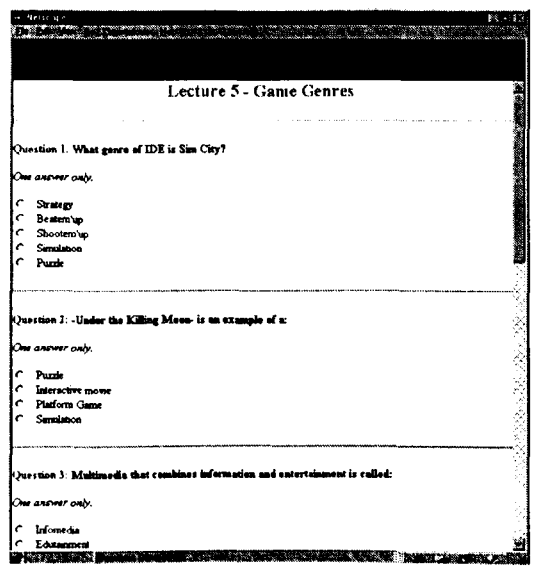


Figure 5.6 IDE Courseware - On-line Assignment

5.6.4 Implementation of Stage 1 of the Proposed Framework in IDE Courseware

After discussing the way that the Stages 2-5 was implemented in the current courseware, it is important to examine how the different instructional design factors identified in Stage 1 of the proposed framework were fulfilled during the course of this study.

5.6.4.1 Instructional Theory

The nine events of instruction that Gagné suggested were fulfilled in the IDE courseware in conjunction with the physical module's instructional plan in the following way.

1. *Gaining attention.* The courseware managed to gain the users' attention through the use of colour and shape throughout the interface and also with the 'game like' characters used to illustrate the different sections of the courseware.
2. *Informing learner of the objective(s).* The learners get informed of the objectives of the instruction through the 'aims and objectives' section of the courseware.
3. *Stimulating recall of prior learning.* The hierarchical sequencing of the lectures facilitated reference to previous lectures to stimulate prior learning.
4. *Presenting the stimulus material.* The provision of the lectures' content and the several examples given achieved this.
5. *Providing learning guidance.* Learners were provided with guidance through the unitary structure of the courseware, the navigational aids, and the help file.
6. *Eliciting the performance.* The on-line tests for self-assessment were used to elicit the performance of the learners.
7. *Providing feedback.* The confirmation on the correctness of performance in the on-line assignment was used to provide feedback.
8. *Assessing the performance.* Learners' performance was assessed through assignments and group projects in the physical module.
9. *Enhancing retention and transfer.* A critical evaluation assignment and group design project in the physical module were used to enhance retention and transfer of knowledge.

5.6.4.2 Courseware Design Factors

Courseware's structure - The courseware was structured according to the 'network-structure' type of hypertext suggested by Jonassen. The sequence of the learning materials was hierarchical and was based on the content expert's opinion (author of the learning material) and the hierarchy of learning outcomes involved in the intellectual skills suggested by the Gagné-Briggs theory of instruction. The overall performance objectives was provided from the 'Teaching and Learning Plan' of the physical module.

Interactivity and Feedback - The design allows the learner to discover information through active exploration in the courseware (internal and external links). The learning materials are chunked into small segments (lectures) with built in summaries and keywords for each segment. The courseware provides a great amount of navigational assistance through various versions of the introductory block, other navigational aids already part of the Web software (buttons that facilitate back up or forward a node at a time), and keyword search. The introductory block is also a content map displaying the options of the courseware available to the learner, such as the menu key (IDE MAIN) for exiting the lecture and returning to the main menu. Another method of providing interactivity included in the courseware is the on-line assignments, which also provide immediate feedback to verify the correctness of responses. Moreover, learners can print out their feedback as well as any other information included in the courseware by utilising the print facility of the Web software. In addition the courseware allows interaction with other learners and tutors through the communication channels provided.

Screen Design - The way that some of the screen design guidelines discussed in Chapter 4 were implemented in the current courseware has already been discussed in Section 5.6.1. In addition, an effort had been made to design low-density screens because as discussed in Chapter 4 (Section 4.5.1) high-density screens can make difficult demands on the concentration of the user. As far as 'good practices' particularly for Web design are concerned (Section 4.6) the Web-courseware provided local (internal) links together with external links, consistency and flexibility through the use of colour and visuals, and the supply of links on every page to provide the user with access to other parts of the body of information. Moreover, in order to achieve

good response time small graphics and typographic styling were used instead of large graphics in order to achieve the visual impact required.

5.7 Programming and Software Engineering

5.7.1 Stage 3 of Proposed Framework: Development of Prototype Courseware

As mentioned earlier the courseware was designed for two types of users: (a) for advanced students wishing to refer to material for research and development, and (b) for new students requiring a structured approach to learning Programming and Software Engineering. Therefore the courseware would have two functions: as a reference resource and a structured learning application. For ease of reference the terms 'Resource' and as 'Module Structure' will be used throughout this thesis to illustrate the different approaches.

The Resource consists of all the lecture notes and of a number of examples presented both in FORTRAN-77 and C. Cross-referencing was introduced to help establish suitable correlation between concepts, theory and practice with regards to the two different programming languages (FORTRAN-77 and C) and different operating systems (MSDOS, UNIX, and VAXVMS). The Resource therefore was an 'electronic book', which utilises hypertext technology to ensure rapid access to the information required.

In the 'Module Structure' the learning materials were chunked into several meaningful units based on experience of conventional lecturing from the author of the material. The sequence of the units was hierarchical and was based on the content expert's opinion (author of the material) and the hierarchy of learning outcomes involved in the intellectual skills suggested by the Gagné-Briggs theory of instruction, similarly to the IDE courseware. Every unit clearly stated its aims and objectives, and also contained keywords of the information covered in each one of them. These keywords were linked with their corresponding content in the 'electronic book'.

Similarly to the IDE, the structure of the courseware was not entirely user lead but partly tutor lead in terms of the information the student is required to know, and it was structured according to the 'network structure' suggested by Jonassen (1986). However,

in this case only the method that makes a set available from any other set was used, in contrast with the IDE where both this method and the 'introductory block' method were used. The 'introductory block' in the IDE courseware was used to preface the 'game like' character of the courseware. Hence, in the case of the PSE courseware there was no such need and therefore the one method was considered as adequate. The information was arranged into the following four main sections: (a) *Student's Handbook,* (b) *Module Structure*, (c) Resource information on *Programming and Software Engineering*, *FORTRAN-77* and *C,* and (d) *Operating Systems*. Figure 5.7 illustrates the structure of the courseware according to Jonassen's 'Network Structure'.

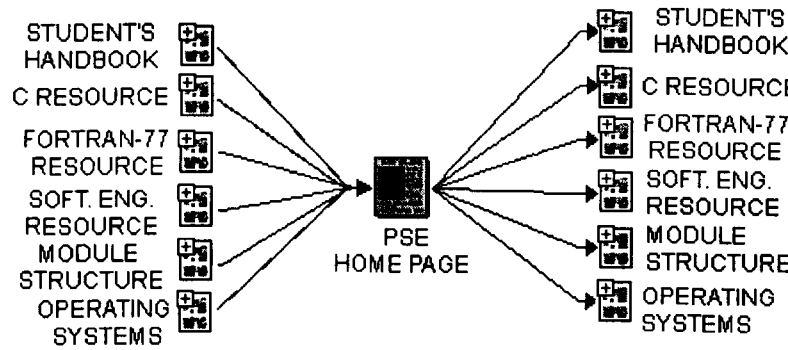


Figure 5.7 The structure of the PSE courseware according to Jonassen's 'Network Structure'

In detail the different areas were as follows:

- The *Students Handbook* section contained the description of the MSc course, entry qualifications, employment of graduates, course context and rationale, course structure, teaching and learning strategies, course management, module specification (where this particular module was discussed in detail), bibliography and information about the teaching staff.
- The *Module Structure* consisted of the structured units in FORTRAN-77, C, and Programming and Software Engineering.
- The *Resource* on FORTRAN-77 and C included the entire lecture notes and exercises on these programming languages respectively. In addition the resource on Programming and Software Engineering discussed techniques for structured and modular programming using FORTRAN-77 and C. However, the principles

presented were independent of the programming language used. In this section there was also a set of problem sheets with suggested solutions and test procedures for students to practice programming in FORTRAN-77 and C.

- The *Operating Systems* section discussed in detail three different operating systems: MSDOS, UNIX, and VAXVMS.

Supplementary to the above areas in line with IDE courseware, a search engine, a bulletin board, and access to lecturer's e-mail were included.

All the information was presented on a white background with 12 point black colour fonts for the main body of text and a dark red for the headings and the navigation tools. A white background with black colour text was selected because this particular module involves mathematical equations and programming codes, and thus this combination was considered as the best possible to display these accurately. The dark red colour for the subheadings and the navigation tools was selected because it gives a high contrast with the background and is also the colour used in the logo of De Montfort University which is displayed in the main page of the courseware. This was also a particular request of De Montfort University's webmaster.

The screen was divided in two frames as shown in Figure 5.8: the left-hand side narrow frame displayed a graphical map of the courseware's sections, which is also a navigation tool and is constantly on view. The right hand side frame was the main frame of the screen where all the links were displayed. Certain colours were assigned to the Module Structure: blue for C, green for FORTRAN-77, and orange for Programming and Software Engineering. The headings of each unit in these three different sections were displayed using these colours as background to ensure consistency as shown in Figure 5.9.

5.7.2. Stage 4 of the Proposed Framework: Formative Evaluation of Prototype

One-to-one Evaluation

Similarly to the previous study (IDE courseware), three subjects took part in the one-to-one evaluation in order to represent the whole sample: one German student, one Russian student, and one British student. A content analysis (see Table VI.1 in Appendix VI) of

the data collected from the one-to-one evaluation showed that subjects felt that the Web is a very good medium to present learning material for computer based courses, because the learner does not have to switch between paper-based learning material and the computer screen. With regards to the particular courseware, they stated that its structure was clear and consistent and it was easy to follow due to the navigation toolbar which was constantly on view. They also felt that the design of the interface, concerning the choice of typeface, colors, amount of hyperlinks and overall presentation, was very helpful and appealing.

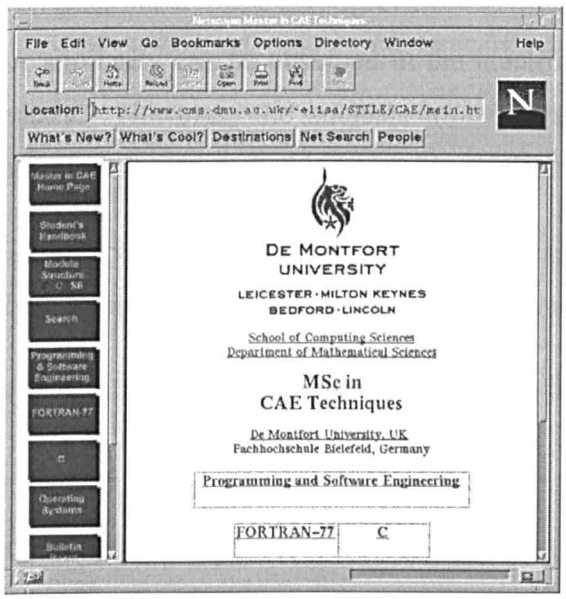


Figure 5.8 PSE Courseware - Main Page

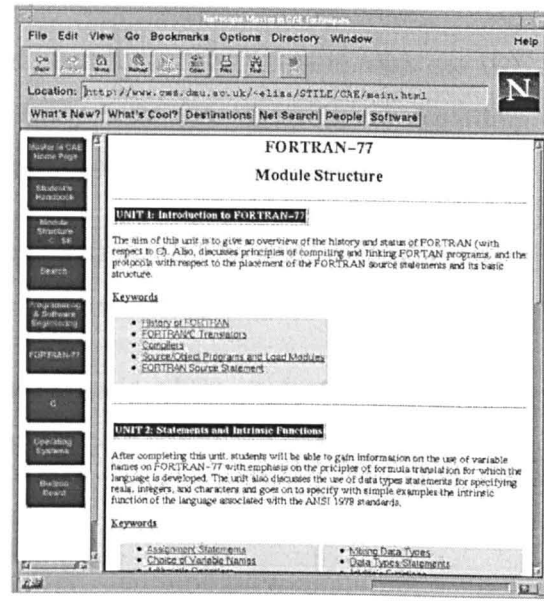


Figure 5.9 PSE Courseware - Module Structure

In addition they considered that the search engine and the content lists included in the electronic book were of great importance because by using them they could access the required information very quickly. The communication channels, i.e. bulletin board and e-mail, were rated high in importance because they allowed users to communicate in spite of time and location. However, subjects felt that they would prefer to use this courseware as support learning material and not instead of the physical lectures because they felt that the human element to clarify uncertainties was essential. Moreover, they stated that the use of audio or video files should be carefully considered, because it needs powerful computers and would slow down the download process adding frustration to the learning process.

Subjects' dissatisfaction and suggestions for improving the design are summarised into the following points.

- A help file for novice users was needed, in order to explain further the features included in the courseware.
- A virtual open discussion area for virtual conferencing and on-line tutorials was needed for those users who access the courseware remotely.
- Solution 'hints' for programming exercises instead of ready-made solutions.
- A graphical map of the courseware's structure to help avoid disorientation.

A similarity can be observed in the identified need for a help file here with the IDE study. However, the subjects in the IDE study went into more detail regarding interface issues, something possibly resulted from their design background.

In line with the previous study all the subjects' suggestions were considered and implemented in the revision of the courseware in the form of the following additions:

(1) A virtual open discussion area for on-line tutorials where students could interact with their colleagues and tutors at the same time within a virtual environment as shown in Figure 5.10.
(2) A help file with site description and navigation tips.
(3) A graphical map of the courseware's structure as shown in Figure 5.11.
(4) Solution 'hints' for programming exercises.

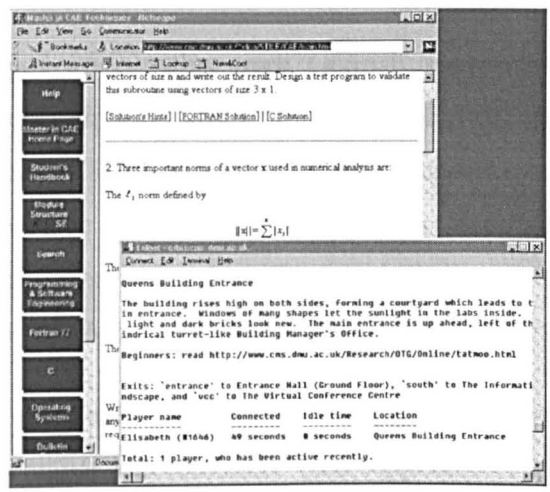


Figure 5.10 PSE Courseware - Screen grab of the virtual conferencing facility

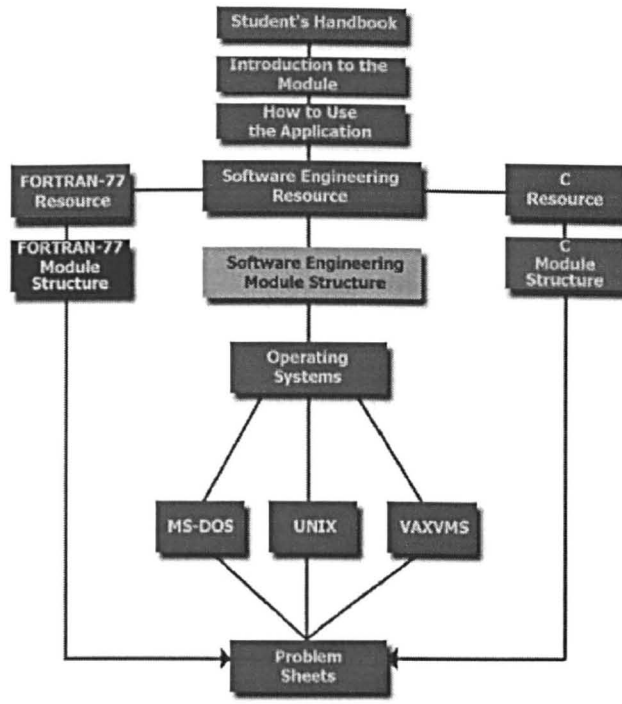


Figure 5.11 Graphical map of the PSE courseware's structure

In addition, the suggestion derived from the previous study regarding the loading of communication channels, search engine and external links in a second browser was implemented in this courseware as well, because it was considered by the author as a very significant suggestion.

Field Test

Five subjects aged 26-29 who were German students studying Computer Aided Engineering were willing to participate in the field test. 4 of the subjects were male and only one female. They were all highly computer literate and welcomed the use of new technologies (see Table VI.2 in Appendix VI). Unit 1 on Binary Number Systems, and Unit 2 on Numerical Error and Accuracy from the Programming and Software Engineering 'Module Structure' were used as the example learning materials.

Two instruments were used in the field test: a pre-test, and a post-test, which include an attitude and acceptance questionnaire (see Appendix V). In addition a debriefing session followed the completion of the attitude questionnaire. Table 5.7 presents the means of the pre-test and post-test performance scores on a scale of one to ten.

The results of the performance test indicated that subjects' demonstrated a high prior knowledge in the learning materials. This was because the subjects had already undertaken the module in Programming and Software Engineering earlier in their studies. However, there is always room for improvement and indeed their performance had increased after the instruction.

	Pre-test	Post-test
Performance Means	5.8	7.8

Table 5.7 PSE Field Test. Performance means on pre-test and post-test

A difference of 2 was observed between the means of pre- and post-test, and also a difference of 2 between the medians respectively (see Table VI.3.1 in Appendix VI). Moreover, a Pearson correlation coefficient test showed that subjects' prior knowledge scores correlated absolutely positively and consistently with their performance in the post test (r=1) (see Table VI.3.2 in Appendix VI). Subjects with higher prior knowledge scores, demonstrated a better performance in the post-test, than subjects with lower prior knowledge scores.

The attitude and acceptance questionnaire included in the post-test was similar to the one that was administered to the IDE subjects. Some amendments were made in the formulation of the items, i.e. the word 'unit' instead of the word 'lecture', and also new items were added in order to confirm the revisions suggested by the subjects (see Appendix V). Table 5.8 demonstrates the total value of the responses to the scaled items, based on the selected values presented in Table 5.1 (see Tables VI.4.1, VI.4.2, VI.4.3 and VI.4.4 in Appendix VI). As five subjects were participated in the field evaluation the highest value of agreement and disagreement is 10 and -10 respectively.

In general, these results indicated that the majority of the students felt that the Web-based courseware was clear and easy to understand and after working with it they had a better understanding of the area studied. In addition they felt challenged by the instruction and they stated that they wanted to use the courseware again. In spite of the fact that in general they did not identify any details lacking, they made suggestions for the improvement to the courseware in the comment section of the scaled items, in the

open-ended items (see Table VI.4.5 in Appendix VI) and in the debriefing session that followed the post-test. These suggestions are outlined in the following points.

- More detailed help in solution process.
- Feedback on programming i.e. an on-line compiler.
- More content, in terms of information in other operating systems and programming languages.

	Total	(10)	(-10)
1. I know how to work with the application	7	Strongly agree	Strongly disagree
2. Any learner can use the application easily	5	Strongly agree	Strongly disagree
3. The purpose of the units was clear	5	Strongly agree	Strongly disagree
4. The info was clearly presented	4	Strongly agree	Strongly disagree
5. Better understanding of the area.	5	Strongly agree	Strongly disagree
6. I feel challenged by the instruction	6	Strongly agree	Strongly disagree
7. I want to use it again	6	Strongly agree	Strongly disagree
8. I need more examples	-4	Strongly agree	Strongly disagree
9. Need more visuals to clarify concepts	0	Strongly agree	Strongly disagree
10. Need more explanation	0	Strongly agree	Strongly disagree
11. In general, there are some lacking details	0	Strongly agree	Strongly disagree
12. Chat rooms for remote learning	10	Strongly agree	Strongly disagree
13. External link opened in a second browser	8	Strongly agree	Strongly disagree
14. Solution hints	10	Strongly agree	Strongly disagree
15. Graphical map	10	Strongly agree	Strongly disagree

Table 5.8 PSE. Field Test Post-test. Total value of responses to the scaled items

Expert Evaluation

Two lecturers from the engineering field were willing to review the courseware and comment upon its clarity, its completeness, and its ease of use and effectiveness. The techniques for the data gathering in this method were a self-completion questionnaire (see Appendix V) and a debriefing session. The comments made are summarised in the following points.

- The content was current, accurate and complete.

- There was enough explanation on how to use the courseware. In addition, the courseware was very clearly structured and thus students could use it in general without help. However, this depends upon many factors, such as the background knowledge of student and their computer literacy.
- It is not easy to judge if students would find this approach interesting. Some students like to work in a solitary state with a computer; others prefer a more social environment with personal contact.
- The greatest strength of the courseware were the clear and easy to use structure; the solution hints for the problems and the tree structure of the course. In addition, it was felt that the bulletin board and the on-line tutorial could prove to be the most valuable aspect of computer-based learning in higher education.
- The greatest weakness of the courseware was that the material was clearly adapted from lecture notes and not really suitable for self-learning. However, this was felt to be a weakness of the source material rather than the courseware itself.
- The lecturers would recommend the courseware to their students as an additional resource to traditional material, but they felt that it could not be used instead of the actual lecture in the classroom because the current 'lecture notes' style of the material needs accompanying lectures to be effective. A much more purpose-built range of source material might partially replace lectures.
- It was felt that it was not clear that such a courseware could produce savings in staff teaching time because students who do not learn from such packages may insist on more tuition from staff. However, it could produce savings in other university resources, for instance reduction of the library budgets.

5.7.3 Stage 5 of the Proposed Framework: Revisions Based on Stage 4

The lecturers suggested no improvements, and therefore the revision of the courseware was based only on subjects' suggestions. The revisions suggested by the subjects in the one-to-one evaluation have already been discussed. Therefore, only the revisions made based on the results from the field test will be discussed here. According to subjects' suggestions the following improvements were implemented in the courseware:

- An example of a step-by-step tutorial on the solution of programming exercises in the form of a video file as shown in Figure 5.12.
- An on-line assignment providing immediate feedback using an on-line compiler as shown in Figures 13 and 14.

Subjects in one-to-one evaluation suggested that the use of audio and video should be carefully considered because it needs powerful computers and would slow down the download process. However, the video file developed needed only 40 seconds to download, and therefore it was used as an element of the courseware in order to investigate subjects reaction on this medium for tutorial application.

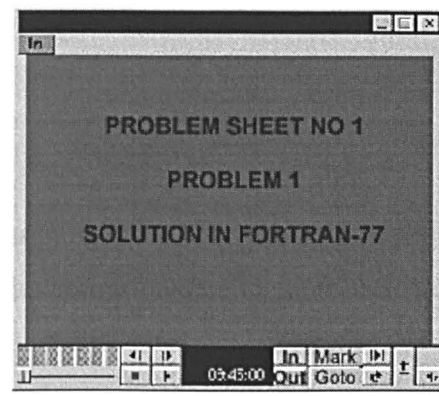


Figure 5.12 PSE Courseware - Screen grab of the video step-by-step tutorial

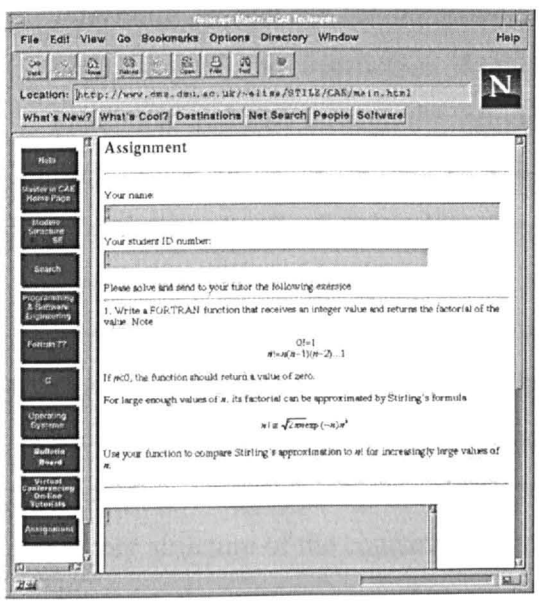


Figure 5.13 PSE - On-line assignment

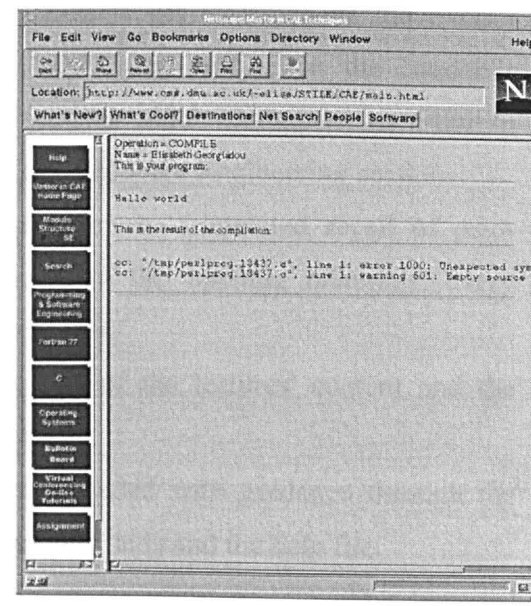


Figure 5.14 PSE - Compiled programming code

The suggestions of the subjects with regards to extending the content were not implemented because as mentioned in the introduction of this chapter, the aim of the presented research was to produce Web-based instructional applications that would facilitate the development of the proposed framework and not to develop complete instructional applications.

5.7.4 Implementation of Stage 1 of the Proposed Framework in IDE Courseware

After discussing the way that the Stages 2-5 were implemented in the current courseware, it is important to examine how the different instructional design factors identified in Stage 1 of the proposed framework were fulfilled during the course of this study.

5.7.4.1 Instructional Theory

Similarly with the IDE courseware, the author is now in a position to address how the nine events of instruction that Gagné suggests were fulfilled in this courseware in conjunction with the physical module's instructional plan.

1. *Gaining attention.* The courseware managed to gain the user's attention through the use of colour and shape throughout the interface.
2. *Informing learner of the objective(s).* The learners get informed of the overall objectives of the instruction through the 'objectives' section in the 'student's handbook' and also through the individual objectives which accompany each unit in the 'Module Structure' for FORTRAN-77, C, and Software Engineering sections.
3. *Stimulating recall of prior learning.* The courseware stimulated recall of prior knowledge due to the hierarchical sequencing of the learning materials; every previous unit is prerequisite for every following unit.
4. *Presenting the stimulus material.* The provision of the lectures' content and the several examples given were used to achieve this.
5. *Providing learning guidance.* Learners were provided with guidance through the unitary structure of the courseware, the navigational aids and the help file.
6. *Eliciting the performance.* The on-line assignments were used to elicit learners' performance.

7. *Providing feedback.* The on-line compiler for the testing of learners' programming codes would provide immediate feedback on the performance of the learners regarding programming codes.
8. *Assessing the performance.* Learners' performance was assessed through tests and assignments in the physical module.
9. *Enhancing retention and transfer.* Examinations in the physical module were used to enhance retention and transfer.

5.7.4.2 Courseware Design Factors

Courseware's structure - The courseware was structured according to 'network-structure' type of hypertext suggested by Jonassen. The sequence of the learning materials was hierarchical and was based on the content expert's opinion (author of the material) and the hierarchy of learning outcomes involved in the intellectual skills suggested by the Gagné-Briggs theory of instruction. The overall performance objectives was provided through the 'objectives' section in the 'student's handbook' and also through the individual objectives which accompany each unit in the 'Module Structure'.

Interactivity and Feedback - The design allowed the learner to discover information through active exploration in the electronic book and the 'Module Structure'. The learning materials were divided into small segments (units) with built in keywords for each segment. The courseware provided a great amount of navigational assistance through a graphic (navigation toolbar) that includes links to all sections of the courseware and was constantly on view, a graphical map of the courseware's structure, keyword search, and other navigational aids already part of the Web software (buttons that facilitate back up of forward a node at a time). Another method of providing interactivity included in the courseware was the on-line assignments, which provided immediate feedback on programming codes through an on-line compiler. Moreover, learners could print out their feedback as well as any other information included in the courseware by utilising the print facility of the Web software. In addition the courseware allows interaction with other learners and tutors through the communication channels provided.

Screen Design - The way that some of the screen design guidelines discussed in Chapter 4 were implemented in the current courseware has already been discussed in Section 5.7.1. In addition, an effort had been made to design low-density screens because as discussed in Chapter 4 high-density screens can make difficult demands on the concentration of the user. As far as 'good practices' particularly for Web design is concerned (section 4.6 in Chapter 4) the Web-courseware provided local (internal) links, consistency and flexibility through the use of colour and visuals, and the provision of links on every page both in 'Resource' and in 'Module Structure' to give the user access to other parts of the body of information.

5.8 Courseware Applications' Production

The two pieces of courseware were produced both on an IBM compatible Personal Computer and a UNIX workstation. The PSE courseware comprised of 234 HTML files, 75 graphics and a video file. The whole courseware occupied about 20 Mbytes on hard disk. The IDE courseware comprised of 58 HTML files, 114 graphics and animation, and a video file. It occupied about 7 Mbytes on hard disk. Both courseware applications had a good response time (few seconds) because the Web-servers and Web-browsers were located in De Montfort University on the same local network. The following paragraphs briefly describe the implementation of each file type used for developing the different interface elements.

- HTML files

All the HTML files were generated manually in HTML using a text editor. It was possible to use HTML editors that give 'WYSIWYG', which stands for What You See Is What You Get to generate the HTML pages without knowing the HTML code. However, there are problems with such editors. For example when something goes wrong it is difficult to correct without editing the HTML code directly. After some experimentation with such packages the author decided to generate the HTML files directly because it was felt that this method was much more reliable.

- Navigation toolbars

The navigation toolbars of both pieces of courseware were generated manually using Adobe Photoshop, which is a two-dimension bitmapped graphic construction software.

- Graphics and Animation

Most of the graphics included in both pieces of courseware were GIF and JPEG files, which are the file formats for graphics accepted by the Web software. They were generated manually using Adobe Photoshop. The animations were constructed using Microsoft Gif Animator software, which allowed the conversion of a sequence of still images into animation. The mathematical equations that were included in the PSE software were GIF images because at the time of the development of this courseware Web browsers could not support the display of mathematical symbols. Therefore all the equations and other mathematical symbols included were generated manually using the Microsoft Equation software.

- Video files

The video file included in the IDE courseware was a QuickTime movie that was created by digitising video footage from the computer game 'Star Wars'. The duration of this QuickTime movie was 40 seconds and it occupied 1 Mbyte on the hard drive. The video file used in the PSE courseware was created in a different way. First of all, a sequence of PICT files was created, in Adobe Photoshop. Also, an audio file was created by digitising the recorded sound from an audio tape. Then, a software package called Adobe Premiere was used to convert the sequence of PICT files and the audio file into a digital video file, known as AVI or Video for Windows. The duration of the video was 3,45 minutes and occupied 10 Mbytes on the hard drive.

- Audio files

A software package called Cool Edit Pro was used to digitise and edit the sound included in the video file of the PSE courseware.

- Search Engine, Bulletin Board, On-line Assignments

CGI scripts and Perl programming language were used to implement the output of the search engine, the bulletin board and the on-line assignments (see Appendix VII).

- Virtual conferencing (chat room).

A ready-made MOO residing in De Montfort University was used to implement virtual conferencing. It is called DMUMOO that stands for De Montfort University MUD Object Oriented and was implemented by Chris Hand, Principal Lecturer in Computing

at De Montfort University. It was set up in November 1993 to facilitate experiments with virtual environments, metaphors and object-oriented programming. Many facilities are included in DMUMOO such as a seminar room, meeting rooms and tape recorders for logging the sessions (Hand, 1995). To access DMUMOO a login and a password is needed.

5.9 Summary

This chapter has described how Stages 2-5 of the proposed framework were implemented through a survey and the experimental design of two Web-based pieces of courseware, and also how the different instructional design factors identified in Stage 1 of the proposed framework were fulfilled in these two experimental applications. Now the main issue of this research can be addressed - testing the validity of the proposed approach that a Web-based courseware developed according to the experimental framework could effectively support the delivery of physical modules by promoting learning and providing significant improvements in users' performance and satisfaction in higher education compared with conventional teaching methods.

Chapter 6 Empirical Studies

6.1 Introduction

The main task of the research described in this thesis is to test the validity of the approach that a Web-based courseware developed according to the proposed framework could effectively support the delivery of physical modules by promoting learning and providing significant improvements in users' performance and satisfaction in higher education as compared with conventional teaching methods. This chapter reports on two empirical studies, which were designed to accomplish this task. Since the evaluation of the empirical studies is intended to investigate both the users' performance and satisfaction with using the Web-based courseware the multi-faceted approach of summative evaluation described in Chapter 3 has been employed. The procedures followed, results obtained, and their implications will now be described in detail.

6.2 Study One: Interactive Digital Entertainment

The purpose of this study was to investigate the effectiveness of a Web-based courseware on Interactive Digital Entertainment (IDE), regarding students' satisfaction and performance. This was investigated under the hypothesis that students undertaken the IDE courseware could experience more satisfaction and increase their performance compared to those participated in a traditional classroom lecture. In statistical terms this hypothesis is called an experimental or an alternative hypothesis, meaning that the independent variable, which is the Web-based courseware, could exert an effect. However, there is a second hypothesis involved in every experiment, the statistical or else the null hypothesis, which suggests that the population means are the same and that any observed difference between sample means is merely the product of sampling error (Klugh, 1974).

6.2.1 Method

Participants

Twenty volunteer subjects, who were second year students on the BA (Honors) Multimedia Design course, took part in this study. Fourteen were males and six were

females, aged 21-31 years old of various nationalities, mainly British but also Greek, Spanish and Malaysian. They were randomly divided into two equal-sized groups, namely, an intervention group and a control group. The subjects had an average computer literacy and they welcomed the use of new technologies (see Tables IX.1.1 and IX.1.2 in Appendix IX).

Learning Materials

Lecture number seven on three dimensional (3D) development was used as the example learning materials. The lecture covered 3D character development techniques, such as animation, kinemation, dynamation and motion capture. The Web-based lecture offered a set of keywords, the lecture content, a summary of the lecture content, a set of visual examples on the several techniques in the form of graphics and animation, and finally several links to Web sites of commercial companies in the area of 3D design. In addition, at the subjects' disposal were all the tools embedded in the courseware: the help file, the search engine, the bulletin board as well as all the information about the aims and the objectives of the module, the teaching and learning strategies, the assessment information, the reading list, and the news section. The lecturer who delivered the content in the classroom used as a teaching aid an overhead projector to demonstrate examples of the 3D techniques described, as well as a white board and group discussion.

Instruments

Four testing instruments were used in this study (see Appendix VIII). The first was a printed pre-test with ten both multiple choice and open-ended items, which was designed to investigate what background knowledge both groups of subjects had in 3D developments. The second was an immediate post-test for the control group, which consisted of a performance test with the same items as the pre-test to verify any increase in understanding at the end of the traditional instruction, and a printed attitude and acceptance questionnaire to ascertain subjects' experience in the classroom. The third one was an immediate post-test for the intervention group. This immediate post-test consisted of the same performance test used in pre-test, and an attitude and acceptance questionnaire that included items relating to the completeness and ease of

use of the courseware, and also items on subjects' satisfaction and willingness to use the courseware. The fourth instrument was a delayed post-test. The delayed post-test consisted of the same performance test used in the pre-test and the immediate post-test which was used to determine how much the subjects of both groups had retained after a month delay, and an attitude and acceptance questionnaire that involved items on the effectiveness of the Web-based courseware. The same delayed post-test was administered across the subjects of both groups, as will be explained in the following subsection.

Procedure

The procedure was completed in four stages for both intervention and control groups. In the first stage all the subjects were asked to do the pre-test. Next was the intervention stage. The control group attended the lecture in the classroom and the intervention group followed the lecture through the Web-based courseware (Web-based lecture).

However, before starting to work with the Web-based courseware those subjects in the intervention group who were unfamiliar with the courseware because they did not participate in the field test discussed in Chapter 5, received a short introduction on how to use it and were advised to work at their own pace without being given any time limit. In the third stage the post-test and the attitude questionnaire were administered to the subjects of both groups. The subjects in the control group completed the post-test at the end of the lecture, and the intervention group completed it when they felt that they had covered the Web-based lecture material sufficiently. On average the subjects spent 60 minutes with the courseware. After the third stage was completed both groups' subjects were told that they could use the courseware for the rest of the course if they were willing to, as a supplement to the physical module. After a month's delay, at the end of the semester, in the fourth and final stage, the subjects were asked to complete the delayed post-test which consisted of the same performance test that was used in the pre-and the immediate post-test, and an attitude and acceptance questionnaire. The attitude and acceptance questionnaire was exactly the same for both groups, in contrast with stage three where different questionnaires were used for the different groups, because now both groups had used the IDE courseware. Obviously,

the control group had used the courseware as support material to the physical lecture and the intervention group as a substitute to the physical lecture as well as support material, and therefore the two groups were not equally exposed to the Web-based courseware. Nevertheless, the comparison of the results of this last stage provided data on how different attitudes may be established with regard to different uses of the courseware. In addition, debriefing sessions with the intervention group subjects followed the completion of the immediate post-test.

6.2.2 Results

The results of the summative evaluation address both the outcomes and the processes of learning.

6.2.2.1 Learning Outcomes

Table 6.1 presents the means of the pre-test and post-test scores, and also the differences in the means between the immediate post-test and the pre-test, as well as between delayed post-test and immediate post-test for both the intervention and the control group on a scale of one to ten.

Performance Means	Pre	post	delayed	post-pre difference	post-delayed difference
Intervention Group	3.2	6.9	6.5	3.7	0.4
Control Group	5.2	7.2	6.5	2	0.7

Table 6.1 IDE, Summative evaluation - Means on pre-test, immediate and delayed post-test and their between differences for both groups

The results of the performance test, as indicated in Table 6.1 showed that the control group had a slightly better performance in the immediate post-test than the intervention group. However, in the delayed post-test both groups had the same performance as displayed in the same table. Yet, it cannot be immediately concluded that the different teaching methods have produced the difference, because some difference due to sampling error is expected, even if the teaching procedures were equally effective. The question that needs to be answered is "How probable is the obtained sample mean difference on the basis of sampling error alone, when no mean difference exists between the population being sampled?". If the sample mean difference is highly improbable on

the basis of sampling error we can reject the statistical null hypothesis that sampling error alone was responsible. This permits us to accept the alternative hypothesis that the difference between the sample means was the result of sampling from populations with different means, a difference that presumably resulted from the different conditions of instruction.

In statistics, there are several ways to measure the significance of an observation, such as Analysis of Variance (ANOVA), Chi Square and *t-test*. However, the *t-test* is considered the most appropriate one when the sample size is small, which was the case in this study. Moreover, because the sample size is small (10 in each group) it can be assumed that the two different samples have equal variances. Therefore, a two sample - assuming equal variances - *t-test* was performed between the (a) pre-tests, (b) immediate post-tests, and (c) delayed post-tests scores of the two groups. (see Tables XI.2.1, XI.2.2, and XI.2.3 in Appendix XI). The *t-test* at the a=0.05 level yielded for each of the cases the following: (a) t=2.85, df=18, p=0.01, (b) t=0.55, df=18, p=0.587, (c) t=0, df=18, p=0.01. Since t=2.101 is required for the 0.05 level and a t=2.85 was obtained only in the case of the pre-test, the null hypothesis can be rejected at the 5% level for this case and can be accepted that the difference resulted from the different conditions of instruction.

However, a further exploration of this result was required because even though the subjects were assigned at random to the groups, an initial difference in prior knowledge scores in favour of the control group was observed (see Tables IX.3.1 and IX.3.2 in Appendix IX). A Pearson correlation coefficient test showed that subjects' prior knowledge scores correlated positively and consistently with their performance in the post-test across both groups. However, in the control group the positive correlation between the immediate and the delayed post-test was far stronger ($r_{immed/delay}=0.92$) than it was between the pre- and the immediate post-test ($r_{pre/immed.}=0.52$). Regarding the intervention group, the results correlated almost equally positively between the immediate and the delay post-test, and also between the pre-test and the immediate post-test ($r_{pre/immed.}=0.94$, $r_{pre/immed}=0.91$) (see Tables IX.4.1 and IX.4.2 in Appendix IX). Therefore, the subjects with higher prior knowledge scores demonstrated a better

performance in the post-test and the delayed post-test, than subjects with lower prior knowledge scores.

In order to further explore the learning outcomes another *t-test* at the α=0.05 level assuming two-sample equal variances was performed between the differences in the means of the two groups in (a) the immediate post-test and the pre-test (immediate post-test – pre-test), and (b) the delayed post-test and the immediate post-test (delayed post-test – immediate post-test) (see Tables IX.5.1 and IX.5.2 in Appendix IX).

From the *t-tests* the following results were obtained: (a) t=-3.9, df=18, p=0.001, and (b) t=-1.3, df=18, p=0.19. (The table that demonstrate the values of t required for different level of significance with various degrees of freedom record only the positive values of t regardless if t is positive or negative, see Klugh, 1974, p. 419). Since t=2.101 is required for the 0.05 level and t=2.878 is required for the 0.01 level and a t of 3.9 was obtained in the case of the differences in the means between the immediate post-test and the pre-test, again the null hypothesis can be rejected at the 1% level for this case, and can be accepted that the difference resulted from the different conditions of instruction.

Therefore, the *t-test* showed that the subjects of the intervention group outperformed the subjects of the control group in the immediate post-test. Compared to Table 6.1, Figure 6.1 presents the performance means of both groups and the differences between them graphically.

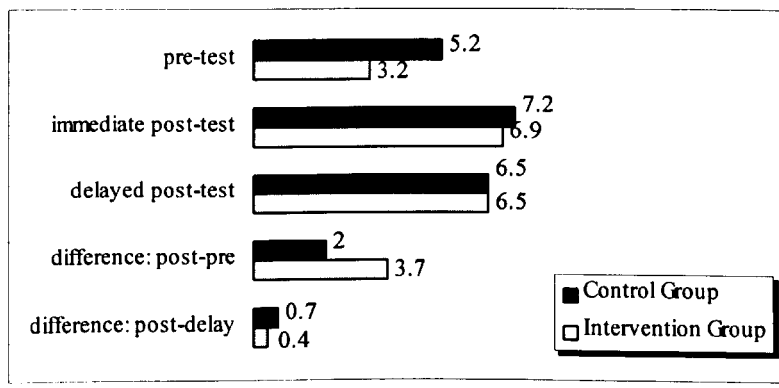


Figure 6.1 IDE, Summative evaluation - Performance means on pre-test, immediate and delayed post-test and their between differences for both groups

6.2.2.2 Learning Processes

The learning processes, that are in this case the way that the subjects interacted with the Web-based courseware was investigated in this study through the attitude questionnaires that were part of the immediate post-test, and the delayed post-test (Appendix VIII).

Immediate Post-test

The immediate post-test attitude questionnaire for the intervention group included items on the subjects' satisfaction and willingness to use the courseware, and also items regarding the completeness and ease of use of the Web-based courseware. It consisted of thirteen items; eight of them were five-point scaled items (Q1, Q2, Q3, Q4, Q5, Q6, Q8, Q12), four of them were five-point scaled items with a comment option (Q7, Q9, Q10, Q11), and one of them was open-ended (Q13), as listed below:

Q1. Have you understand the directions on: (a) How to use the instructional material, (b)What section to look at next, (c) How to operate the application.
Q2. The application is easy to use by every learner.
Q3. The purpose of the lecture was clear.
Q4. The information in the lecture was clearly presented.
Q5. I was able to easily obtain answers to questions I did not understand.
Q6. I now have a better understanding of this area.
Q7. Do you feel challenged by the instruction as a whole?
Q8. Should more examples be used?
Q9. Is there any place where a visual or graphic could help clarify what was being said?

Q10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding it?
Q11. Are some lacking details in general?
Q12.Do you feel that hypertext links distract you from the main issues?
Q13. If you were to be in charge of the development of these particular multimedia lectures what features would you insist on seeing in it and why?.

Similarly to chapter 5 in order to analyse the responses of the five-point scaled items selected values were assigned to each of the answers as shown in Table 5.1 in the previous chapter. In this case the highest values are 20 and -20 respectively as ten subjects participated in this stage of the evaluation. The items Q3, Q4, Q5, Q6, Q7 were also included in the attitude questionnaire for the control group so that a comparison on subjects' attitudes between the two different teaching methods could be possible. Table 6.2 demonstrates the total of the responses of the intervention group

subjects to the five-point scaled items that are not included in the control group's attitude questionnaire (see Tables IX.6.1 and IX.6.2 in Appendix IX). The items here as well as in all similar tables that follow are mentioned in brief for easy reference.

	Total	(20)	(-20)
(Q 1) I know how to work with the application	9	Strongly agree	Strongly disagree
(Q 2) Any learner can use the application easily	6	Strongly agree	Strongly disagree
(Q 8) The examples were enough	11	Strongly agree	Strongly disagree
(Q9) I need more visuals to clarify concepts	10	Strongly agree	Strongly disagree
(Q10) I need more explanation	1	Strongly agree	Strongly disagree
(Q11) There are some lacking details	-6	Strongly agree	Strongly disagree
(Q12) I get distracted by hyperlinks	1	Strongly agree	Strongly disagree

Table 6.2 IDE Summative evaluation - Post-test. Intervention group subjects' responses to the scaled items

Content analysis was performed in order to analyse the data obtained from the comment section of scaled items (Q9, Q10) and from the open-ended item (Q13) (see Table IX.7 in Appendix IX.7). The point of convergence in the subjects' responses in these items was as follows:

- need for more visual examples in the form of graphics and animation, and
- on-line training on multimedia software development.

Table 6.3 demonstrates comparatively the responses from both group subjects on items Q3-Q7 (see Tables IX.7.1 and IX.7.2 in Appendix IX), which were included in both questionnaires, where for ease of reference WWW refers to the intervention group and Class to the control group.

	WWW	Class	(20)	(-20)
The purpose of the lecture was clear	8	11	Strongly agree	Strongly disagree
The information was clearly presented	8	11	Strongly agree	Strongly disagree
I was able to obtain answers easily	2	9	Strongly agree	Strongly disagree
I have a better understanding of the area	15	9	Strongly agree	Strongly disagree
I feel challenged by the instruction	4	-5	Strongly agree	Strongly disagree

Table 6.3IDE, Summative evaluation - Post-test. Both group subjects' responses to the scaled items

Delayed Post-test

The attitude questionnaire that was part of the delayed post-test included ten items, five of them were open-ended (Q1, Q2, Q3, Q4, Q10), and the other five (Q5, Q6, Q7, Q8, Q9) were five-point scaled items from which only item Q9 had a comment option. The items included are as follows:

Q1. What did you like about the application?
Q2. Which are the most important features of the application and why?
Q3. In what ways could the application have done more to help you?
Q4. Would you want to use it again? Please say why or why not
Q5. Did you find this a good way of learning?
Q6. Is the application an effective learning aid?
Q7. Should it be used to support existing lectures?
Q8. Should all modules provide similar support?
Q9. Could it be used instead of the lecture?
Q10. How would the application need to be changed for use by students studying entirely at home?

Table 6.4 demonstrates comparatively the subjects' responses to the five-point scaled items (see Tables IX.8.1 and IX.8.2 in Appendix IX).

	WWW	**Class**	**(20)**	**(-20)**
(Q5) Good way of learning	**8**	**3**	Strongly agree	Strongly disagree
(Q6) Effective learning aid	**10**	**6**	Strongly agree	Strongly disagree
(Q7) Support existing lectures	**14**	**13**	Strongly agree	Strongly disagree
(Q8) Similar support for all modules	**16**	**12**	Strongly agree	Strongly disagree
(Q9) Instead of the physical lecture	**-4**	**-20**	Strongly agree	Strongly disagree

Table 6.4 IDE, Summative evaluation - Delayed post-test. Both group subjects' responses to the scaled items.

Content analysis was performed on the subjects' answers to the open-ended items (see Table IX.8.3 in Appendix IX). The majority of subjects stated that the most important features of the courseware were in order of preference as follows:

- The visual/graphical examples and the game characters, as they are links to other sources of information.
- The fact that the courseware allows the student to learn at his/her own pace.
- The amount of information available.

- The courseware's clear structure.
- The communication channels.
- The on-line assignment which gives students feedback on their learning.

The vast majority also felt that they wanted to use the courseware again because it was visually interesting and provided external links to interactive games design companies' Web sites. However, they stated that they would prefer to use it as support learning material and not as a substitute to the physical lectures because of the lack of physical interaction with fellow colleagues and teacher and also because it could not answer questions immediately in the way that a teacher can do in the physical classroom. The responses to the open-ended item "How would the application need to be changed for use by students studying entirely at home?" showed that the courseware should include a virtual discussion area (chat room) and other computer conferencing facilities, so that tutors and learners can communicate in real time.

Subjects suggestions for improving the courseware are summarized into the following three points:

- More visual examples.
- More in depth information.
- On-line training on multimedia software development.

6.2.3 Implications and Discussion

Similarly to the field test in the formative evaluation discussed in Chapter 5, subjects were observed throughout the whole time they worked with the courseware and they behaved in the same manner as in the field-test; they looked around the courseware, they read the content and examined the examples included, they visited other external links and they interacted with each other physically. No use of the communication channels was reported this time as well.

However, the results from the pre-test and the post-test suggest that the Web-based courseware for IDE, which was designed according to the proposed framework, can effectively deliver the theoretical background of the module, in other words the lectures, and promote learning. First, the results from the learning outcomes showed

that subjects in the intervention group did outperform subjects in the control group in the immediate post-test. Second, the responses on the items addressed to the intervention group subjects indicated a widespread satisfaction with the Web-based courseware. The majority of the subjects agreed that they clearly understood how to use the courseware and that a student could use this courseware easily. They also stated that they were not distracted by hyperlinks, that the examples used in the Web-lecture were enough, and that they did not find any major details lacking. Third, subjects' responses to the immediate post-test attitude questionnaire also indicated that subjects in the intervention group felt they had a better understanding of the area taught, and felt more challenged by the instruction than subjects in the control group.

The difference of degree of understanding and challenge will now be discussed. The total values of the subjects' responses to the item "I now have a better understanding of the area" were 15 for the intervention group and 9 for the control group out of possible 20, which is the maximum value for total agreement, despite the fact that the control group previously demonstrated a higher prior knowledge in the area. Similarly to the item "Did you feel challenged by the instruction?", the total values of the responses were 4 for the intervention group and -5 for the control group, where the maximum value for total disagreement is -20. This result implied that the Web-based instruction was more appealing than the classroom instruction. As subjects stated at the debriefing session that followed the completion of the attitude questionnaire, a reason for this was the novelty of the medium through which the instruction took place. Subjects were accustomed to classroom instruction, however a different kind of instruction appeared more challenging to them. However, they felt that they needed time to adjust themselves to this new technology and this was possibly the reason why they did not use any of the communication channels available.

Nevertheless, subjects from the intervention group suggested some improvements that could be made to the Web-based courseware. Their suggestions focused on the need for more visual examples in the form of graphics, animation and on-line training on multimedia software development. However, the experimental system on which the courseware is based was not designed to provide support the practical side of the module, which is concerned with multimedia software development, as it is not taught

in the physical module but supported by practical tutorials. Moreover, from the early stages of the evaluation procedure, during the preliminary survey and the development of the experimental systems (Stage 2 and 4 of the proposed framework), subjects stated that the major problem they identified in Web-based materials was the lengthy downloading times that result from large data files. However, graphics and animation increase downloading time and therefore it was necessary to compromise in this identified need.

An agreement was observed between both group subjects' responses to the item "The purpose of the lecture was clear" and "The information was clearly presented" with a small difference that favoured the classroom instruction. The difference in degree of agreement between the two groups could be described more specifically as this. The total value of the responses for the intervention group subjects was 8 for both items and for the control group was 11 respectively. However, a major difference in the responses was observed in the item "I was able to obtain answers to questions I did not understand". The total value of the responses of the intervention group was 2, and for the control group 9. The results in this last item indicate that despite the strenuous efforts of the author of the learning materials to give a detailed account of the content and avoid leaving any ambiguities so that students could find most of the answers to their questions in the lecture content, a tutorial session is essential to clarify uncertainties. Virtual tutorials could be used in the case of remote learning through the utilisation of the computer conferencing tools of the Internet.

The fact that the Web-based courseware could not provide answers to questions immediately was the main reason that subjects were unwilling to use the courseware as a substitute for physical lecture as indicated, in the open items of the attitude questionnaire included in the delayed post-test. A content analysis on the responses revealed that the vast majority of the subjects wanted to use the courseware again because it was visually interesting, and it allowed them to learn at their own pace. Also, it offered a range of information in the area of Interactive Digital Entertainment with a clear structure and provided communication channels and feedback through the on-line assignment. However, as mentioned above they stated that they would prefer to use it as support learning material rather than as an exclusive learning resource,

mainly because it could not give immediate answers to their questions and deprived them of the physical presence and interaction between classmates and tutors (see Table IX.8.3 in Appendix IX).

The item "Could it be used instead of the physical lecture?" also had a five scale part where the total value for the intervention group was -4 and for the control group -20. It can be observed here that the intervention group subjects' demonstrated a lesser degree of disagreement (-4) than their counterparts in the control group, who exhibited a total disagreement (-20). This result indicates that the subjects who used the Web-based instruction instead of the physical lecture were more acceptant of the on-line delivery than their counterparts in the control group who were categorically negative. The results of the rest of the scaled items included in the delayed post-test attitude questionnaire also provided useful information. As mentioned in the *Procedure* section of this chapter, after the immediate post-test both groups used the courseware as support material to the physical lectures. Obviously the two groups were not equally exposed to the Web-based courseware, but the comparison of their responses in the attitude questionnaire that formed part of the delayed post-test, provided data on how different uses of the courseware can result in different attitudes towards it. Subjects' responses to the scaled items indicated that subjects in the intervention group favoured the courseware more than their counterparts in the control group. This is clearly illustrated in the Table 6.4. Based on Table 6.4, Figure 6.2 demonstrates the subjects' responses to the scaled items.

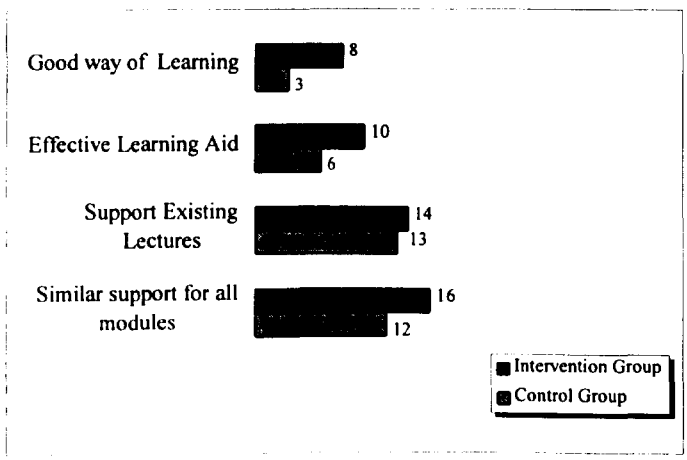


Figure 6.2 IDE, Summative evaluation - Delayed post-test. Both groups subjects' responses to the scaled items.

Based on these results it can be argued that the more time subjects spend with the Web-based courseware the more familiar they become with its function and potential, and more likely they are to favour it and be more positive about its value. It was not possible within the current research to measure resistance to change because such an attempt may require repetitive evaluation sessions for long periods of time with a large number of subjects. However, such efforts would have fallen outside the remit of this study. Nevertheless, this issue is considered for further research in Chapter 7.

6.3 Study Two: Programming and Software Engineering

The purpose of this study was to investigate the effectiveness of the Web-based courseware on Programming and Software Engineering, regarding students' satisfaction and performance. In the first study, this investigation was carried out by comparing the learning outcomes and the learning processes of the intervention and the control group. However, this procedure was not followed in this second study due to the problem of not having an adequate number of subjects to implement a comparative study in the summative evaluation phase. In addition, the subjects in this study, who were the students who studied this module, did not form a homogeneous group. There were three different groups of students as discussed in section 3.3 in Chapter 3. The first group consisted of German students studying MSc in 'Computer Aided Engineering'. The second group consisted of British students studying MSc in 'Software Techniques in Image Processing' at De Montfort University, UK. De Montfort University, UK delivers this MSc, in collaboration with the Fachhoshule Bielefeld, Germany. Finally, the third group consisted of Russian Ph.D. students studying in Moscow's Buaman Technical University, Russia in collaboration with De Montfort University, UK. In all cases the groups were small due to the advanced nature and academic remit of the postgraduate provision being offered. It was therefore statistically unsound to develop a comparative study based on this mixed cohort of students. In addition, each MSc course was different and the Ph.D. students were undertaking research, which was very diverse. In this sense any comparative study in statistical terms would be self-selecting and therefore inconsistent with a true comparative study.

The field test in the formative evaluation, which was followed in the development of the experimental systems described in Chapter 5, was completed in the same mode as in the IDE study. The conditions were more auspicious because at the beginning of the second semester, when the field test took place, the German students who formed the subjects of the field test, were all located in De Montfort University, UK and were willing to participate. However, in the summative phase, which took part at the end of the semester, not all the German students were still located simultaneously in the U.K. Also, the Russian students were not located in UK, but only visited De Montfort University separately for short periods of time. Moreover, the author's efforts to gather the British students together at one time were not successful as these students were preparing their dissertation during the time period that the summative evaluation took place. In order to tackle the problem of not having all the subjects simultaneously in one location it was agreed to test one subject at a time, when it was convenient for them.

Moreover, the Masters' students had completed this module three months before this study took place. Also, the PhD students had to a lesser or greater degree some knowledge of the subject of Programming and Software Engineering. Therefore, in terms of investigating the learning outcomes, the Web-based courseware could be used only as a revision tool, and not as a primary learning resource as in the IDE study.

The possibility of testing each subject twice, once under the intervention condition, and once under the control condition, was investigated. In statistical terms this is called 'matched pair test', and as Klugh (1974) argues if the experimental design permits this, it is the best possible match because each subject serves as his/her own control. However, this idea was relinquished for the following reasons. During the intervention condition subjects would revise using the Web-based courseware, and in the control condition subjects would revise using the paper-based lecture notes. However, in order to provide comparative results the subjects would have to be tested using the same performance test for both conditions, having the same prior knowledge, meaning they would revise the same learning materials. However, this is not possible because during the intervention condition it would be assumed that the subjects have already revised the material using the Web-based courseware and therefore they would proceed in the

control condition with an extended prior knowledge than in the previous condition and vice versa.

Despite these problems, it was agreed to conduct a performance test prior and after the use of the Web-based courseware for two main reasons. Initially, to give the subjects a purpose for using the system, in order to investigate the learning processes, and additionally to verify an increase in understanding. Moreover, through the results of this performance test possible evidence on incidental learning during the information retrieval could be examined. As Jones (1989) points out "browsing, with its decreased cognitive load, might allow more short-term memory and episodic memory resources to be freed for the processing of incidental facts. By emphasising the existing interrelationships among ideas, it would be easier to tie together related webs of information" (p. 235).

6.3.1 Method

Participants

Sixteen subjects age 22-31 years old, who were the postgraduate students in the field of Engineering mentioned previously took part in this study. Fifteen of them were males and one of them was female. Six of them were British, five were Russians and five were Germans. All the users were highly computer literate and they were supportive of the use of new technologies (see Table XI.1 in Appendix XI).

Learning Materials

Units seven, eight and nine on Programming and Software Engineering, were used as the example learning material for the revision. These units covered issues on process specification, program specification, and program design respectively. The Web-based courseware provided the objectives for each of the units, a set of keywords that were hyperlinked to the content provided within the 'Resource', and also visual examples in the form of graphics where needed. In addition subjects were asked to solve a programming exercise in order to investigate if incidental learning occurred. At the subjects' disposal were all the tools embedded in the courseware: the help file, the search engine, the bulletin board, the virtual conferencing tool (DMUMOO), the on-

line compiler, the programming examples with solution hints and test procedures, and also a step-by-step video tutorial on the solution of a programming exercise using FORTRAN-77.

Unfortunately, subjects could not make use of the communication channels during the procedure because as mentioned earlier one subject was observed at a time. Nevertheless, it was felt that an experiment regarding the use of DMUMOO from the subjects of this study was necessary in order to examine the potential of this tool for the three different groups of students who were located in three different countries and would make use of the PSE courseware. Finally, five of the subjects made use of the virtual conferencing room, during an on-line tutorial at a later stage as it will be explained in more detail in the *Learning Processes* section later in this chapter.

Instruments

Two testing instruments were used in this study (see Appendix X). The first was a printed pre-test which consisted of one item with three sections and one programming exercise followed by an open-ended item which was used to determine the subjects' expectation regarding the knowledge or skills they would like to improve during the course of the session. The second instrument was an immediate post-test, which consisted of a performance test with the same items as the pre-test but with a different open-ended item aimed at investigating whether the subjects' met their initial expectations regarding their knowledge or skills improvement at the end of the session. In addition this immediate post-test included an attitude and acceptance questionnaire with both open-ended and five-point scaled items designed to study the subjects' satisfaction and willingness to use the courseware.

Procedure

The procedure was completed in four stages. In the first stage subjects were asked to do the pre-test. Next was the intervention stage, where subjects worked with the Web-based courseware. Before this stage started subjects who were unfamiliar with the Web-based courseware, that is all the subjects who did not participate in the formative phase of the evaluation, received a short introduction to the use of the courseware. In

addition, all subjects were advised to work at their own pace without being given any time limit. When subjects felt that they had covered the units' material sufficiently they proceed to the next stage that was the completion of the immediate post-test. In the final stage, a short debriefing session was carried out with the subjects. Delayed post-test were not used in this study because the subjects were not available.

However, due to the nature of the investigation, where only one subject was observed at a time, the subjects could not make use of the communication channels provided. To tackle this problem an on-line tutorial was carried out after the completion of all the three stages of the procedure, with the lecturer and five of the subjects, who were available, in order to investigate the subjects' attitude towards virtual conferencing.

6.3.2 Results

6.3.2.1 Learning Outcomes

The learning outcomes were investigated in this study by examining the subjects' answers to the items included in the performance test, as well as by comparing subjects' responses to the items designed to investigate their expectations regarding knowledge and skills improvement, prior and after the intervention. These items were included in the pre-test and the post-test respectively and are as follows:

- Pre-test item: "What are you hoping to learn/revise from doing this exercise? Please note down the knowledge or skills you would like to improve during the course of this session".
- Post-test item: "Look back at what you wrote for the pre-test, and note down (a) what you did learn/revise that you had hoped to (b) what you did not learn/revise that you had hoped to, and (c) anything you learnt that was unexpected?".

On average, subjects spent ninety minutes revising the learning material. Table 6.5 presents the means of the pre-test and post-test scores on a scale of one to ten.

	Pre-test	Post-test
Performance Means	6.5625	8.1875

Table 6.5 PSE, Summative Evaluation - Performance means on pre-test and post-test

The results of the performance test indicate that the subjects had a high prior knowledge, something that was expected considering that they had studied this module before this study took place. Moreover, a Pearson correlation coefficient test showed that subjects' prior knowledge scores correlated positively and consistently with their performance in the post test (r=0.55) (see Table XI.2.1 in Appendix XI). Subjects with higher prior knowledge scores, demonstrated a better performance in the post-test, than subjects with lower prior knowledge scores. A difference of 1.6 was observed between the means of pre- and post-test, and also a difference of 1.5 on the median respectively (see Table XI.2.2 in Appendix XI). Therefore, an increase in subjects' performance was observed after the intervention condition.

Furthermore, a content analysis of the subjects' responses to the open-ended item that followed the programming exercise indicated that incidental learning had occurred during the revision. The majority of the subjects stated that they had revised everything that they had hoped. Only two out of the sixteen subjects argued that they had been unable to learn everything they had hoped to. Also, six of the subjects stated that they had learnt other things unexpected as a result of browsing the Web-based courseware (see Table XI.3 in Appendix XI).

6.3.2.2 Learning Processes

The learning processes, that is the ways in which the subjects interacted with the Web-based courseware, were explored through an attitude questionnaire - part of the post-test, and from debriefing sessions with the subjects. The attitude and acceptance questionnaire included items regarding completeness and ease of use of the courseware, and also items on subjects' satisfaction and willingness to use the courseware. It consisted of sixteen items; seven of which were five-point scaled items (Q1, Q2, Q11, Q12, Q13, Q14); five of which were five-point scaled items with a comment option (Q3, Q4, Q5, Q6, Q15); and five of which were open-ended items (Q7, Q8, Q9, Q10, Q16) as listed below:

Q1. Have you understand the directions on: (a) How to use the instructional material, (b) What section to look at next (c) How to operate the application.
Q2. The application is easy to use by every learner.
Q3. The information in the application was clearly presented.

Q4. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding it?
Q5. Are some lacking details in general?
Q6. Do you feel challenged by the instruction?
Q7. What did you like about the application?
Q8. Which are the most useful features of the application and why?
Q9. In what ways could the application have done more to help you?
Q10. Would you want to use it again? Please say why or why not
Q11. Did you find this a good way of learning?
Q12. Is the application an effective learning aid?
Q13. Should it be used to support physical lectures?
Q14. Should all modules provide similar support?
Q15. Could it be used instead of the actual lecture in the classroom?
Q16. How would the application need to be changed for use by students studying entirely at home?

Similar to study one, to analyse the responses of the five-point scaled items, selected values were assigned to each of the answers as shown in Table 5.1 in Chapter 5. The highest values of total agreement and total disagreement were 32 and -32 respectively as 16 subjects participated in this study. Table 6.6 demonstrates the total value of the responses to the five-point scaled items (see Tables XI.4.1, XI.4.2 and XI.4.3 in Appendix XI).

	WWW	(32)	(-32)
1. I know how to work with the application	**25**	Strongly agree	Strongly disagree
2. Any learner can use the application easily	**23**	Strongly agree	Strongly disagree
3. The information is clearly presented	**23**	Strongly agree	Strongly disagree
4. I need more explanation	**-10**	Strongly agree	Strongly disagree
5. There are some lacking details	**-6**	Strongly agree	Strongly disagree
6. I feel challenged by the instruction	**22**	Strongly agree	Strongly disagree
11. Good way of learning	**23**	Strongly agree	Strongly disagree
12. Effective learning aid	**25**	Strongly agree	Strongly disagree
13. Support physical lectures	**27**	Strongly agree	Strongly disagree
14. Similar support for all modules	**24**	Strongly agree	Strongly disagree
15. Instead of the physical lecture	**13**	Strongly agree	Strongly disagree

Table 6.6 PSE, Summative evaluation - Post-test. Total value of responses to the scaled items

Moreover, content analysis was employed to analyse the comments made on the scaled items (Q3, Q4, Q5, Q6, and Q15), and the open-ended items (Q7, Q8, Q9, Q10, and

Q16) (see Table XI.5 in Appendix XI). The subjects' responses were examined further, through debriefing sessions that follow the completion of the post-test. The majority of subjects felt that the most important features of the courseware were in order of preference as follows:

- The simple and clear structure and consequently the user friendliness.
- The navigation toolbar as it was constantly on view, because it made the courseware very easy to follow, allowing the user to easily locate the information needed.
- The video tutorial on the programming exercise solution, because it provided a step-by-step guide on how to solve an exercise.
- The on-line compiler because it provided immediate feedback on the correctness of a programming code without leaving the Web-based courseware.
- The programming examples and especially the solution hints because they provided instructions regarding where to start with a problem and inferentially speed up the solution process.
- The search engine because it speeded up the information retrieval.
- Fast access of information.
- The amount of information available within a single application.
- The fact that the courseware allowed the user to learn at his/her own pace and therefore it allowed students to enhance their understanding without a teacher being present.
- The communication channels because they prevented the user from becoming isolated and disheartened.
- The help file because it provided all the information necessary for a novice user.

The subjects also made suggestions for improving further the courseware which are summarised into the following two points:

- More explanation and solution hints to the problems.
- Inclusion of past exam papers in the courseware.

The vast majority also felt that they wanted to use the courseware again because it allowed them to work at their own pace, it had a very clear and simple structure and also it provides a wide range of examples. The total value of the responses on the item

"Could it be used instead of the physical lecture?" was 13 out of a possible 32, implying that the subjects demonstrated a tendency towards agreement. However, those subjects who did not agree stated that they would prefer to use it as a support to physical lectures because of the lack of physical interaction, and also because students with no or 'negative' experience on programming need regular reassurance (see Table XI.5 in Appendix XI).

Moreover, on the open-ended item "How would the application need to be changed for use by students studying entirely at home?" the majority of the subjects responded that the Web-based courseware needed only to be changed by adding more programming examples. In addition, a one-day introduction session was needed.

It was mentioned earlier that only one subject was observed at a time, and the subjects could not therefore make use of the communication channels. In order to observe subjects' attitude towards the communication provided through the Web-based courseware another experiment was conducted. An on-line tutorial was carried out with the lecturer and the five subjects. The subjects were assigned to solve a programming exercise. During the assignment the subjects 'met' with the lecturer on-line, in the virtual conferencing room provided within the courseware. Throughout that virtual tutorial subjects had the opportunity to ask questions and get answers from the lecturer, as with a physical tutorial. Unfortunately, it was not possible to keep the log file of that conference due to a problem with the server. In the debriefing session that followed this virtual tutorial subjects displayed general satisfaction. They stated that this virtual tutorial could prove to be the most important of all the features included in the courseware because it allowed the students to 'meet' with fellow students and tutor in real time. Therefore, it could help to clarify uncertainties that might occur during the self-study and also it could decrease the feeling of isolation that accompanies self-study and remote learning. However, they agreed that such a mode of study was not absolutely ideal because physical contact is irreplaceable. They would prefer a situation where both traditional and Web-based tuition were available, so that students could have a choice according to their needs.

6.3.3 Implications and Discussion

The results of this study suggest that the Web-based courseware for '*Programming and Software Engineering*', which was designed according to the proposed framework, can be an effective tool to support the delivery of the physical module and promote learning. Moreover, it can form the basis for a stand-alone courseware which can be used for remote learning and also promote the collaboration between educational institutions in different locations.

First, the results from the evaluation of the learning outcomes showed that subjects increased their performance after revising using the Web-based courseware. Also, approximately one third of the subjects recorded the occurrence of unexpected learning in the post-test as a result of browsing the Web-based courseware. Additionally, the responses on the items involved in the attitude questionnaire indicated a widespread satisfaction with the courseware. The vast majority of the subjects agreed that they clearly understood how to use the courseware and that any user could work with the courseware easily. They also stated that the information was clearly presented and that they did not want more explanation in the information provided. Moreover, they did not find any major details lacking and overall they felt challenged by the instruction. Subjects also resolved that the courseware provided a good way of learning; it was an effective learning aid and similar courseware applications should be used to support physical lectures in all modules; also they felt that it could be effective for remote learning. The degree of agreement is demonstrated more clearly in Figure 6.3.

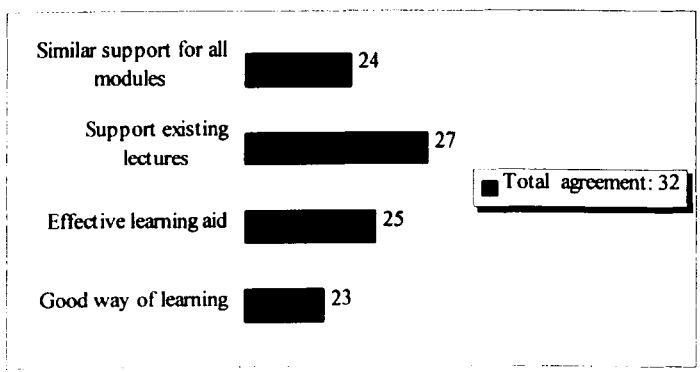


Figure 6.3 PSE, Summative Evaluation - Post-test. Total value of responses to the scaled items

Subjects also stated that they wanted to use the courseware again because it allowed them to work at their own pace and access a great amount of information within a single application in a very short time. It also provided a wide range of programming examples with solution hints and step-by-step tutorial. Moreover, it offered many subsidiary tools such as the search engine, the on-line compiler and the communication channels.

The total value of the subjects' responses to the item "Could it be used instead of physical lectures?" was 13, where the maximum value for total agreement is 32. A tendency towards agreement can be observed in contrast with the IDE study where subjects demonstrated a high degree of disagreement. On the debriefing session that followed the post-test, subjects stated that the reason for this positive attitude was their familiarity with computers resulted from the nature of their studies. These subjects spend much of their studying time on the computer and therefore they felt that if they could refer to information, examples and solutions directly without leaving the workstation they could save valuable studying time. The subjects who disagreed were concerned that such an application would make them work in isolation from others and deprive them of the physical contact experienced in the classroom. However, the subjects who participated in the virtual tutorial felt that it was very important because it allowed them to meet their colleagues and their tutor 'virtually' in real time, which could decrease the feeling of isolation that accompanies self-study.

Nevertheless, the positive attitude towards the Web-based courseware of the subjects in this study fortifies the argument of 'familiarity' that was raised in the 'Implication and Discussion' section of the IDE study. It was observed in the IDE study that the more time subjects spend with the Web-based courseware the more familiar they become with its function and potential and inferentially the more positive they become about its value. Similarly, in this study subjects demonstrated a high degree of satisfaction as a result of their high computer literacy and consequently of their extreme familiarity with computers.

6.4 Overall Findings from the Empirical Studies

The results of the empirical studies showed the potential of Web-based courseware as a viable alternative to the usual instruction and have proved its use as a successful instructional tool. It could gradually replace lectures if supported by physical tutorials. It has to be accepted that in the case of the second study (postgraduate students), the evidence is less clearly defined due to difficulties in data collection. Nevertheless, the results have confirmed the validity of the proposed approach, that is, when a Web-based courseware is designed according the experimental framework, it can effectively support the delivery of physical modules in higher education. It can do so by promoting learning and providing significant improvements in users' performance and satisfaction.

In the IDE study, the results of the learning outcomes evaluation showed that the subjects of the intervention group outperformed the subjects of the control group in the immediate post-test. Similarly, in the PSE study, the results showed that subjects increased their performance after revising using the Web-based courseware. Also, approximately one third of the subjects recorded the occurrence of unexpected learning as a result of browsing the Web-based courseware. Moreover, the subjects in both studies demonstrated a high degree of satisfaction with using the Web-based courseware applications. However, they felt that they would prefer to use the Web-based courseware as support learning material and not as a substitute to the physical lectures because the courseware cannot give immediate answers to their questions and it deprives them of the physical presence and interaction between classmates and tutors.

However, the subjects who participated in the virtual tutorial in the PSE study felt that the virtual tutorials may prove to be the most important feature in a Web-based courseware aimed at supporting remotely located users because it allows students to meet with their tutor and other fellow students in real time regardless of the location. By participating in virtual tutorial students can clarify uncertainties that might occur during the self-study. In addition, virtual tutorials could help decrease the feeling of isolation that accompanies self-study and remote learning. The aim of the Web-based courseware applications was to support university based students, but the results of the

virtual tutorial trial indicated that a Web-based courseware may effectively be used for remote learning due to the nature of the Web's ability to support synchronous and asynchronous communication. Therefore, Web-based courseware which aims to be used for remote learning need to fully exploit all the communication channels of the Internet, such as e-mail, bulletin boards, on-line virtual conferencing and all the other communication tools that the Web provide as discussed in Chapter 2, in order to provide an effective and rewarding learning environment.

Moreover, the results of the empirical studies indicate that the users' satisfaction and acceptance of Web-based courseware is analogous to their computer literacy and their familiarity with Web-based instruction. The results from the delayed-post test in the IDE study indicate that the more time subjects of the intervention group spend with the courseware the more familiar they became with its function and potential and the more they favour it and are positive about its value. This indication was fortified by the results of the PSE study where subjects demonstrated a high degree of satisfaction as a result of their high computer literacy.

Most of all the positive attitude of the subjects towards the Web-based courseware applications and the increase in their performance verified the effectiveness of the proposed framework for designing support learning material for physical modules. It is true that the scale of the study was modest, basically because people do not generally like to participate in experiments and therefore the study had to rely on volunteers both in participating subjects, content providers, and content experts for the necessary evaluation. Nevertheless, it can be argued that through these two empirical studies a significant contribution was made regarding the validity of the framework.

In addition, the overall research proved that the end-users' input is a very important consideration in designing instructional material for two main reasons. First, it verified the effectiveness of the proposed framework, and second it offered a set of additional interface design considerations/guidelines for Web-based courseware, which were derived from the preliminary survey (Stage 2) and the formative evaluation of the applications (Stage 4). Moreover, those guidelines that derived from Stage 4 were tested empirically through the field test evaluation. However, they should be viewed with flexibility and should be applied in the light of content, type of learner and

environment in which the instructional material will be used. The guidelines derived from this research are as follows:

(1) The structure of a Web-based courseware should be as clear and simple as possible and self-explanatory so that a student can use it without external help.
(2) The effective use of a content map and sophisticated search facilities are important to avoid user disorientation and ensure rapid access to any piece of information required. Thus, the main navigation tools should always be on display to increase speed of use and save backtracking.
(3) External links - those that refer to a document elsewhere in the Internet and not within the study material - and communication channels should be opened in a second browser for two main reasons. Firstly to enable students to still view the instructional application, and secondly to allow students to work with the learning material while they are waiting for an external link to download.
(4) Graphical backgrounds within each lecture page should be consistent, but different from other lecture background to help students realise when a link is part of another lecture.
(5) Links to further information at the end of a lecture might be distracting for students because they will attempt to visit them and not concentrate fully on the main content of the lecture.
(6) The effective use of communication channels has the potential to enhance the learning process and should always be included in Web-based courseware aiming to deliver distance learning.
(7) At this stage of technological development complex graphics and video should be used sparingly because current bandwidth limitations results in unacceptable download times for multimedia rich elements which frustrate the learning process.

6.5 Summary

The results of the empirical studies suggest that the framework outlined in this research has positive influences on learning, and thus they confirm the validity of the approach. More specifically a Web-based courseware can effectively support the delivery of physical modules in higher education when it is designed according to the proposed framework. Table 6.7 on the following page demonstrates the different phases that

constitute each of the stages of the proposed framework. Stages 4 and 5 are presented together due to the strong interrelationship between evaluation and revision. In the light of the empirical studies, however, another stage must be added to the framework - Stage 6 - that is concerned with research on how to overcome resistance to change, thus how to embed and implement the Web-based courseware into the curriculum once it has been produced, to ensure success. However, this particular issue and some other issues that have emerged in this research are entitled to further investigation and they will be discussed in the next and final chapter.

Stage 1 Review in the area of instructional design in order to identify design and development considerations potentially applicable in the development of Web-based courseware that aims to support the delivery of physical modules in higher education.	**Phase 1** Instructional theories: Gagné-Briggs theory of instruction **Phase 2** Courseware Design Factors: (a) Structure: Networked Structure suggested by Jonassen (b) Feedback, interactivity, and screen design: empirically tested guidelines found in the literature
Stage 2 Seek of end-users' input through a survey that aims to determine the users' preferences in terms of general Web-based educational design practices.	**Phase 1** Administration of Questionnaire **Phase 2** Analysis of results (Qualitative and Quantitative)
Stage 3 Development of prototype courseware according to the results from Stages 1 and 2.	**Phase 1** Identifying the sections of the courseware (content expert's opinion and end-users' input -questionnaire) **Phase 2** Structuring the sections of the courseware (network structure) **Phase 3** Sequencing of learning materials (lectures, units) hierarchically (Gagné's intellectual skills) **Phase 4** Implementing the prototype (HTML, CGI, graphics software)
Stage 4 Evaluation of prototype with end-users - Formative evaluation. **Stage 5** Revisions based on evaluation results.	**Phase 1** One-to-one evaluation **Phase 2** Analysis (Quantitative/Qualitative) - Revision **Phase 4** Field Evaluation **Phase 5** Analysis (Quantitative/Qualitative) - Revision **Phase 6** Expert Evaluation **Phase 7** Analysis (Quantitative/Qualitative) - Revision

Table 6.7 Stages and Phases of the Proposed Framework

Chapter 7 Conclusion

7.1 Introduction

This last chapter summarises the main achievements of the current research, provides a critical evaluation of the research, and proposes ways to extend the findings from the current work through further research.

7.2 Achievements

The main achievements of the current research address three different areas: designing effective Web-based courseware, instructional design considerations, development and implementation of Web-based courseware.

Designing Effective Web-based Courseware

The recent explosion of Web-based instruction is currently demanding research in the area of the instructional design process. Researchers have started to suggest potential models (James, 1997; Fritts and Krawchuk, 1997). However, there appears to be no instructional design model, which provides empirical evidence regarding its effectiveness in the development of Web-based educational hypermedia, since this medium is so new in education. One of the main achievements of the current research has been the proposal of a framework for the development of effective Web-based courseware which is based largely on the use of knowledge sources in the field of instructional design and the end-users' own input. This framework has been validated empirically through the adaptation of Marchionini's method of evaluating hypermedia-based learning in terms of enabling effective Web-based educational design to support physical modules in higher education.

The results of the empirical studies indicated that the students who studied with the Web-based courseware applications demonstrated an increase in their performance. The results from the performance tests in the IDE study showed that the subjects who participated in the Web-based lecture outperformed the subjects who participated in the classroom lecture. Moreover, in the PSE study the results showed that subjects

increased their performance after revising using the Web-based courseware, and approximately one third of them recorded the occurrence of unexpected learning as a result of browsing the Web-based courseware. Moreover, the subjects in both studies demonstrated a high degree of satisfaction on using the Web-based courseware applications.

Table 7.1 presents the stages of the proposed framework (details of the stages and phases of the framework are presented in Table 6.7 in Chapter 6). However, Stage 6 was not included in the original framework but it was added in light of the empirical studies. The results of the empirical studies indicated that the users' demonstrated a resistance to change from traditional teaching methods to Web-based courseware. Users' satisfaction and acceptance of Web-based courseware were analogous to their computer literacy and their familiarity with Web-based instruction. In light of these results it was felt necessary to add Stage 6 to the framework that is concerned with research into how to overcome resistance to change and how to embed the Web-based courseware into the curriculum once it has been produced, to ensure success. The implementation of Stage 6 was outside the remit of the presented research, however some suggestions are discussed in the '7.4 Further Research' section later in this chapter.

Stage 1	Review of the area of instructional design in order to identify design and development considerations potentially applicable to the development of Web-based courseware that aims to support the delivery of physical modules in higher education.
Stage 2	Acquisition of end-users' input through a survey aimed at determining the users' preferences in terms of general Web-based educational design practices.
Stage 3	Development of prototype courseware based on results from Stages 1 and 2.
Stage 4	Evaluation of prototype with end-users - Formative evaluation.
Stage 5	Revision based on evaluation results from Stage 4.
Stage 6	Embedding Web-based courseware into the curriculum.

Table 7.1 Proposed Framework with Modifications

Instructional Design Considerations

There exists a wide range of resources in the literature regarding design and development factors in the production of computer-based learning in general and hypermedia based courseware in particular. This literature consists of books, journal articles, conferences' proceedings, reports from European and national initiatives, electronic documents on the Web and several databases addressing issues of instructional design such as theories of instruction and courseware design factors that are concerned with hypermedia structure, learner control, feedback, interactivity, and screen design elements. The research presented in this thesis has attempted to bring together many of the available sources of information so that all the different factors meriting consideration in the production of Web-based courseware can be integrated. In that respect it has provided an up to date overview of instructional design considerations in the design and development of Web-based courseware. These instructional design considerations have included instructional theories, with particular emphasis on the Gagné-Briggs theory of instruction, courseware design factors such as structure, learner control, feedback, interactivity, and screen design, and also specific factors that need to be considered particularly in Web design. In addition, during the preliminary survey (Stage 2) and the formative evaluation of the Web-based courseware applications that have been used in the empirical studies, a set of additional interface design guidelines have emerged through the end-users' input. The guidelines derived during the formative evaluation have been tested through the field test evaluation of the experimental design and they are mainly concerned with interface elements (see section 6.4 in Chapter 6).

Development and Implementation of Web-based Courseware.

Despite the fact that the Web-based courseware applications used in this research were designed in order to facilitate the development of the proposed framework, they were highly approved by the end-users and are useful in supporting the delivery of physical modules in Interactive Digital Entertainment and Programming and Software Engineering. In addition, the IDE courseware is currently being used by ten volunteer students studying the module in place of physical lecture. Some of these students chose this mode of study because of conflicts in their timetable with other modules that they were attending. The courseware has been praised highly by these users. All the

students have contributed to the courseware by providing suggestions regarding additional learning material that they found on the Web through the bulletin board and the e-mail facility (see Appendix XII).

De Montfort University is currently implementing an 'electronic campus' where Web-based courseware applications are being developed, aimed at supporting the delivery of physical modules to a large number of students. As part of this initiative four courseware applications are currently being developed in the School of Design and Manufacture using the framework established as a result of the research presented in this thesis.

To summarise, the research presented in this thesis has achieved the following:

(1) It has proposed a framework for the development of Web-based courseware that aimed at supporting the delivery of physical modules in higher education in terms of its design, user input and evaluation. Moreover, it has confirmed the validity of the proposed framework empirically, through the adaptation of Marchionini's method of evaluating hypermedia-based learning.

(2) It offered an up to date overview of instructional design considerations in the design and development of hypermedia-based courseware. In addition it offered a set of empirically tested additional interface design considerations for Web-based courseware.

(3) It has resulted in the development of two Web-based courseware applications, which can be used to support the delivery of physical modules in Interactive Digital Entertainment and Programming and Software Engineering. The URLs for these two Web-based courseware applications are as follows:

IDE - http://severn.dmu.ac.uk/~nick/STILE/IDE/main.HTM

PSE - http://www.cms.dmu.ac.uk/~elisa/STILE/CAE/main.html

7.3 Criticisms and Limitations

One criticism of the research presented in this thesis is that it could have been more complete if the number of subjects participating in the two empirical studies was bigger. As already discussed the studies had to rely on volunteers and this resulted in a modest number of subjects and content experts.

Another criticism relates to the PSE courseware study. As discussed in Chapter 6 the conditions in this study were not suitable to conduct a comparative study between an experimental and a control group mainly because postgraduate students follow a more independent mode of study compared to undergraduate students. However, it is felt that this does not weaken the study because other techniques were used to fill this omission, such as investigating incidental learning from browsing the Web-based courseware and virtual conferencing trial.

In addition, there are some technical weaknesses in the current research. They are likely to be improved by applying appropriate techniques as discussed in the Further Research section. These technical weaknesses are as follows:

(1) Both courseware applications lack a system to track each student's progress, so that a student would be aware at any given time how much of the learning materials s/he had covered and also those that s/he still needed to cover.

(2) In the PSE courseware all the mathematical notations are images (GIF files). The reason for this is that mathematical and other technical notations are not supported by the current version of the HTML language (3.2). However, as will be discussed in the following section a very recent innovation is now available to solve this problem, the MathML.

7.4 Further Research

The issue of further research is twofold. First, it is concerned with elaboration of the existing research, and second with longer term research in order to extend the findings from the current research.

Elaboration of Current Research

If the research could be continued, the first step would be to conduct repetitive evaluation sessions for a full academic year in order to examine two issues. The first concerns the evaluation of two of the five usability parameters identified by Nielsen (1990) on 'few errors' and 'easy to remember' that have not been included in the present research. The evaluation of these two parameters besides the repetitive evaluation sessions possibly requires analysis of the navigation patterns of the users in order to investigate which route users prefer to follow and/or to avoid and why. The second concerns the measurement of resistance to change. It has been argued, based on the evaluation results of the empirical studies, that the more time students spend with the Web-based courseware and the more familiar they become with its function and potential, and the more likely they are to favour it and be positive about its value. However, it was not possible within the current research to measure resistance to change because such an attempt would require repetitive evaluation sessions for long periods of time and on a larger scale. Moreover, there appears to be no methodology regarding ways to measure resistance to change. Present evaluation methods such as attitude and acceptance questionnaires may give some indication but it is believed that this indication is not enough to examine this important issue. Therefore, this issue does not only concern elaboration of the current research, but is also concerned with more general longer-term research in the field of Web instruction.

This kind of research should examine also potential ways on how to embed and implement the Web-based courseware into the curriculum once it has been produced, to ensure success. For example, higher education institutions should provide computer labs dedicated exclusively for resource-based learning and also induction sessions in order to familiarise users with the Web-based courseware. A recent research study in the School of Design and Manufacture, De Montfort University regarding this issue showed that 95% of the computer labs in this School were booked for teaching throughout the academic year. Based on these results the School has decided to try and provide computer labs exclusively for self directed learning so that students can utilise the Web-based courseware applications produced within the 'Electronic Campus' initiative in this School.

Another step would be to implement a system to track each student's progress and to conduct research in order to determine if such a system would be useful. De Bra (1996) from Eindhoven University of Technology, The Netherlands, has developed such a system. This system works as follows: students have to register at the beginning of the course. A CGI program that runs on the Web server, and keeps track of a student's actions delivers all the pages of the course. The student is tracked by supplying pages with the student's identification embedded in the URL (name) of each page. A list of pages that have been read, and pages still to be read, is part of a standard banner, added to every page of the course. A student can therefore easily find out which pages still have to be read, and the generated list also contains active links to these pages.

Finally, another step would be to examine the replacement of the existing GIF files that refer to mathematical notations in the PSE courseware with the Mathematical Markup Language (MathML). In 1997 the World Wide Web Consortium in order to address the demand for effective means of electronic scientific communication has developed a core specification in HTML documents. After one year of study, discussion and experimentation, a working draft entitled MathML is currently available. The MathML provides a way of encoding both mathematical content and visual presentation for mathematics at all levels, from elementary school to scientific research (WWW Consortium, 1998).

Extensions of Current Research

An interesting area for further research is an investigation of end-users' preferences regarding Web instruction in terms of their age, gender, and culture. A recent report from the Higher Education Funding Council for England (April 1996) discusses that in the recent period the students' expansion in higher education has created a diverse student population. In particular, more people are going into higher education later in life; over a third of undergraduate entrants are now over 21 years. In addition, ethnic minorities are now well represented in higher education and also part-time study is an important part of higher education in general, contributing to wider access in particular and is increasing in terms of size and scope. However, it is important to investigate potential ways of accommodating individual differences in terms of age, gender, and culture into the curriculum and in particular to Web-based learning because the Web has

the potential to provide a flexible and adaptive learning environment to accommodate such differences and could be used worldwide.

Another area that merits further investigation is the exploitation of virtual reality techniques in education. The Advisory Group in Computer Graphics has funded such research, concerned particularly with technological issues (Kalawsky, 1996). However, design issues are also very important particularly now that the Web provides the possibility to integrate various media including virtual reality. Research is needed into how to integrate 3D graphics and virtual reality with 2D elements such as text, 2D graphics, audio, and video because virtual reality could provide access to high fidelity computer simulations such as sophisticated laboratory facilities albeit in a virtual environment.

Finally, it is very important to investigate whether and how the proposed framework needs to be adapted for Web-based courseware aimed at addressing distance learning. As mentioned in Chapter 4 Cognitive Flexibility Theory may be seen as a good underlying instructional theory for such courseware applications. However, it is strongly believed that the stages and phases of the proposed framework can provide a detailed starting point for this particular research.

7.5 Summary

The findings from the current research have made a significant contribution to the area of Web-based learning systems design. The work has implications for the research area of instructional design. However, as stated in the discussion, the current work has certain limitations. In order to contribute more to the understanding of Web-based learning the further research areas discussed in this chapter need to be addressed particularly given the potential rapid growth in this area.

General Practices in WWW-based Courseware Development Questionnaire

This questionnaire should take approximately ten minutes of your time to complete. Please respond to all questions by either: (a) entering in the appropriate details; or, (b) ticking the appropriate box.

Personal Details (name not required)

Age (in years)

Gender ❑ **male** ❑ **female**

Nationality

How would you rate your computer literacy?

❑ **Very High** ❑ **High** ❑ **Average** ❑ **Low**

How would you rate your acceptance of and general attitude towards new technologies?

❑ **Very Welcome**
❑ **Welcome**
❑ **Not bothered**
❑ **Resistant**
❑ **Unsupportive**

A: Multimedia Systems in General

A1. What applications do you see multimedia being specifically suited to, list at least three

a) .....

b) .....

c) .....

d) .....

A2. What features distinguish a multimedia application from a more traditional one, list at least three

a) .....

b) .....

c) .....

d) .....

A3. Of the multimedia applications you have seen and used, what problems did you find with them, list at least three

a) .....

b) .....

c) .....

d) .....

A4. What are the main advantages on using the WWW for courseware delivery in Higher Education, list at least three.

a) .....

b) .....

c) .....

d) .....

A5. What are the main disadvantages (if any) on using the WWW for courseware delivery in Higher Education, list at least three

a) .....

b) .....

c) .....

d) .....

A6. If you were to be in charge of the development of a new multimedia application for courseware delivery on the WWW what features would you insist on seeing in it? List at least three

a) .....

b) .....

c) .....

d) .....

B. Multimedia system Users:

Examine the following statements and rate your response appropriately

B1. Multimedia users must be able to follow different routes in an application according to their prior knowledge

strongly agree agree no preference disagree strongly disagree

B2. Multimedia users must be able to add personal notes and bookmarks

strongly agree agree no preference disagree strongly disagree

B3. Multimedia users must be able to print textual and graphical information

strongly agree agree no preference disagree strongly disagree

B4. Multimedia users must be able to copy information to other application

strongly agree agree no preference disagree strongly disagree

C: Media elements

Examine the following statements and rate your response appropriately considering a WWW-based educational multimedia application

C1. The spoken word must replace written text whenever possible

strongly agree agree no preference disagree strongly disagree

C2. Text is the most important media element

strongly agree agree no preference disagree strongly disagree

C3. Any spoken words must also be available as text

strongly agree agree no preference disagree strongly disagree

C4. Hypertext links distract the learner from the main issue

strongly agree agree no preference disagree strongly disagree

C5. Hypertext must be available in any multimedia package

strongly agree agree no preference disagree strongly disagree

C6. The facility to locate information by keywords is essential

strongly agree agree no preference disagree strongly disagree

C7. Graphics must occupy more space on the screen than written text

strongly agree **agree** **no preference** **disagree** **strongly disagree**

C8. A diagram/graphic map of the structure of the multimedia application is essential

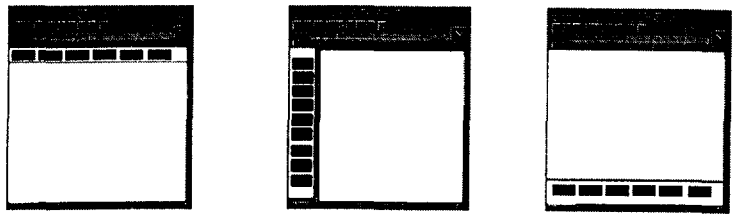
strongly agree **agree** **no preference** **disagree** **strongly disagree**

C9. The navigation tools (i.e. an active map of the application's structure) must be constantly on view

strongly agree **agree** **no preference** **disagree** **strongly disagree**

C10. Which of the following options you identify as appropriate for the navigation tools to be displayed?

(a) ❑ (b) ❑ (c) ❑



(d) no preference ❑

C11. A communication channel, like a bulletin board, and a 'chat' room is an essential feature of any WWW-based multimedia application

strongly agree **agree** **no preference** **disagree** **strongly disagree**

D: Multimedia Design and End-Users

Examine the following statements and rate your response appropriately considering a WWW-based educational multimedia application

D1. It is useful to involve end-users during the design process

strongly agree **agree** **no preference** **disagree** **strongly disagree**

D2. It is useful to involve end-users during all stages of the production process

strongly agree **agree** **no preference** **disagree** **strongly disagree**

D3. End-users opinions are worth seeking

strongly agree **agree** **no preference** **disagree** **strongly disagree**

D4. A multimedia application should be designed according to the end-user's needs

strongly agree **agree** **no preference** **disagree** **strongly disagree**

D5. For what types of learning is an educational multimedia application useful?

.....

.....

.....

D6. For what types of learning is not so useful?

.....

.....

.....

Thank you for your participation and help

Table II.1 Preliminary Survey - Demographics of the Subjects

Subjects	Age	Gender	Nationality	IT Literacy	Acceptance of new technologies
1	28	M	German	High	Welcome
2	26	M	German	High	Welcome
3	30	F	German	High	V. Welcome
4	26	M	German	High	Welcome
5	26	M	German	High	Welcome
6	25	M	Russian	High	Welcome
7	22	M	Russian	High	Welcome
8	25	M	Russian	High	V. Welcome
9	24	M	Russian	High	V. Welcome
10	23	M	Russian	High	V. Welcome
11	32	M	British	High	Welcome
12	28	M	British	High	Welcome
13	24	M	British	High	Welcome
14	23	M	British	High	V. Welcome
15	23	M	British	High	V. Welcome
16	27	M	British	High	V. Welcome
17	22	M	British	Average	V. Welcome
18	24	M	British	Average	Welcome
19	24	M	British	Average	V. Welcome
20	22	F	British	Low	Welcome
21	30	F	British	Average	Welcome
22	23	F	British	Average	Welcome
23	22	F	British	Average	V. Welcome
24	23	M	British	Average	V. Welcome
25	19	M	British	Average	Welcome
26	20	M	British	Average	V. Welcome
27	20	M	British	Average	Welcome
28	24	M	British	Average	V. Welcome
29	21	M	British	Average	V. Welcome
30	22	M	British	Average	Welcome
31	30	F	British	Average	Welcome
32	31	M	British	Average	Welcome
33	21	M	British	Average	V. Welcome
34	25	M	Greek	Average	V. Welcome
35	23	F	Spanish	Average	Welcome
36	23	M	Malaysian	Average	Welcome
	Age	**Gender**	**Nationality**	**IT Literacy**	**Acceptance of new technologies**
	24.5	**M=29**	**British=23**	**Low=1**	**V. Welcome=16**
		F=7	**German=5**	**Average=19**	**Welcome=20**
			Russian=5	**High=16**	**Not bothered=0**
			Greek=1	**Very High=0**	**Resistant=0**
			Spanish=1		**Unsupportive=0**
			Malaysian=1		

Table II.1.1: Preliminary Survey - Content Analysis of Open-ended Items of First Section

A1. What applications do you see multimedia being specifically suited to, list at least three

- Education/Research/Development of Educational Methods
- Education/Further expansion of learning/Research
- Study/Research/Enjoy
- Director/Photoshop
- Background education/Games/Communication
- Teaching/ Entertainment/Information transfer/ /Reference
- Interactive Learning/Simulation/Video Conferencing
- Learning/Self-study/Teaching/Games
- Education/Games
- Communication/Learning/Games
- Games/Virtual Reality
- Education/Leisure/Information
- Education/Business/
- Director/Photoshop
- Education/Entertainment/Information Provision
- Interactive entertainment/Advertising
- Education/Games/Information Systems
- Education/Entertainment/Design – personal and commercial
- Education/Fun/Information
- Teaching/Games/Information Systems
- Learning/Music/Video
- Director/Photoshop
- Education/Entertainment/Retail
- Advertisement/Presentation
- Advertising/Information Gathering/Creating and Performing presentations in business
- Education/Leisure/General reference
- Internet search/Sending information/Leisure activities
- Databases/Games/Communication
- Entertainment/Presentations/Commercials
- Director/Photoshop
- Education/Animation/Games Design
- Games design/Internet Design/Animation
- Presentations/Commercial use
- Broadcasting
- Education/Entertainment/Information
- Director/Photoshop

Frequency of similar words/phrases

Education	21
Entertainment	18
Information/Reference	11
Communication	6
Multimedia Software	6
Commerce/Business	4
Presentation	4
Advertising	3
Design	3

A2. What features distinguish a multimedia application from a more traditional one, list at least three

- Interaction/Accessibility/Tailored to meet individual needs/Maintain greater user interest
- Better communication/Not so boring for the user/can be set up for individuality
- Interaction/Easy to use/Involvement
- Interactive/Access/Combination of multiple media
- More interesting presentations/Higher memory requirements (slow)/Clearer presentation of information
- Pictures/Sound/Fast access to information world wide
- Sound/Interactivity
- Feedback in various forms/Communication in various forms/Sound/Graphics
- Support by animated pictures and audio/Access to huge information databases/Working place is fixed to a computer
- Pictures/Sound clips/Video clips
- Movies/Animation/Interaction
- Interactivity/Sound/3D
- Technology/Range of roots/Interaction
- Interactivity/Hyperlinking/Mixed media
- Multiple digital media/User freedom of exploration/Interaction
- Better presentation of information/More interesting
- Variety of features-options/Ease of use/More capabilities
- Interactive/Animation/Digital sound
- Highly attractive/Simple in use/Multiple ways of giving information simultaneously
- Slower/More redundant information/Sometimes distracting structure
- Interaction/Ease of use/Interesting
- Navigational freedom/Easy access to required part of application/Updated regularly
- Interaction/Video/Sound
- Interaction/Sound and Video/E-mail
- Use of multiple media/Real time communication
- Friendly user interface/Overall interactive functionality/Interactive with other applications
- Visuals/Sound/Animation
- More graphics/More free movement/User can have control of the application
- More options/Sound and graphics
- Interactivity/Combination of visuals and sound/Moving images
- Mixture of multiple media

Frequency of similar words/phrases

Interactivity	16
Sound	11
Tailored to meet individual needs Freedom of exploration	9
Graphics/Visuals	8
Interesting	6
Multiple media	5
Accessibility	5
Friendly user interface	5
Communication	4
Animation	4
Video	3
Higher memory requirements	2

A3. Of the multimedia applications you have seen and used, what problems did you find with them, list at least three

- Slowness of speed/Lack of details/Inflexibility of structure.
- Relatively slow speed/Limited availability/Not friendly for new users.
- Eye strain/Time consuming/Initial familiarity problems.
- Classification/Search facility/Speed.
- Slow/Eye strain/Difficult to refer to different sections to compare them.
- Time consuming/Unclear structures/Not updated regularly
- Lack of support for the less experienced/Level of help
- Find the right information/Respond time to a link could be long/Badly arranged web pages
- Memory problems/Required high specification machine/Not many features
- Not very user friendly for novices/Limited capabilities
- Too slow
- Slow/Boring
- Slow/Bad structure
- Navigation/Colour clash/Finding information
- Complicated to use sometimes/Need a lot of memory
- Sometimes slow/Poor graphics/Not very interactive
- Weak search engines/Overloaded communication/Not clear, logical structure of applications
- It takes a lot of memory/No common standard/Too slow
- Slow/Distracting links/Appearance
- Time consuming
- Usage limited, constrained/Incompatibility between platforms
- Not detailed enough/Takes too much memory/Sound is not clear
- Speed of Internet
- Not clear instructions/Privacy/Slow
- Memory/Cross platform differences
- Not user friendly
- Not enough help
- Very slow in peak hours
- Difficulty to take in
- Not enough help
- Help is not comprehensive enough
- Eye strain from screen if used for a long period/Size of applications (large)

Frequency of similar phrases

Slowness of speed	22
Unclear structure	10
Not user friendly/Level of help	10
Eye strain	3
Lack of efficient search facility	3
Limited availability/capability	3
Not common standards	3
Lack of details	2
Poor graphics/Appearance	2
Not updated regularly	1
Privacy	1
Not clear sound	1
Not very interactive	1
Difficulty to take in	1

A4. Which are the main advantages on using the WWW for courseware delivery in Higher Education, list at least three.

- Greater Audience/Lesson disparities between different institutions/Less teachers, lecturers required/Greater availability of subjects
- Greater understanding of subjects/Easy to find info on specific topics/Accessibility
- Any kind of information/Any time accessibility/Updated information
- Interaction/Communication/You can be anywhere at any time.
- Visually striking presentations/Accessible from anywhere/Neater than carrying lots of papers
- Data access/Data transfer (communication)/Reference
- Good for research/Print option/Huge range of information available
- To be used without being present at a specific place/Remote learning/ Reliable and potentially fast
- Easy to modify/Learn on the same device you work on programming
- Easy access/Freely available
- Able to print out/Work at any time/Involves multiple media
- Home use/You don't miss out if ill or absent/Don't have to write lecture notes
- Endless information/E-mail options/Suits all ages
- Available 24 hours/Easily improved
- No need to tolerate patronising input from lecturers
- Access from home possible/Easier communication with lecturers
- Variety of info available/More enjoyable/Practical experience
- Easily available/Available any time/Visit more than once
- Easy access from anywhere anytime/Advanced means of presenting info/Cost-effective
- Time independent
- Time independent/Location independent/Students can study at their own pace
- Learn how to study alone
- Student can always get to the information instead of relying on a lecture/More enjoyable
- Saves travelling to university/Easily accessible
- Access/Amount of information/Search options
- Access to specific information/Work from anywhere at your own time
- Overnight downloading/Multi-interface set up/International expense of information
- Accessible 24 hours/Allows you to view-learn at your own pace/Allows user feedback without embarrassment
- Study from home
- Good scope of research/People can leave their own opinions/Range of text, pictures and sound
- Easily obtainable and accessible
- Research/Being able to access straight away
- Good research source/Communication/Informative
- Amount of info/Ability to communicate with others
- Can browse at own pace/Access to more detailed info if needed/Visuals and sound adds more interest

Frequency of similar phrases

Independent of time and location	20
Range and amount of information available	14
Accessibility	12
Communication	6
Mix of multiple media	5
Work at own pace	5

More enjoyable way of learning	2
Feedback	2
Cost-effective	2
Up to date information	1

A5. Which are the main disadvantages (if any) on using the WWW for courseware delivery in Higher Education, list at least three

- Decrease in personal contact/Translation problems/Availability of facilities
- Takes too long to download information/Difficulties in students assessments/Lack of physical proximity
- On-line costs/Slow/Not well structured information.
- Transmission speed and quality/Lack of personal contact.
- Problems with servers/Download times/Memory requirements/Need for hard copies
- Speed/Many students-one lecturer
- Speed/Time consuming
- High quality computer hardware is required for excessive use/You can't learn in a group
- Slow/Access/Sometimes hard to find specific info
- Questions can be left unanswered/Not as much interactivity with other students
- Eye strain
- Lack of input from lecturers
- Time consuming
- Lose personal contact/Server problems (too busy)/Sore eyes
- Lack of discussion with live teacher/Absence of control behind the students/Subject to availability of communications/High specification computers required
- WWW is too big/A big choice of any material
- Students are isolated/No communication developed/No teamwork experience
- Time consuming
- Students won't learn note taking skills/Vulnerability of information/Expense (cost and time)
- Network dependent/Slow
- Lack of motivation/False environment/Server delays
- De-humanising the classroom/May get lost in cyberspace
- Speed of on-line access/Operator incompetence
- Information maybe unclear-misleading/Only accessible to those who have the technology required/Video demos are limited due to download time
- Limited access for some people/Slow in peak hours
- No contact with real people/Not being able to ask questions
- Lack of discussion
- Links become distracting/May go through it but no take anything in

Frequency of similar phrases

Speed of on-line access (slow)	18
Lack of physical contact and communication	11
Limited accessibility (to those who have the technology required)	7
Unanswered questions/Lack of discussion	5
Unclear/Misleading information	3
Lack of teamwork experience	3
Rich media's quality (video, audio) is	2

limited	
Too many information	2
Eye strain	2
Distracting links	1
Many students-one lecturer	1

A6. If you were to be in charge of the development of a new multimedia application for courseware delivery on the WWW what features would you insist on seeing in it? List at least three

- Flexibility/Communication between users/Communication between users and academic staff
- More on screen instructions/Faster operation speeds/Flexibility according to user needs.
- Clear structure/User friendliness/User intercommunication.
- Search facility/Clear presentation/Speed
- E-mail contact/Only basic audio and animation requirements/Checking of layout in grey scale
- Keyword search/Feedback/Simple structure
- Speed up the system by making it as simple as possible
- Simple and clear layout/Layout consistency
- Easy to operate/Easy and free access
- Few links to speed up process
- Animation/Strong visuals/Step by step guides
- Ability to register as present for marking purposes/Lecture notes, handouts, briefs
- Graphics/Text/Navigation bar
- Help options/Simple interface/Interesting features
- Module description/Lecture notes, guides/FAQ section or similar
- Advanced search engine/logical structure/Various routes for users with various initial knowledge
- Good logical structure/Platform independent
- Search option
- Graphics/Easy navigation through layout/Appealing to the eye
- User guide/Simplicity of design/Good layout
- Nice and simple explanations/User friendly
- A help page/User guide/Simplicity of design
- Good user interface/Clearly defined operating method/Functionality to first time users
- Feedback facility (2-way)
- Sound/Image/Animation
- Animated examples/Chance for students to leave own opinion
- E-mail help services/Links to similar subjects/A lot of visuals
- Video lecture/Sound/Graphics
- Map of site to aid navigation

Frequency of similar words/phrases

Clear and simple structure to speed up process/Appealing user interface/ User friendly/Functional to novice users	17
Visuals (Graphics, Video, Animation)	9
More on-screen instructions/help	7
Communication channels	6

Search facility	4
Flexibility according to user's needs	2
Navigation map	2
Sound	2
Feedback	2
Ability to register as present for marking purposes	1
Lecture note, handouts, briefs	1
Checking of layout in grey scale	1
Platform independent	1

Table II.2 Preliminary Survey - Subjects' responses to the scaled items of the Second section

Subjects	B1	B2	B3	B4
1	s. agree	s. agree	s. agree	s. agree
2	no preference	agree	s. agree	no preference
3	s. agree	s. agree	no preference	no preference
4	agree	agree	agree	agree
5	agree	agree	s. agree	s. agree
6	agree	agree	agree	agree
7	s. agree	agree	s. agree	s. agree
8	agree	agree	s. agree	s. agree
9	disagree	disagree	agree	agree
10	no preference	no preference	s. agree	s. agree
11	agree	agree	agree	agree
12	agree	s. agree	s. agree	s. agree
13	s. agree	agree	agree	agree
14	s. agree	s. agree	s. agree	s. agree
15	s. agree	s. agree	s. agree	s. agree
16	s. agree	s. agree	s. agree	s. agree
17	agree	no preference	no preference	no preference
18	agree	s. agree	s. agree	s. agree
19	no preference	agree	s. agree	s. agree
20	agree	agree	agree	agree
21	no preference	disagree	s. agree	agree
22	agree	agree	s. agree	agree
23	agree	no preference	agree	agree
24	agree	agree	s. agree	s. agree
25	disagree	no preference	no preference	no preference
26	agree	agree	s. agree	s. agree
27	s. agree	s. agree	s. agree	s. agree
28	no preference	no preference	no preference	no preference
29	s. agree	s. agree	s. agree	s. agree
30	no preference	s. agree	s. agree	s. agree
31	agree	agree	s. agree	s. agree
32	agree	agree	agree	agree
33	agree	agree	s. agree	agree
34	s. agree	s. agree	s. agree	s. agree
35	disagree	agree	s. agree	s. agree
36	agree	s. agree	s. agree	s. agree

Score		Diff. routes according to prior knowledge	Add personal notes and bookmarks	Print textual and graphical information	Copy information to other applications
Strongly Disagree	-2	0	0	0	0
Disagree	-1	3	2	0	0
No Preference	0	6	5	4	5
Agree	1	17	17	8	11
Strongly Agree	2	10	12	24	20
Total score		**34**	**39**	**56**	**51**

Total score: -72=strongly disagree, 72=strongly agree

Table II.3 Preliminary Survey - Subjects' responses to the scaled items of the Third section (a)

Subjects	C1	C2	C3	C4	C5
1	no preference	agree	s. agree	disagree	s. agree
2	agree	no preference	no preference	no preference	agree
3	no preference	no preference	no preference	no preference	no preference
4	no preference	agree	no preference	s. agree	no preference
5	no preference	agree	agree	disagree	no preference
6	no preference	agree	no preference	disagree	agree
7	disagree	agree	agree	disagree	agree
8	disagree	s. agree	agree	disagree	no preference
9	disagree	agree	agree	disagree	agree
10	agree	agree	agree	agree	agree
11	no preference	agree	no preference	disagree	no preference
12	agree	agree	agree	no preference	no preference
13	no preference	agree	no preference	no preference	no preference
14	no preference	agree	agree	no preference	no preference
15	disagree	s. agree	agree	disagree	agree
16	disagree	agree	disagree	disagree	s. agree
17	no preference	agree	disagree	no preference	no preference
18	disagree	s. agree	s. agree	disagree	no preference
19	disagree	agree	agree	no preference	no preference
20	disagree	disagree	agree	no preference	no preference
21	disagree	disagree	no preference	agree	disagree
22	no preference	disagree	agree	agree	disagree
23	disagree	agree	no preference	agree	no preference
24	disagree	agree	s. agree	disagree	agree
25	no preference	disagree	no preference	no preference	no preference
26	s. disagree	agree	s. agree	disagree	s. agree
27	no preference	s. agree	s. agree	agree	disagree
28	disagree	no preference	agree	disagree	no preference
29	no preference	disagree	s. agree	disagree	no preference
30	disagree	agree	agree	agree	agree
31	no preference	agree	agree	agree	no preference
32	disagree	agree	s. agree	disagree	s. agree
33	agree	agree	no preference	no preference	agree
34	s. agree	agree	agree	no preference	agree
35	disagree	s. agree	agree	agree	no preference
36	no preference	s.agree	s. agree	agree	agree

Score		Spoken word must replace text	Text is the most important medium	Spoken words also avaiable as text	Hypertext links distract the user	Hypertext must be available
Strongly Disagree	-2	1	0	0	0	0
Disagree	-1	15	5	2	15	3
No Preference	0	15	3	10	11	18
Agree	1	4	22	16	9	11
Strongly Agree	2	1	5	8	1	4
Total score		**-11**	**27**	**30**	**-4**	**16**

Total score: -72=strongly disagree, 72=strongly agree

Table II.4 Preliminary Survey - Subjects' responses to the scaled items of the Third section (b)

Subjects	C6	C7	C8	C9	C11
1	s. agree	s. agree	s. agree	s. agree	s. agree
2	agree	disagree	agree	no preference	s. agree
3	no preference	no preference	no preference	no preference	no preference
4	s. agree	no preference	no preference	agree	no preference
5	agree	agree	agree	disagree	agree
6	agree	no preference	no preference	agree	agree
7	s. agree	agree	s. agree	agree	agree
8	s. agree	disagree	no preference	disagree	disagree
9	s. agree	disagree	disagree	agree	agree
10	s. agree	no preference	s. agree	s. agree	agree
11	agree	no preference	no preference	agree	agree
12	agree	no preference	agree	agree	agree
13	agree	no preference	agree	agree	no preference
14	s. agree	agree	no preference	s. agree	s. agree
15	no preference	disagree	no preference	agree	no preference
16	s. agree	no preference	agree	disagree	no preference
17	disagree	agree	s. agree	no preference	disagree
18	no preference	disagree	no preference	agree	no preference
19	agree	agree	s. agree	s. agree	agree
20	agree	disagree	agree	disagree	s. agree
21	agree	agree	disagree	no preference	disagree
22	s. agree	disagree	disagree	disagree	s. agree
23	agree	no preference	disagree	agree	disagree
24	agree	no preference	agree	agree	agree
25	disagree	disagree	agree	agree	no preference
26	agree	no preference	no preference	s. agree	s. agree
27	s. agree	s. disagree	agree	agree	agree
28	no preference	no preference	no preference	agree	agree
29	s. agree	agree	agree	agree	agree
30	s. agree	no preference	agree	agree	agree
31	agree	disagree	agree	s. agree	agree
32	agree	disagree	disagree	agree	agree
33	s. agree	disagree	agree	agree	agree
34	agree	agree	agree	agree	s. agree
35	s. agree	no preference	agree	agree	no preference
36	s. agree	s. disagree	disagree	s. agree	agree

Score		Locate info by keywords	More graphics than text	A structure map is essential	Navigation tools constantly on view	Communicati on channels are essential
Strongly Disagree	-2	0	2	0	0	0
Disagree	-1	2	11	6	5	4
No Preference	0	4	14	10	4	8
Agree	1	15	8	15	20	17
Strongly Agree	2	15	1	5	7	7
Total score		**43**	**-5**	**19**	**29**	**27**

Total score: -72=strongly disagree, 72=strongly agree

Table II.4.1 Preliminary Survey - Subjects' responses to the scaled item C10 of the Third section

Subjects	C10
1	left
2	top
3	top
4	left
5	left
6	left
7	top
8	left
9	top
10	bottom
11	top
12	bottom
13	no preference
14	no preference
15	bottom
16	top
17	bottom
18	left
19	left
20	no preference
21	top
22	bottom
23	top
24	no preference
25	no preference
26	bottom
27	no preference
28	bottom
29	no preference
30	bottom
31	left
32	left
33	bottom
34	top
35	no preference
36	no preference

Results	
Top	9
Left	9
Bottom	9
No preference	9

Table II.5 Preliminary Survey - Subjects' responses to the scaled items of the Fourth section

Subjects	D1	D2	D3	D4
1	s. agree	s. agree	s. agree	s. agree
2	agree	no preference	agree	no preference
3	no preference	no preference	no preference	no preference
4	no preference	no preference	agree	s. agree
5	no preference	no preference	agree	agree
6	no preference	no preference	no preference	agree
7	agree	agree	agree	agree
8	agree	no preference	s. agree	s. agree
9	agree	disagree	agree	agree
10	s. agree	s. agree	s. agree	s. agree
11	agree	agree	agree	agree
12	agree	disagree	s. agree	s. agree
13	no preference	no preference	agree	agree
14	s. agree	agree	s. agree	agree
15	agree	agree	agree	agree
16	agree	agree	agree	s. agree
17	agree	agree	no preference	disagree
18	agree	no preference	s. agree	s. agree
19	s. agree	s. agree	disagree	agree
20	agree	disagree	s. agree	agree
21	no preference	agree	agree	agree
22	s. agree	no preference	s. agree	s. agree
23	disagree	no preference	agree	disagree
24	agree	agree	agree	agree
25	no preference	no preference	agree	disagree
26	s. agree	agree	s. agree	s. agree
27	agree	agree	agree	agree
28	no preference	no preference	agree	agree
29	s. agree	s. agree	s. agree	s. agree
30	agree	agree	agree	s. agree
31	s. agree	agree	s. agree	agree
32	s. agree	s. agree	s. agree	s. agree
33	agree	no preference	s. agree	agree
34	s. agree	agree	agree	agree
35	s. agree	agree	agree	s. agree
36	s. agree	agree	s. agree	s. agree

Score		Involve end-users in design process	Involve end-users in production	End-users opinions are worth seeking	Design based on end-users needs
Strongly Disagree	-2	0	0	0	0
Disagree	1	1	3	1	3
No Preference	0	8	13	3	2
Agree	1	15	15	18	17
Strongly Agree	2	12	5	14	14
Total score		**40**	**28**	**47**	**48**

Total score: -72=strongly disagree, 72=strongly agree

Table II.6: Preliminary Survey - Content Analysis of Open-ended Items of Fourth Section

D5. For what types of learning is an educational multimedia application useful?

- Theoretical subjects/Computer based subjects
- Mathematics/Theoretical
- Languages/History/CAD
- General reference
- Self-learning
- For primary/initial learning
- Language learning/Science/Mathematics
- Encyclopaedias
- Reading and writing/Languages/Communication
- Almost all
- Any, as it allows a greater access to a large resource of information
- All
- All types
- All
- Distance Learning/Adult education
- All knowledge based
- Self-learning/Revision for exams
- Research/Revision
- Most
- Almost all
- Projects that require visual aids, and where other opinions can be sought in more detail (links)
- Information seeking
- Open university
- Design/technology
- Where technology and design is involved

Frequency of similar words/phrases

Almost all	7
Reference	4
Maths/Science	3
Theoretical Subjects	2
Design and Technology	2
Revision	2
Remote learning	2
Computer based subjects	1
Self-learning	1
Subjects that require visual aids	1

D6. For what types of learning is not so useful?

- Practical subjects/Discursive courses/Artistic
- Artistic/Practical work
- Painting/Practical studies
- In depth learning
- Physical
- Physical activities/Music

- Scuba diving
- Practical hands on but it can be used alongside development applications
- Physical training
- Primary school
- Creative
- Practical side of learning may require hands on experience
- Detailed learning
- Practical based subjects (dance, speech etc.)
- Physical activities/Crafts
- Complex issues that requires personal discussion
- Creative learning
- Physical activities

Frequency of similar words/phrases

Physical/practical activities	13
Creative/artistic learning	5
Issues that require discussion	2
Detailed learning	2
Primary school	1

Interactive Digital Entertainment (IDE)
Formative Evaluation - Field Test - Pre-test

Leicester, 18th of March 1997

Questions related to the lecture

1. What was the main purpose of this lecture?

2. Which platform has the most IDE titles available for it?

3. Name the key technologies, which are being used in the new generation of IDE platforms

4. What was the name of the 3D shoot'em up which established the IBM PC as a serious computer games platform?

5. Name 3 of the new generation IDE platforms, which are currently successful

6. Give 2 reasons for this success

7. Name three of the new generation IDE platforms, which have failed to be successful

8. Give two reasons for this failure

9. Which IDE platform is likely to dominate in the immediate future and why?

10. What does NC stand for?

Thank you for your valuable help and co-operation.

Interactive Digital Entertainment (IDE)

Formative Evaluation - Field Test - Post-test

Leicester, 18th of March 1997

Underline, tick or fill in blanks where appropriate

General

What is your age?

What is your gender? ❑ **male** ❑ **female**

What is your nationality?

Which term best describes your level of computer literacy?

❑ **novice** ❑ **general user** ❑ **programmer**

The Lecture Itself

1. I understood the directions on:

- How to use the instructional material

strongly agree **agree** **no preference** **disagree** **strongly disagree**

- What section to look at next

strongly agree **agree** **no preference** **disagree** **strongly disagree**

- How to operate the application

strongly agree **agree** **no preference** **disagree** **strongly disagree**

2. The application is easy to use by every learner.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

3. The purpose of the lecture was clear.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

4. The information in the lecture was clearly presented.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

5. I now have a better understanding of this area.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

6. I felt challenged by the instruction.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree and you feel that the instruction was a waste of time will you please explain why in the box below?

7. I want to use it again

strongly agree **agree** **no preference** **disagree** **strongly disagree**

8. Should more examples be used?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

9. Is there any place where a visual or graphic could help clarify what was being said?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, could you please explain further in the box below where visuals or graphics could help?

10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding it?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below:

11. Are some lacking details in general?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below:

12. Do you find helpful that the external links, communication channels, and search engine are loaded in a second browser?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

13. Do you think that graphical backgrounds within each lecture should be consistent but different from other lecture's background?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

14. Do you think that the fact that there are there are no links to further information at the end of each lecture's page help you to concentrate more to the lecture's content?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

15. If you were to be in charge of the development of these particular multimedia lectures what features would you insist on seeing in it and why?

Questions Related to the Lecture (post-test)

1. What was the main purpose of this lecture?

2. Which platform has the most IDE titles available for it?

3. Name the key technologies, which are being used in the new generation of IDE platforms

4. What was the name of the 3D shoot'em up which established the IBM PC as a serious computer games platform?

5. Name 3 of the new generation IDE platforms, which are currently successful

6. Give 2 reasons for this success

7. Name three of the new generation IDE platforms, which have failed to be successful

8. Give two reasons for this failure

9. Which IDE platform is likely to dominate in the immediate future and why?

10. What does NC stand for?

Thank you for your valuable help and co-operation.

IDE Formative Evaluation – Expert Review

The questionnaire should take approximately ten minutes of your time to complete. Please respond to all questions by either: (a) entering in the appropriate details; or, (b) ticking the appropriate box.

Date: .....

Personal Details

Name: .....

Type of Employment

- ❑ **Academic**
- ❑ **Computer Technician**
- ❑ **Programmer**

Details (i.e. senior Lecturer in....): .....

Length in present occupation .....

How would you rate your computer literacy?

❑ **Very High** ❑ **High** ❑ **Average** ❑ **Low**

How would you rate your acceptance of and general attitude towards new technologies?

- ❑ **Very Welcome**
- ❑ **Welcome**
- ❑ **Not bothered**
- ❑ **Resistant**
- ❑ **Very Unsupportive**

<u>On the Application</u>

1. Were the directions clear on?

- How to use the instructional material

very easy **easy** **normal** **difficult** **very difficult**

- How to operate the application

very easy **easy** **normal** **difficult** **very difficult**

2. Was the content current?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

3. Was the content complete?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

4. Was the content accurate?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

5. Could students use this without help?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

6. Would students find the approach interesting?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

7. Will the instruction solve performance problems?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

8. What were the greatest weaknesses of the application?

.....

.....

9. What were the greatest strengths of the application?

.....

.....

10. What do you think about the overall instructional design?

.....

.....

11. If you could add or change one thing, what would it be?

.....

.....

12. Do you feel that the application has comparative value towards more traditional teaching methods?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

13. Would you recommend it to your students? Why or why not?

.....

.....

14. Do you feel that it can produce savings in student learning time?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

15. Do you feel that it can produce savings in staff teaching time?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

16. Do you feel that it can produce savings in other resources?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

Please specify

.....

.....

17. Do you feel that the time spent on it is worthwhile?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

.....

18. Could it be used instead of the actual lecture in the classroom?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

.....

19. Should it be used to support existing teaching methods?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

.....

20. Should all modules provide similar support?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

.....

21. How effective would the existing application be for students working at home?

very effective **effective** **not sure** **not effective**

If you find the application not effective, please explain further

.....

.....

22. How would the application need to be changed for use by students studying entirely at home?

.....

.....

23. Can you think of any further support or improvements that the application should offer?

.....

.....

.....

24. Other comments

.....

.....

.....

Thank you for your valuable help and co-operation.

Table IV.1 IDE – Content analysis of data collected from one-to-one evaluation

DESIGN

+	Choice of text and color Game characters Navigation tool constantly on view Amount of hyperlinks
-	Use of same graphical backgrounds in every lecture Download of external links in main window Hyperlinks at the end of each lecture

COMMUNICATION

+	Bulletin Board (ensure is regularly checked) E-mail
-	Lack of open forum (on-line tutorial, chat room)

OTHER LACKING DETAILS

Help file for novice users Keywords and summary in each lecture More visual examples

SUMMARY OF SUGGESTIONS FOR IMPROVEMENT

Keywords and summary in every lecture More visual examples A help file Downloading of external links in a secondary window within the same browser Different graphical backgrounds in each lecture No hyperlinks at the end of each lecture

SPECIAL CONSIDERATIONS

Download time

Q1. Are you happy with the choice of colors regarding the text?
A1. Yes, the text looks really nice and I find it absolutely readable.
A2. Yes, I am happy with it and what I like better is that the colors in lecture contents are reversed. That makes it more readable (black text in light background).
A3. No problem at all. To be honest you can use all sorts of color, I think that's not really important other than you follow it through each page and you have the same colors associated with the graphics.
Q2. Are the directions on how to use the application clear enough?
A1. It is quite clear. I like that the navigation map is always on display, wherever you are on the page it is always there for you. You don't have to scroll back.

A2. In general is ok. The game characters, as navigation guides is a very good idea.
A3. It is easy to follow. Although I don't particularly like frames I believe that the navigation frame saves you from backtracking.

Q3. What do you think about the presentation of the lectures?
A1. Keep consistent backgrounds but different in each lecture. At the beginning I thought that it is very intensive because I didn't realise that a link inside the lecture I was looking at was part of another lecture.
A2. I think that is fine as it is.
A3. The presentation is fine in general. But I believe that the external links should be opened in another window within the browser because it takes so long to download things that are in Japan or in USA. But don't split the window into two of smaller size. It's better to have a full window to read everything and open a slightly smaller window for the links in the document so that you can flick between a number of windows while you waiting for something to download.

Q4. What do you think about the use of hyperlinks in the lectures?
A1. I never like links. They distract you because when you go on a hyperlink there are other hyperlinks in that so it is distracting. I didn't find it too bad in that material because when you go at the bottom of the page there is no link to other page that you have to go to, the links were only in that page. So it wasn't too bad. What I did I read through all the text and then at the end I didn't see anything though I was expected to, so I went back and tried to work some of the links. I wouldn't like to have something at the bottom of the page that will refer to another one as mostly happen. People would say "Oh! Another page and another page". This is what I find distracting, because basically you have a way forward here, then you go to a link and from that site you have another way forward so you have got the main pages you hyperlinked to other pages and then you say "Oh! I came to the bottom here then I have to go all the way back and reread all that staff again, and a lot of these things actually crosses over. If you go up there and you say "Oh! That is really interesting" and then you jump down here read something, and then you jump down into the middle and then you say "Oh! Hang on a minute I am three pages forward and I haven't read some information. And then it starts to get really confusing. But this doesn't do this, because you can read this page which are the basic information of the lecture and then you don't have links to another page at the bottom but only within the text. So when you finish with the main issues then you start exploring the links within the text.
A2. Links help you to think and learn more because you see and read more. But, I don't like too many links in a page because you get disoriented very easily. I really liked the fact that there were only main links in this material because when you have too many options you don't know what to do and you will not concentrate on reading the basic staff and in that way maybe you skip essential information.
A3. I believe that the amount of links in these pages is really enough. It is possible to lose your path when you have many links, but when I want to go into a particular part of the material then links are important.

Q5. What do you think about the amount of graphics within the application?
A1. Some more visual examples may be needed in the material but if you have too many graphics then you wait ages to download and this really puts you off.
A2. I believe that the more visual examples you have the better because I understand more when I am looking to a picture and also adds interest in the page, but some times it is really annoying when you have to wait ages to see something.
A3. I would add more examples on IDE applications.

Q6. What do you think about the bulletin board?
A1. I think that the bulletin board is a very good idea because it allows users to exchange ideas and information.

A2. It will be popular with students if they know that they can find answers in it.
A3. It is a good idea if it is regularly checked. You have to ensure somehow that it's gonna be used.

Q7. Do you think that you need more communication channels?
A1. No, I think bulletin board and e-mail are fine.
A2. If you are based in the University then the e-mail and the bulletin board are more than enough to communicate, but if you are accessing this application from home then you need more, something like IRC.
A3. No, they are enough if they are regularly checked.

Q8. What you would add in the application?
A1. A help file is needed for novice users that will explain how the application should be used rather than assuming that students already know how to use it.
A2. A brief summary and a set of keywords of what the lecture contains, so that the students can know roughly the content of each lecture.
A3. I would add more examples of IDE applications and more visuals to motivate students. But don't use too much because then you wait ages to download the site and this puts you off.

Q9. Do you think that this application can be used for distance learning?
A1. I think that as a resource is great and I wouldn't do anything more. It's fine as it stands except the corrections I already mention, which I believe that are relatively minor. But for distance learning I believe that it needs lots more, like a chat room and other sources of communication. But to be honest I really don't know if it's gonna work because in real classroom students can present their ideas in front of everybody so they can see how everybody is doing and they compare with what they doing. Also, they might do something that somebody else do, something similar, but they are not gonna copy exactly this idea but they can get some. But if you are sitting in front of a computer and you can't see what everybody else is doing is difficult to see other people's progress. In tutorials you have a group tutorial and you got to show your idea in front of other people, that will be lost. In a distance learning situation you can use something as attached files in the e-mail but it is not the same.
A2. I believe that it is very good as a resource to supplement the real lectures because it gives much more than the lecture notes. But for distance learning the situation is different. It needs to offer more communication between users than the e-mail and the bulletin board. Something like computer conferencing or something similar.
A3. I believe that the situation in distance learning is quite strange. In a way by using this application you can have all the learning material that the university offers but how teachers can know what I am doing, if I do it myself or if somebody else do this for me. Of course in the case of distance learning chat rooms and computer conferencing are really important for communication between students and teachers.

Table IV.2 IDE Field Test - Demographics of the Subjects

Subjects	Age	Gender	Nationality	IT Literate
1	27	M	British	Novice
2	22	F	British	Gen. User
3	20	M	British	Gen. User
4	21	F	British	Gen. User
5	20	M	British	Gen. User
6	20	M	British	Gen. User
7	19	M	British	Gen. User
8	22	M	British	Gen. User
9	20	M	British	Gen. User
10	20	F	British	Gen. User
	Age	**Gender**	**Nationality**	**Analysis**
	21.1	**M=8**	**British=10**	**Novice=1**
		F=3		**Gen. User=9**

Table IV.3.1 IDE Field Test - Performance scores in pre- and post-test and its descriptive statistics

Subjects	Pre-test	Post-test
1	2	6
2	4	7
3	1	6
4	1	6
5	3	8
6	3	8
7	6	8
8	4	6
9	7	10
10	3	7

	Pre-test	Post-test
Mean	3.4	7.2
Standard Error	0.6182412	0.433333333
Median	3	7
Mode	3	7
Standard Deviation	1.9550504	1.370320319
Sample Variance	3.8222222	1.877777778
Kurtosis	-0.093656	2.396224622
Skewness	0.6334221	1.19179149
Range	6	5
Minimum	1	5
Maximum	7	10
Sum	34	69
Count	10	10

Table IV.3.2 IDE Field Test - The matrix of Pearson's *r* between two data sets for the IDE group

	Pre	Post
Pre	1	
Post	0.7856514	1

Table IV.4.1 IDE Field Test - Subjects responses to the scaled items (a)

1a	1b	1c
agree	agree	agree
agree	agree	agree
s. agree	s. agree	s. agree
s. agree	s. agree	s. agree
s. agree	s. agree	s. agree
agree	agree	agree
s. agree	s. agree	s. agree
agree	agree	agree
agree	agree	agree
s. agree	s. agree	s. agree

I understood the directions on:		how to use the instructional material	what section to look at next	how to operate the application
Strongly Agree	2	5	5	5
Agree	1	5	5	5
No Preference	0	0	0	0
Disagree	-1	0	0	0
Strongly Disagree	-2	0	0	0
Total score		**15**	**15**	**15**

Table IV.4.2 IDE Field Test - Subjects responses to the scaled items (b)

Subjects	2	3	4	5
1	agree	s. agree	agree	s. agree
2	agree	s. agree	agree	s. agree
3	s. agree	s. agree	s. agree	s. agree
4	s. agree	agree	s. agree	no preference
5	agree	no preference	no preference	agree
6	agree	agree	agree	agree
7	s. agree	agree	agree	s. agree
8	s. agree	agree	agree	agree
9	s. agree	agree	s. agree	agree
10	agree	agree	s. agree	agree

Score		The application is easy for every learner	The purpose of the lecture was clear	The info was clearly presented	Better understanding of the area.
Strongly Agree	2	5	3	4	4
Agree	1	5	6	5	5
No Preference	0	0	1	1	1
Disagree	-2	0	0	0	0
Strongly Disagree	-1	0	0	0	0
Total score		**15**	**12**	**13**	**13**

Total score: -20=strongly disagree, 20=strongly agree

Table IV.4.3 IDE Field Test - Subjects responses to the scaled items (c)

Subjects	6	7	8	9	10
1	agree	agree	no preference	agree	no preference
2	agree	agree	no preference	no preference	disagree
3	agree	s. agree	agree	agree	no preference
4	agree	agree	agree	agree	no preference
5	no preference	no preference	agree	agree	disagree
6	agree	agree	no preference	s. agree	agree
7	agree	s. agree	agree	agree	no preference
8	agree	agree	no preference	s. agree	no preference
9	agree	agree	agree	s. agree	disagree
10	agree	agree	no preference	agree	disagree

Score		I feel challenged by the instruction	I want to use it again	I need more examples	Need more visuals and graphics to clarify concepts	Need more explanation
Strongly Agree	2	0	2	0	3	0
Agree	1	9	7	5	6	1
No Preference	0	1	1	5	1	5
Disagree	-1	0	0	0	0	4
Strongly Disagree	-2	0	0	0	0	0
Total score		**9**	**11**	**5**	**12**	**-3**

Table IV.4.4 IDE Field Test - Subjects responses to the scaled items (d)

Subjects	11	12	13	14
1	no preference	s.agree	agree	agree
2	disagree	s.agree	agree	s. agree
3	no preference	s.agree	no preference	s. agree
4	no preference	s.agree	agree	s. agree
5	agree	agree	s. agree	agree
6	no preference	s.agree	s. agree	agree
7	no preference	s.agree	agree	no preference
8	disagree	s.agree	s. agree	agree
9	no preference	s.agree	agree	agree
10	disagree	agree	agree	s. agree

Score		In general, there are some lacking details	External links are opened in a second browser	Different backgrounds in each lecture page	No links at the end of the lecture's page
Strongly Agree	2	0	8	3	4
Agree	1	1	2	6	5
No Preference	0	6	0	1	1
Disagree	-1	3	0	0	0
Strongly Disagree	-2	0	0	0	0
Total score		**-2**	**18**	**12**	**13**

Total score: -20=strongly disagree, 20=strongly agree

Table IV.4.5 IDE Field Test - Content analysis of open-ended items

(**Note**: Questions Q9 and Q11 were scaled questions with a comment option)

Q9. Is there a place where a visual or graphic would help clarify what was being said?

- It would help if more graphics were present in instilling in the viewer an idea of some of the concepts described.
- To visualise individual products and theories.
- Where you are explaining about Genres, multiplayer, etc. there is a lot of text to take in. It would probably help if you brake this up with some graphics.
- Examples of software, graphics from games.

Q11. Are some lacking details in general?

- Involve extra illustrations, examples.
- Demonstration examples so as to view for yourselves and tryout.

Q15. If you were to be in charge of the development of these particular multimedia lectures what features would you insist on seeing in it and why?

- Facility to save/print for reference at home.
- Save/print options
- More illustrations and examples.

Frequency of similar phrases

More graphics, examples	7
Save/print facility	3

Programming and Software Engineering
Formative Evaluation
Field Test - Pre-test

Date.....

Time.....

Student.....

Questions

1. Write the decimal number 8.25 in the following form:

- Binary
- Binary Coded Decimal

2. Explain the meaning of:

- Fixed point storage of binary numbers
- Floating point representation of binary numbers

What are the advantages of using a floating point representation?

3. Discuss the different types of errors in computing and also discuss how to reduce errors and maintain accuracy in programming.

Programming and Software Engineering
Formative Evaluation Questionnaire
Field Test - Post-test

Please respond to all questions by either: (a) entering in the appropriate details; or, (b) Ticking the appropriate box.

Personal Details

Name:

Age (in years)

Gender ❑ **male** ❑ **female**

Nationality

How would you rate your computer literacy?

❑ **Very High** ❑ **High** ❑ **Average** ❑ **Low**

How would you rate your acceptance of and general attitude towards new technologies?

❑ **Very Welcome**
❑ **Welcome**
❑ **Not bothered**
❑ **Resistant**
❑ **Very Unsupportive**

The Application

1. I understood the directions on:

- How to use the instructional material

strongly agree **agree** **no preference** **disagree** **strongly disagree**

- What section to look at next

strongly agree **agree** **no preference** **disagree** **strongly disagree**

- How to operate the application

strongly agree **agree** **no preference** **disagree** **strongly disagree**

2. The application is easy to use by every learner.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

3. The purpose of the units was clear.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

4. The information in the unit was clearly presented.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

5. I now have a better understanding of this area.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

6. I felt challenged by the instruction.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree and you feel that the instruction was a waste of time will you please explain why in the box below?

7. I want to use the application again.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

8. Should more examples be used?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

9. Is there any place where a visual or graphic could help clarify what was being said?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, could you please explain further in the box below where visuals or graphics could help?

10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding them?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below:

11. Are some lacking details in general?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below:

12. Do you think that a virtual discussion area (chat room) should be included in the application to facilitate communication between off campus learners and on campus learners and tutors?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

13. Do you find helpful that the external links, communication channels and search engine are opened in a second browser?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

14. Do you find the solution hints useful?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

15. Do you find the graphical map of the application's structure useful?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

16. If you were to be in charge of the development of this application what features would you insist on seeing in it and why?

Post-test Performance Questions

1. Write the decimal number 8.25 in the following form:

- Binary
- Binary Coded Decimal

2. Explain the meaning of:

- Fixed point storage of binary numbers
- Floating point representation of binary numbers

What are the advantages of using a floating point representation?

3. Discuss the different types of errors in computing and also discuss how to reduce errors and maintain accuracy in programming.

PSE Formative Evaluation – Expert Review

The questionnaire should take approximately ten minutes of your time to complete. Please respond to all questions by either: (a) entering in the appropriate details; or, (b) ticking the appropriate box.

Date: .....

Personal Details

Name: .....

Type of Employment

- ❑ **Academic**
- ❑ **Computer Technician**
- ❑ **Programmer**

Details (i.e. senior Lecturer in....): .....

Length in present occupation .....

How would you rate your computer literacy?

❑ **Very High** ❑ **High** ❑ **Average** ❑ **Low**

How would you rate your acceptance of and general attitude towards new technologies?

- ❑ **Very Welcome**
- ❑ **Welcome**
- ❑ **Not bothered**
- ❑ **Resistant**
- ❑ **Very Unsupportive**

<u>On the Application</u>

1. Were the directions clear on?

- How to use the instructional material

very easy **easy** **normal** **difficult** **very difficult**

- How to operate the application

very easy **easy** **normal** **difficult** **very difficult**

2. Was the content current?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

3. Was the content complete?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

4. Was the content accurate?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

5. Could students use this without help?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

6. Would students find the approach interesting?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

7. Will the instruction solve performance problems?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

8. What were the greatest weaknesses of the application?

.....

.....

9. What were the greatest strengths of the application?

.....

.....

10. What do you think about the overall instructional design?

.....

.....

11. If you could add or change one thing, what would it be?

.....

.....

12. Do you feel that the application has comparative value towards more traditional teaching methods?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

13. Would you recommend it to your students? Why or why not?

.....

.....

14. Do you feel that it can produce savings in student learning time?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

15. Do you feel that it can produce savings in staff teaching time?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

16. Do you feel that it can produce savings in other resources?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

Please specify

.....

.....

17. Do you feel that the time spent on it is worthwhile?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree please explain further

.....

.....

.....

18. Could it be used instead of the actual lecture in the classroom?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

.....

19. Should it be used to support existing teaching methods?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

.....

20. Should all modules provide similar support?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain further

.....

.....

.....

21. How effective would the existing application be for students working at home?

very effective **effective** **not sure** **not effective**

If you find the application not effective, please explain further

.....

.....

.....

22. How would the application need to be changed for use by students studying entirely at home?

.....

.....

23. Can you think of any further support or improvements that the application should offer?

.....

.....

.....

24. Other comments

.....

.....

.....

Thank you for your valuable help and co-operation.

Table VI.1 PSE – Content analysis of data collected from one-to-one evaluation

DESIGN

+	Choice of text and color Navigation tool constantly on view Amount of hyperlinks Content hyperlinks in 'electronic book' Graphics Search engine

COMMUNICATION

+	Bulletin Board E-mail
-	Lack of open forum (on-line tutorial, chat room)

OTHER LACKING DETAILS

Help file for novice users Solution 'hints' Structure map of the whole application

SUGGESTIONS FOR IMPROVEMENT

Help file for novice users Solution 'hints' Structure map of the whole application A chat room for virtual conferencing and on-line tutorials

SPECIAL CONSIDERATIONS

No video or audio files due to download time/Close to plain text for fast access

Q1. Do you believe that the Internet is a suitable medium to teach PSE?
A1. Yes, it is a very good idea, because you can work with it any time, night or day, when you cannot attend the lectures.
A2. I think that the Internet is a very good medium for teaching especially computer based courses, because you don't have to switch between books and the screen.
A3. Yes, because you can have everything that you want in one medium, theory, examples, e-mail.

Q2. What do you think about the design of the pages: the text, the graphics, and the layout?
A1. I believe that the presentation is really clear. I like the idea that it is not very 'busy'. The white background is perfect for mathematical equations. I don't think that any other color would do the job better. The diagrams of the programming procedure are very helpful as well.
A2. It is well structured. It's better than to have all the information in paper, this is much faster. Black text in white background is the best choice; it is like the book, no problem in reading the information. I like that the diagrams are in the relevant chapters and not in a separate file like a book appendix.
A3. I like it as it is, black text in white background. It's much easier to read. I don't like some web sites with color or graphical background because you need more time to download them

and sometimes is difficult to read especially when both the text and the background are dark. As about the layout I believe that it is quite clear and well structured. I think that the content list is a useful function because scrolling is not good at all and also it's boring.

Q3. Are the directions on how to use the application clear enough?
A1. It was very easy to use as the on screen commands were very simple and precise.
A2. Yes because of the navigation toolbar. Also, the structure of the application was very clear.
A3. The navigation bar is very useful in finding what you want.

Q4.What do you think about the overall presentation of the content?
A1. I quite like the unit section because if you don't know much about programming you can follow them step by step. It is also good that distinctive colors easily identify each wider section.
A2. The overall layout allows the user to seek a wide variety of information and help.
A3. I like the way that the content lists are set up because they can give you very fast access to the requested information.

Q5. What do you think about the amount of hyperlinks available within the application? Do they distract you?
A1. I wasn't distracted at all from the links because first I don't think that they were too many to become distracting. On the contrary they help you to go through the material faster and that's good.
A2. I believe that hypertext can distract you only when you don't know what you are looking for. If you know what you are looking for they can help you to find it faster.
A3. I didn't find them annoying at all.

Q6. Would you like to have audio or video files?
A1. It is very slow to translate some big files. It is very important for a web site to be fast. Text is best and more important and let you concentrate on the material without being distracted by audio or video.
A2. I don't think that this is a good idea now. You need time to download files like this and most of the times the quality is really low. It adds nothing more than frustration.
A3. No, because first of all you need a very powerful machine to handle such data and not all the students have that. Also, it creates great databases and you need time to download them.

Q7. Which do you think is the biggest advantage of the application?
A1. The search facility is very important because you can gain fast access to the information needed and this save you time. The bulletin board is very important as well because it allows you to leave messages and communicate with all the other students.
A2. I think that the biggest advantage is the examples. They are very useful especially because you can cut, paste, compile the solution and run the program.
A3. The content list and the search facility, anything that can make you save time is of great importance. I also like the step by step presentation, this unit section, because if you know nothing about programming you can follow this for your study.

Q8. What would you add or change in the application?
A1. I would like if the application can have forum discussions to ask questions and to communicate with others. It is good to have things like that because it is not good at all to work alone. A structure map of the whole application would help to avoid disorientation within the great amount of information provided and maybe a help file to explain further all the functions included.
A2. I would change the ready-made solutions in the example section. I would prefer to have some hints on how to solve a problem and not the solution itself, because I would be tempted to

use the solution without trying for myself. Also I would add a help section on how to use the application, what it can offer and how to get the most out of it.
A3. A chat room, to take advantage of what the web can offer in terms of communication. When you communicate with others even through a chat room gives you the possibility to ask questions or just to say hallo and so you don't feel lonely.

Q9. Do you believe that it can substitute the physical lectures?
A1. Not really, because as it is very difficult to learn something just from books, it is difficult to do so just by using the Internet. A combination of lectures and the Internet is more effective.
A2. Some times there is something that you cannot understand which is not a big deal. You can talk to somebody for ten minutes and 'that's it'. Its hard to do it just by reading. The Internet gives you another way of reading, more interesting I admit, but still it's hard to do it just by reading.
A3. It needs more that some examples and text to be a substitute. You need more immediate explanations. You need help from your teacher or the other students. It is not good to learn just from a web site. It is really uncomfortable to read from the screen.

Table VI.2 PSE Field Test Evaluation - Demographics of the Subjects

Subjects	Age	Nationality	Gender	IT Literacy	Acceptance
1	28	German	M	High	Welcome
2	26	German	M	High	Welcome
3	29	German	F	High	V. Welcome
4	26	German	M	High	Welcome
5	26	German	M	High	Welcome

Age	Nationality	Gender	IT Literacy	Acceptance
27	German=5	M=4	High=5	Welcome=4
		F=1		V. Welcome=1

Table VI.3.1 PSE Field Test - Performance scores in pre- and post-test and its descriptive statistics

Subjects	Pre-test	Post-test
1	5	7
2	6	8
3	6	8
4	5	7
5	7	9

	Pre-test	Post-test
Mean	5.8	7.8
Standard Error	0.374165739	0.374165739
Median	6	8
Mode	5	7
Standard Deviation	0.836660027	0.836660027
Sample Variance	0.7	0.7
Kurtosis	-0.612244898	-0.612244898
Skewness	0.512240833	0.512240833
Range	2	2
Minimum	5	7
Maximum	7	9
Sum	29	39
Count	5	5

Table VI.3.2 PSE Field Test - The matrix of Pearson's *r* between two data sets for the PSE group

	Pre-test	Post-test
Pre-test	1	
Post-test	1	1

Table VI.4.1 PSE Field Test - Subjects responses to the scaled items (a)

Subjects	1a	1b	1c
1	agree	agree	agree
2	agree	agree	agree
3	s. agree	s. agree	s. agree
4	agree	agree	agree
5	s. agree	s. agree	s. agree

I understood the directions on:		how to use the instructional material	what section to look at next	how to operate the application
Strongly Agree	2	2	2	2
Agree	1	3	3	3
No Preference	0	0	0	0
Disagree	-1	0	0	0
Strongly Disagree	-2	0	0	0
Total score		7	7	7

Table VI.4.2 PSE Field Test - Subjects responses to the scaled items (b)

Subjects	2	3	4	5	6
1	agree	agree	agree	agree	agree
2	agree	agree	agree	agree	agree
3	agree	agree	no preference	agree	s. agree
4	agree	agree	agree	agree	agree
5	agree	agree	agree	agree	agree

Score		The application is easy for all learners	Purpose of the unit was clear	The information is clearly presented	Better understanding of the area	I feel challenged by the instruction
Strongly Agree	2	0	0	0	0	1
Agree	1	5	5	4	5	4
No Preference	0	0	0	1	0	0
Disagree	-1	0	0	0	0	0
Strongly Disagree	-2	0	0	0	0	0
Total score		5	5	4	5	6

Total score: -10=strongly disagree, 10=strongly agree

Table VI.4.3 PSE Field Test - Subjects responses to the scaled items (c)

Subjects	7	8	9	10
1	agree	disagree	no preference	no preference
2	agree	disagree	agree	agree
3	s. agree	no preferen	disagree	disagree
4	agree	disagree	no preference	no preference
5	agree	disagree	no preference	no preference

Score		I want to use the application again	More examples are needed	More visuals are needed to clarify concepts	Need more explanation
Strongly Agree	2	1	0	0	0
Agree	1	4	0	1	1
No Preference	0	0	1	3	3
Disagree	-1	0	4	1	1
Strongly Disagree	-2	0	0	0	0
Total score		**6**	**-4**	**0**	**0**

Table VI.4.4 PSE Field Test - Subjects responses to the scaled items (d)

Subjects	11	12	13	14	15
1	no preference	s. agree	s. agree	s.agree	s.agree
2	no preference	s. agree	s. agree	s.agree	s.agree
3	no preference	s. agree	s. agree	s.agree	s.agree
4	no preference	s. agree	agree	s.agree	s.agree
5	no preference	s. agree	agree	s.agree	s.agree

Score		Lacking details in general	Chat room for remote learning	Open external links in a second browser	Solution hints	Graphical structure map
Strongly Agree	2	0	5	3	5	5
Agree	1	0	0	2	0	0
No Preference	0	5	0	0	0	0
Disagree	-1	0	0	0	0	0
Strongly Disagree	-2	0	0	0	0	0
Total score		**0**	**10**	**8**	**10**	**10**

Total score: -10=strongly disagree, 10=strongly agree

Table VI.4.5 PSE Field Test - Content Analysis of open-ended Items

Q8. Should more examples be used?

- Maybe more advanced example as well as simple examples, high level usage are good to further reading
- Activities to give feedback to the user would have been useful
- Exercises of various levels
- More detailed hints/clues on solutions

Q10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding them?

- Sometimes more deep explanation of various language features is required, not only the sample. Example: In dynamic memory allocation more broad explanation is required concerning types of heaps and various allocation functions.
- Some comments in the code are necessary. It will be useful to have a link where the problem is described in detail

Q11. Are some lacking details in general?

- I have been unable to find description of memory models (tiny, small, medium, large, huge) and their features. Also, an alphabetical listing of standard functions will be very useful (math, stdio, stdlib, etc.)
- Description of working in Windows OS will be very useful
- Libraries

Q16. If you were to be in charge of the development of these particular application what features would you insist on seeing in it and why?

- Feedback on programming (compiler)
- Compiler

Frequency of similar words/phrases

More content	5
More detailed help in solution process	3
Feedback on programming	2

CGI Script for Search Engine

```
#!/usr/local/bin/perl
##############################################################################
#######
# Simple Search Script                                                       #
##############################################################################
# Define Variables                                                           #

$basedir = '~elisa/public_html/STILE/CAE';
$baseurl = 'http://www.cms.dmu.ac.uk/~elisa/STILE/CAE/';
@files =
('*.html','C++/*.html','Fortran/*.html',
'Module/*.html','Softeng/*.html','opsys/*.html');
$title = "Master in CAE";
$title_url = 'http://www.cms.dmu.ac.uk/~elisa/STILE/CAE/master.html';
$search_url = 'http://www.cms.dmu.ac.uk/~elisa/cgi-bin/search.html';

# Done                                                                       #
##############################################################################
#######

# Parse Form Search Information
&parse_form;

# Get Files To Search Through
&get_files;

# Search the files
&search;

# Print Results of Search
&return_html;


sub parse_form {

   # Get the input
   read(STDIN, $buffer, $ENV{'CONTENT_LENGTH'});

   # Split the name-value pairs
   @pairs = split(/&/, $buffer);

   foreach $pair (@pairs) {
      ($name, $value) = split(/=/, $pair);

      $value =~ tr/+/ /;
      $value =~ s/%([a-fA-F0-9][a-fA-F0-9])/pack("C", hex($1))/eg;

      $FORM{$name} = $value;
   }
}

sub get_files {

   chdir($basedir);
   foreach $file (@files) {
      $ls = `ls $file`;
      @ls = split(/\s+/,$ls);
```

```
        foreach $temp_file (@ls) {
            if (-d $file) {
                $filename = "$file$temp_file";
                if (-T $filename) {
                    push(@FILES,$filename);
                }
            }
            elsif (-T $temp_file) {
                push(@FILES,$temp_file);
            }
        }
    }
}

sub search {

    @terms = split(/\s+/, $FORM{'terms'});

    foreach $FILE (@FILES) {

        open(FILE,"$FILE");
        @LINES = <FILE>;
        close(FILE);

        $string = join(' ',@LINES);
        $string =~ s/\n//g;
        if ($FORM{'boolean'} eq 'AND') {
            foreach $term (@terms) {
                if ($FORM{'case'} eq 'Insensitive') {
                    if (!($string =~ /$term/i)) {
                        $include{$FILE} = 'no';
                    last;
                    }
                    else {
                        $include{$FILE} = 'yes';
                    }
                }
                elsif ($FORM{'case'} eq 'Sensitive') {
                    if (!($string =~ /$term/)) {
                        $include{$FILE} = 'no';
                        last;
                    }
                    else {
                        $include{$FILE} = 'yes';
                    }
                }
            }
        }
        elsif ($FORM{'boolean'} eq 'OR') {
            foreach $term (@terms) {
                if ($FORM{'case'} eq 'Insensitive') {
                    if ($string =~ /$term/i) {
                        $include{$FILE} = 'yes';
                        last;
                    }
                    else {
                        $include{$FILE} = 'no';
                    }
                }
```

```
            elsif ($FORM{'case'} eq 'Sensitive') {
               if ($string =~ /$term/) {
              $include{$FILE} = 'yes';
                  last;
               }
               else {
                  $include{$FILE} = 'no';
               }
            }
         }
      }
      if ($string =~ /<title>(.*)<\/title>/i) {
         $titles{$FILE} = "$1";
      }
      else {
         $titles{$FILE} = "$FILE";
      }
   }
}

sub return_html {
   print "Content-type: text/html\n\n";
   print "<html>\n <head>\n  <title>Results of Search</title>\n
</head>\n";
   print "<body>\n <center>\n  <h1>Results of Search in $title</h1>\n
</center>\n";
   print "Below are the results of your Search in no particular
order:<p><hr size=7 width=75%><p>\n";
   print "<ul>\n";
   foreach $key (keys %include) {
      if ($include{$key} eq 'yes') {
         print "<li><a href=\"$baseurl$key\">$titles{$key}</a>\n";
      }
   }
   print "</ul>\n";
   print "<hr size=7 width=75%>\n";
   print "Search Information:<p>\n";
   print "<ul>\n";
   print "<li><b>Terms:</b> ";
   $i = 0;
   foreach $term (@terms) {
      print "$term";
      $i++;
      if (!($i == @terms)) {
         print ", ";
      }
   }
   print "\n";
   print "<li><b>Boolean Used:</b> $FORM{'boolean'}\n";
   print "<li><b>Case $FORM{'case'}</b>\n";
   print "</ul><br><hr size=7 width=75%><P>\n";
   print "<ul>\n<li><a href=\"$search_url\">Back to Search
Page</a>\n";
   print "<li><a href=\"$title_url\">$title</a>\n";
   print "</ul>\n";
   print "<hr size=7 width=75%>\n";
      print "</body>\n</html>\n";
}
```

CGI Script for Bulletin Board

```
#!/bin/perl
require "cgi-lib.pl";
print &PrintHeader;
&ReadParse(*in);

$HTMLfiles = "/~elisa/public_html/cgi-bin";
$datafiles = "/~elisa/public_html/guestbook";
$name =     $in{'name'};
$email = $in{'email'};
$comments = $in{'comments'};
$outputfile ="$datafiles/bare.htm";
$outputstore ="$datafiles/save.htm";
$redopage = "$HTMLfiles/redo.htm";
$thankyoupage ="$HTMLfiles/thanks.htm";
if ($name eq "") {
      &redo;
      exit; }
if ($comments eq "") {
      &redo;
      exit; }
&addbook;
&writefile;
sub redo {
      open(REDOPAGE,$redopage) || die "cannot open $redopage for
reading";
      while (<REDOPAGE>) {
            print $_;
                        }
      close(REDOPAGE);
      }
sub addbook {
      open(THANKYOUPAGE,$thankyoupage) || die "cannot open
$thankyoupage for reading";
      while (<THANKYOUPAGE>) {
      print $_;
      }
      close(THANKYOUPAGE);
}
sub writefile {
      open(STOREFILE,">$outputstore") || die "cannot create
$outputstore";
      open(OLDFILE,$outputfile) || die "cannot open $outputfile for
reading";
        while (<OLDFILE>) {
        print STOREFILE $_;
      }
      close(OLDFILE);
      close(STOREFILE);
      open(NEWFILE,">$outputfile") || die "cannot create $outputfile";
      print NEWFILE<<stuff;
<HTML>
<HEAD>
<TITLE>Bulletin Board</TITLE>
</HEAD>
<BODY BGCOLOR="#FFFFFF" link="green">
<H1>Bulletin Board</H1>
<P>
```

```
<HR>
<B>Name: </B>$name<BR>
<B>E-mail: </B><A HREF=\"mailto:$email\">$email</A><BR>

<B>Comments: </B>$comments
stuff
      open(SAVEFILE,$outputstore) || die "cannot open $outputstore for
reading";
      $num = 0;
      while (<SAVEFILE>) {
            if ($num >= 7) {
            print NEWFILE $_;
            }
            ++$num;
      }
      close(SAVEFILE);
      close(NEWFILE);
      unlink($outputstore);
}
```

SGI Script for On-line Assignment

```
#!/usr/local/bin/perl

use English;
require "cgi-lib.pl";
&ReadParse(*input);

print "Content-type: text/html\n\n";

{
print <<EOF
<HTML>
<HEAD>
<TITLE>Result</TITLE>
</HEAD>
<BODY>
EOF
}

print "Operation = $input{'Operation'}<BR>\n";
print "Name = $input{'name'}<BR>\n";
print "This is your program:<BR>\n";
print "<HR>\n";
print "<PRE>\n";
print "$input{'other'}\n";
print "</PRE>\n";
print "<HR>\n";

if ($input{'Operation'} eq 'COMPILE')
{
  print "This is the result of the compilation:<BR>\n";
  print "<HR>\n";
  print "<PRE>\n";
  # put the program into a temporary file
  $source = "/tmp/perlprog.$PID.c";
  open (OUT, ">$source");
  print OUT "$input{'other'}";
  close(OUT);

  open (PERL, "cc  -o /dev/null $source 2>&1 |");

  $n=0;
  while (<PERL>)
  {
    print $_;
    $n++;
  }
  if ($n eq 0)
  {
    print "It compiled fine!\n";
  }
  close(PERL);
  print "</PRE>\n";
  print "<HR>\n";
}

if ($input{'Operation'} eq 'RUN')
```

```
  {
    print "This is the result of the compilation:<BR>\n";
    print "<HR>\n";
    print "<PRE>\n";
    # put the program into a temporary file
    $source = "/tmp/perlprog.$PID.c";
    $output = "/tmp/program.$PID";
    open (OUT, ">$source");
    print OUT "$input{'other'}";
    close(OUT);

    open (COMPILE, "cc  -o $output $source 2>&1 |");

    $n=0;
    while (<COMPILE>)
    {
      print $_;
      $n++;
    }
    if ($n eq 0)
    {
      print "It compiled fine!\n";
    }
    close(COMPILE);
    print "</PRE>\n";
    print "<HR>\n";

    print "This is the output from you program:<BR>\n";

    open (RUN, "$output 2>&1 |");
    print "<HR>\n";
    print "<PRE>\n";
    while (<RUN>)
    {
      print $_;
    }
    close(RUN);
    print "</PRE>\n";
    print "<HR>\n";
  }

  if ($input{'Operation'} eq 'SUBMIT')
  {
    $source = "/tmp/perlprog.$PID.c";
    open (OUT, ">$source");
    print OUT "Subject: Source code for assignment\n";
    print OUT "$input{'other'}";
    close(OUT);

    $memail="eg11\@dmu.ac.uk";
    system("mail $memail < $source");
  }

  {
  print <<EOF2
  </BODY>
  </HTML>
  EOF2
  }
```

Multimedia for Interactive Digital Entertainment (IDE)

Summative Phase – Pre-test

Leicester, 3rd of May 1997

1. What is the name given to the animated bitmapped character used in traditional 2D videogames?

2. Name 2 games consoles with dedicated 3D technology.

3. Name two 3D modelling and animation packages used to create 3D game environments.

4. Is DOOM a 1st or 3rd person 3D video game?

5. What is a polygon?

6. Typically how many frames per second does a game console need to render/produce to achieve continuous motion?

7. The rendering capacity of a Sony Playstation in polygons per frame is approximately:

100 500 3,000 15,000 350,000

8. Apart from building a 3D model from scratch using 3D modelling tools what other method can be used to produce such a model?

9. What is the technical term for the user defined skeleton in 3D-character animation called?

10. Name a 3D game employing motion capture technology.

Thank you for your valuable help and co-operation.

Interactive Digital Entertainment (IDE)

Summative Phase, Post-test – Control Group

Leicester, 3rd of May 1997

Underline, tick or fill in blanks where appropriate

General

Which lecture did you take part in? ❑ **physical** ❑ **web lecture**

What is your age?

What is your gender? ❑ **male** ❑ **female**

What is your nationality?

Which term best describes your level of computer literacy?

❑ **novice** ❑ **general user** ❑ **programmer**

The Lecture Itself

1. The purpose of the lecture was clear.

strongly agree **agree** **not sure** **disagree** **strongly disagree**

2. The information in the lecture was clearly presented.

strongly agree **agree** **not sure** **disagree** **strongly disagree**

3. I was able to easily obtain answers to questions I did not understand.

strongly agree **agree** **not sure** **disagree** **strongly disagree**

4. I now have a better understanding of this area.

strongly agree **agree** **not sure** **disagree** **strongly disagree**

5. Do you feel challenged by the instruction as a whole?

strongly agree **agree** **not sure** **disagree** **strongly disagree**

If you disagree and you feel that the instruction was a waste of time will you please explain why in the box below?

Questions Related to the Lecture (post-test)

1. What is the name given to the animated bitmapped character used in traditional 2D videogames?

2. Name 2 games consoles with dedicated 3D technology.

3. Name two 3D modelling and animation packages used to create 3D game environments.

4. Is DOOM a 1st or 3rd person 3D video game?

5. What is a polygon?

6. Typically how many frames per second does a game console need to render/produce to achieve continuous motion?

7. The rendering capacity of a Sony Playstation in polygons per frame is approximately:

100 500 3,000 15,000 350,000

8. Apart from building a 3D model from scratch using 3D modelling tools what other method can be used to produce such a model?

9. What is the technical term for the user defined skeleton in 3D-character animation called?

10. Name a 3D game employing motion capture technology.

Thank you for your valuable help and co-operation.

Interactive Digital Entertainment (IDE)
Summative Phase, Post-test – Intervention Group

Leicester, 3rd of May 1997

Underline, tick or fill in blanks where appropriate

General

Which lecture did you take part in? ❑ **physical** ❑ **web lecture**

What is your age?

What is your gender? ❑ **male** ❑ **female**

What is your nationality?

Which term best describes your level of computer literacy?

❑ **novice** ❑ **general user** ❑ **programmer**

The Lecture Itself

1. Have you understand the directions on:

- How to use the instructional material

very easy **easy** **normal** **difficult** **very difficult**

- What section to look at next

very easy **easy** **normal** **difficult** **very difficult**

- How to operate the application

very easy **easy** **normal** **difficult** **very difficult**

2. The application is easy to use by every learner.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

3. The purpose of the lecture was clear.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

4. The information in the lecture was clearly presented.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

5. I was able to easily obtain answers to questions I did not understand.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

6. I now have a better understanding of this area.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

7. Do you feel challenged by the instruction as a whole?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree and you feel that the instruction was a waste of time will you please explain why in the box below?

8. Should more examples be used?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

9.Is there any place where a visual or graphic could help clarify what was being said?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, could you please explain further in the box below where visuals or graphics could help?

10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding it?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below:

11. Are some lacking details in general?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below:

12. Do you feel that hypertext links distract you from the main issues?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

13. If you were to be in charge of the development of these particular multimedia lectures what features would you insist on seeing in it and why? List at least three.

Questions Related to the Lecture (post-test)

1. What is the name given to the animated bitmapped character used in traditional 2D videogames?

2. Name 2 games consoles with dedicated 3D technology.

3. Name two 3D modelling and animation packages used to create 3D game environments.

4. Is DOOM a 1st or 3rd person 3D video game?

5. What is a polygon?

6. Typically, how many frames per second does a game console need to render/produce to achieve continuous motion?

7. The rendering capacity of a Sony Playstation in polygons per frame is approximately:

100 500 3,000 15,000 350,000

8. Apart from building a 3D model from scratch using 3D modelling tools what other method can be used to produce such a model.

9. What is the technical term for the user defined skeleton in 3D-character animation called?

10. Name a 3D game employing motion capture technology.

Thank you for your valuable help and co-operation.

Interactive Digital Entertainment (IDE)

Summative Phase – Delayed Post-test

Leicester, 28th of May 1997

Underline, tick or fill in blanks where appropriate

General

What is your age?

What is your gender? ❑ **male** ❑ **female**

What is your nationality?

Which term best describes your level of computer literacy?

❑ **novice** ❑ **general user** ❑ **programmer**

Did you take part in the WWW based lecture? ❑ **yes** ❑ **no**

On the application

1. What did you like about the application?

2. Which are the most important features of the application and why?

3. In what ways could the application have done more to help you?

4. Would you want to use it again? Please say why or why not

5. Did you find this a good way of learning?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

6. Is the application an effective learning aid?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

7. Should it be used to support existing lectures?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

8. Should all modules provide similar support?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

9. Could it be used instead of the lecture?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain why in the box below:

10. How would the application need to be changed for use by students studying entirely at home?

Questions Related to the Lecture

1. What is the name given to the animated bitmapped character used in traditional 2D videogames?

2. Name 2 games consoles with dedicated 3D technology.

3. Name two 3D modelling and animation packages used to create 3D game environments.

4. Is DOOM a 1st or 3rd person 3D video game?

5. What is a polygon?

6. Typically how many frames per second does a game console need to render/produce to achieve continuous motion?

7. The rendering capacity of a Sony Playstation in polygons per frame is approximately:

100 500 3,000 15,000 350,000

8. Apart from building a 3D model from scratch using 3D modelling tools what other method can be used to produce such a model?

9. What is the technical term for the user defined skeleton in 3D-character animation called?

10. Name a 3D game employing motion capture technology.

Thank you for your valuable help and co-operation.

Table IX.1.1 IDE Summative Evaluation - Demographics of control group subjects

Subjects	Age	Gender	Nationality	IT Literate
1	22	M	British	Novice
2	23	M	British	Programmer
3	21	M	British	Gen. User
4	31	M	British	Programmer
5	21	M	British	Programmer
6	21	M	British	Gen. User
7	24	M	British	Gen. User
8	24	F	British	Gen. User
9	22	F	British	Gen. User
10	28	M	British	Gen. User

Age	Gender	Nationality	IT Literate
23.7	**M=8**	**British=10**	**Novice=1**
	F=2		**Programmer=3**
			Gen. User=6

Table IX.1.2 IDE Summative Evaluation - Demographics of intervention group subjects

Subjects	Age	Gender	Nationality	IT Literate
1	23	M	British	Gen. User
2	23	M	British	Gen. User
3	23	M	Malaysian	Gen. User
4	24	M	Greek	Gen. User
5	20	M	British	Gen. User
6	23	M	British	Gen. User
7	21	M	British	Gen. User
8	30	F	British	Gen. User
9	24	F	British	Gen. User
10	20	F	Spanish	Gen. User

Age	Gender	Nationality	IT Literate
23.1	**M=6**	**Malaysian=1**	**Gen. User=10**
	F=4	**Greek=1**	
		British=7	
		Spanish=1	

Table IX.2.1 Two-sample t-Test assuming equal variances on the pre-test scores of both groups

Subjects	CPre-Test	IPre-Test
1	3.5	3
2	5	2
3	4	3
4	7	0
5	5.5	5
6	7	5
7	5	5
8	4	5
9	4.5	3
10	6.5	1

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	5.2	3.2
Variance	1.6222222	3.2888889
Observations	10	10
Pooled Variance	2.4555556	
Hypothesized Mean Difference	0	
df	18	
t Stat	2.853909	
P(T<=t) one-tail	0.0052713	
t Critical one-tail	1.7340631	
P(T<=t) two-tail	**0.0105427**	
t Critical two-tail	2.1009237	

Table IX.2.2 Two-sample t-Test assuming equal variances on the post-test scores of both groups

Subjects	CPost-Test	Post-Test
1	8	6.5
2	8	7.5
3	6	7
4	8	4
5	8	8
6	8	8
7	7	8
8	6	8
9	5.5	7
10	7.5	5

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	7.2	6.9
Variance	1.0111111	1.9333333
Observations	10	10
Pooled Variance	1.4722222	
Hypothesized Mean	0	
df	18	
t Stat	0.5528656	
P(T<=t) one-tail	0.2935783	
t Critical one-tail	1.7340631	
P(T<=t) two-tail	**0.5871566**	
t Critical two-tail	2.1009237	

Table IX.2.3 Two-sample t-Test assuming equal variances on the delayed post-test scores of both group

Subjects	CDelay	IDelay
1	7	7
2	8	7
3	5	7
4	7	3
5	7	8
6	7	8
7	7	7
8	5	7
9	5	7
10	7	4

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	6.5	6.5
Variance	1.1666667	2.7222222
Observations	10	10
Pooled Variance	1.9444444	
Hypothesized Mean Difference	0	
df	18	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.7340631	
P(T<=t) two-tail	1	
t Critical two-tail	2.1009237	

Table IX.3.1 Data regarding learning outcomes from the Intervention Group and its descriptive statistics

Intervention	Pre-Test	Post-Test	Delay
1	3	6.5	7
2	2	7.5	7
3	3	7	7
4	0	4	3
5	5	8	8
6	5	8	8
7	5	8	7
8	5	8	7
9	3	7	7
10	1	5	4

Mean	3.2	6.9	6.5
Standard Error	0.5734884	0.4396969	0.5217492
Median	3	7.25	7
Mode	5	8	7
Standard Deviation	1.8135294	1.3904436	1.6499158
Sample Variance	3.2888889	1.9333333	2.7222222
Kurtosis	-0.861682	0.9026244	1.5400726
Skewness	-0.508565	-1.331441	-1.577075
Range	5	4	5
Minimum	0	4	3
Maximum	5	8	8
Sum	32	69	65
Count	10	10	10

Table IX.3.2 Data regarding learning outcomes from the Control Group and its descriptive statistics

Control	Pre-Test	Post-Test	Delay
1	3.5	8	7
2	5	8	8
3	4	6	5
4	7	8	7
5	5.5	8	7
6	7	8	7
7	5	7	7
8	4	6	5
9	4.5	5.5	5
10	6.5	7.5	7

Mean	5.2	7.2	6.5
Standard Er	0.4027682	0.3179797	0.341565
Median	5	7.75	7
Mode	5	8	7
Standard D	1.2736649	1.0055402	1.0801234
Sample Var	1.6222222	1.0111111	1.1666667
Kurtosis	-1.303674	-1.231606	-1.03207
Skewness	0.346858	-0.790948	-0.6613
Range	3.5	2.5	3
Minimum	3.5	5.5	5
Maximum	7	8	8
Sum	52	72	65
Count	10	10	10

Control	Pre-Test	Post-Test	Delay
1	3.5	8	7
2	5	8	8
3	4	6	5
4	7	8	7
5	5.5	8	7
6	7	8	7
7	5	7	7
8	4	6	5
9	4.5	5.5	5
10	6.5	7.5	7

Table IX.4.1 The matrix of Pearson's *r* between pre- post- and delayed post-test for the Control Group

Pearsons Correlation Coefficients (r)			
	Pre	Post	Delay
Pre	1		
Post	0.5292157	1	
Delay	0.4845964	0.9207191	1

Intervention	Pre-Test	Post-Test	Delay
1	3	6.5	7
2	2	7.5	7
3	3	7	7
4	0	4	3
5	5	8	8
6	5	8	8
7	5	8	7
8	5	8	7
9	3	7	7
10	1	5	4

Table IX.4.2 The matrix of Pearson's *r* between pre-, post-, and delayed post-test for the Intervention Group

Pearsons Correlation Coefficients (r)			
	Pre	Post	Delay
Pre	1		
Post	0.9121156	1	
Delay	0.8540808	0.9444456	1

Table IX.5.1 ***t-Test*** **on performance scores differences between immediate post-test and pre-test**

Control	Class Post(-)Pre Test Difference	Web Post(-)Pre Test Difference
1	4.5	3.5
2	3	5.5
3	2	4
4	1	4
5	2.5	3
6	1	3
7	2	3
8	2	3
9	1	4
10	1	4

t-Test: Two-Sample Assuming Equal Variances

	Control	*Intervention*
Mean	2	3.7
Variance	1.277777778	0.622222222
Observations	10	10
Pooled Variance	0.95	
Hypothesized Mean Difference	0	
df	18	
t Stat	-3.900067476	
P(T<=t) one-tail	0.000524629	
t Critical one-tail	1.734063062	
P(T<=t) two-tail	0.001049259	
t Critical two-tail	2.100923666	

Table IX.5.2 *t-Test* on performance scores differences between delayed and immediate post-test

Subjects	Class Delay(-)Post Test Difference	Web Delay(-)Post Difference
1	-1	0.5
2	0	-0.5
3	-1	0
4	-1	-1
5	-1	0
6	-1	0
7	0	-1
8	-1	-1
9	-0.5	0
10	-0.5	-1

t-Test: Two-Sample Assuming Equal Variances

	Control	*Intervention*
Mean	-0.7	-0.4
Variance	0.177777778	0.322222222
Observations	10	10
Pooled Variance	0.25	
Hypothesized Mean Difference	0	
df	18	
t Stat	-1.341640786	
P(T<=t) one-tail	0.098197236	
t Critical one-tail	1.734063062	
P(T<=t) two-tail	0.196394472	
t Critical two-tail	2.100923666	

Table IX.6.1 IDE - Post-test. Intervention Group - Responses to the scaled items (a)

Subjects	1a	1b	1c	2
1	not sure	not sure	not sure	agree
2	agree	agree	agree	agree
3	agree	agree	s. agree	agree
4	not sure	s. agree	agree	agree
5	agree	not sure	agree	disagree
6	s. agree	agree	not sure	agree
7	not sure	agree	agree	agree
8	not sure	not sure	not sure	agree
9	s. agree	s. agree	s. agree	disagree
10	agree	agree	agree	agree

I understood the directions on:		how to use the instructional material	what section to look at next	how to operate the application	The application is easy for every learner
Strongly Agree	2	2	2	2	0
Agree	1	5	5	5	8
Not sure	0	3	3	3	0
Disagree	-2	0	0	0	2
Strongly Disagree	-1	0	0	0	0
Total score		**9**	**9**	**9**	**6**

Table IX.6.2 IDE - Post-test. Intervention Group - Responses to the scaled items (b)

Subjects	8	9	10	11	12
1	agree	disagree	agree	not sure	disagree
2	disagree	disagree	disagree	disagree	not sure
3	s. agree	s. agree	not sure	not sure	disagree
4	s. agree	s. agree	not sure	not sure	s. agree
5	not sure	agree	not sure	disagree	disagree
6	s. agree	s. agree	s. agree	disagree	disagree
7	s. agree	disagree	disagree	disagree	disagree
8	disagree	s. agree	disagree	disagree	agree
9	s. agree	s. agree	agree	disagree	s. agree
10	s. agree	s. agree	not sure	not sure	agree

Score		The examples were enough	Need more visuals and graphics to clarify	Need more explanation	Lacking details	Hypertext links distract from main issues
Strongly Agree	2	6	6	1	0	2
Agree	1	1	1	2	0	2
Not Sure	0	1	0	4	4	1
Disagree	-1	2	3	3	6	5
Strongly Disagree	-2	0	0	0	0	0
Total score		**11**	**10**	**1**	**-6**	**1**

Total score: -20=strongly disagree, 20=strongly agree

Table IX.7 IDE Summative Evaluation, Intervention Group. Content analysis of open-ended items

(**Note**: Items Q9 and Q10 were scaled items with a comment option)

Q9. Is there any place where a visual or graphic could help clarify what was being said?

- In the second lecture notes have more images in motion capture, people who haven't used 3D software wouldn't really understand clearly what kinemation and dynamation do.
- Yes, in the motion capture section a quick time video would have been nice.
- More animation

Q10. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding them?

- There should be a section on technology and how it actually works, e.g. Software programmes.
- In terms of explaining the objectives in the weekly plan lecture. The example of the lecture has to be shown visually to let the user understand more.
- More graphics would have helped.

Q13. If you were to be in charge of the development of these particular multimedia lectures what features would you insist on seeing in it and why?

- Print outs of web lectures, more animation.
- More visuals
- More graphics.
- Training in 3D software.
- Demo videos.
- More graphics
- More info on some of the software mentioned maybe more examples.

Frequency of similar phrases

More graphics, examples	8
Training on software	3

Table IX.7.1 IDE Post-test. Intervention Group - Responses to the scaled items same for both groups

Subjects	3	4	5	6	7
1	agree	s. agree	not sure	agree	not sure
2	not sure	not sure	not sure	s. agree	disagree
3	disagree	disagree	disagree	s. agree	s. agree
4	s. agree	not sure	disagree	s. agree	not sure
5	s. agree	agree	agree	agree	agree
6	s. agree	s. agree	agree	agree	agree
7	not sure	s. agree	s. agree	s. agree	disagree
8	disagree	agree	disagree	agree	not sure
9	agree	s. agree	agree	s. agree	agree
10	s. agree	disagree	not sure	agree	agree

Scores		The purpose of the lecture was clear	The info was clearly presented	I was able to obtain answers easily	Better understanding of this area	I feel challenged by the instruction
Strongly Agree	2	4	4	1	5	1
Agree	1	2	2	3	5	4
Not Sure	0	2	2	3	0	3
Disagree	-1	2	2	3	0	2
Strongly Disagree	-2	0	0	0	0	0
Total score		**8**	**8**	**2**	**15**	**4**

Table IX.7.2 IDE Post-test. Control Group - Responses to the scaled items same for both groups

Subjects	1	2	3	4	5
1	not sure	not sure	not sure	s. agree	not sure
2	s. agree	s. agree	agree	s. agree	not sure
3	s. agree	s. agree	s. agree	s. agree	not sure
4	agree	agree	agree	not sure	disagree
5	agree	agree	agree	disagree	s. disagree
6	agree	agree	agree	not sure	disagree
7	agree	agree	agree	agree	agree
8	agree	agree	s. agree	agree	not sure
9	agree	agree	agree	agree	not sure
10	agree	agree	disagree	agree	s. disagree

Score		The purpose of the lecture was clear	The info was clearly presented	I was able to obtain answers easily	Better understanding of this area	I feel challenged by the instruction
Strongly Agree	2	2	2	2	3	0
Agree	1	7	7	6	4	1
Not Sure	0	1	1	1	2	5
Disagree	-1	0	0	1	1	2
Strongly Disagree	-2	0	0	0	0	2
Total score		**11**	**11**	**9**	**9**	**-5**

Total score: -20=strongly disagree, 20=strongly agree

Table IX.8.1 IDE Delayed Post-Test. Control Group subjects' responses to the scaled items

Class	5	6	7	8	9
1	not sure	agree	agree	agree	disagree
2	not sure	agree	agree	agree	disagree
3	not sure	agree	s. agree	agree	disagree
4	agree	agree	agree	s. agree	disagree
5	not sure	not sure	agree	agree	disagree
6	not sure	not sure	agree	agree	disagree
7	not sure	not sure	s. agree	s. agree	disagree
8	agree	agree	agree	agree	disagree
9	not sure	not sure	s. agree	agree	disagree
10	agree	agree	agree	agree	disagree

Score		Good way of Learning	Effective Learning Aid	Support Existing Lectures	All modules similar support	Instead of the Lecture
Strongly agree	2	0	0	3	2	0
Agree	1	3	6	7	8	0
Not sure	0	7	4	0	0	0
Disagree	-2	0	0	0	0	10
Strongly disagree	-1	0	0	0	0	0
Total score		**3**	**6**	**13**	**12**	**-20**

Table IX.8.2 IDE Delayed Post-Test. Intervention Group subjects' responses scaled items

WWW	5	6	7	8	9
1	agree	agree	agree	agree	agree
2	agree	agree	s. agree	agree	a. agree
3	disagree	not sure	s. agree	s. agree	disagree
4	agree	agree	s. agree	s. agree	not sure
5	s. agree	s. agree	agree	s. agree	s. agree
6	agree	agree	agree	s. agree	disagree
7	agree	agree	agree	agree	not sure
8	agree	agree	s. agree	s. agree	disagree
9	agree	agree	agree	agree	agree
10	agree	agree	agree	s. agree	disagree

Score		Good way of Learning	Effective Learning Aid	Support Existing Lectures	All modules similar support	Instead of the Lecture
Strongly agree	2	1	1	4	6	1
Agree	1	8	8	6	4	2
Not sure	0	0	1	0	0	2
Disagree	-2	1	0	0	0	4
Strongly disagree	-1	0	0	0	0	0
Total score		**8**	**10**	**14**	**16**	**-4**

Total score: -20=strongly disagree, 20=strongly agree

Table IX.8.3: IDE Summative Evaluation, Delayed Post-Test - Analysis of open-ended items

Q1. What did you like about the application?

1. Pictures, time to read, can go back to it.
2. Thorough and clearly structured information.
3. Allowance to go through at own pace. The on-line assignment to test my understanding of the lecture.
4. Amount of information available if you wanted to specialize and look into a certain topic. The bulletin board.
5. You can have a look any time. You don't have to take notes in class because you have access to them in the computer.
6. The graphics and the communication channels.
7. Visually excited and well structured. I really liked the game characters, as they are links to other sources of information.
8. The bulletin board and the on-line tutorials were very interesting.
9. Visually sound.
10. Allows you to learn at your own pace. Non-linear format.
11. The content section
12. Freedom to explore and work at own pace
13. A good concept, detailed notes on lectures

Q2. Which are the most important features of the application and why?

1. Being able to refer back.
2. New technology and how it is applied.
3. The information – the way it is set out, it is easy to understand.
4. Ability to browse at leisure. Structure. Graphics. Amount of info.
5. Examples using designs.
6. Lesson guides because they help clarify the module.
7. Communication channels and external links.
8. The facts, key dates, companies involved.
9. Characters, as they are the links to other sources of info.
10. Content: relevant, interesting. Presentation: clarity, plain English. Animation: adds interest.
11. Educational uses. Informative
12. Linking of pages as you explore the subject as you want
13. The facts, key dates, companies involved

Frequency of similar phrases (Q1, Q2)

Graphics/Game characters	9
Learn at own pace	8
Information available	8
Clear structure	4
Communication	3
On-line assignment	1

Q3. In what ways could the application have done more to help you?

1. More pictures, animation and content.

2. More examples, more visuals.
3. On-line guides and tutorials for Director, HTML etc.
4. A bit more in depth.
5. More technology information on how computer games is designed with examples of this.

Frequency of similar phrases

More examples and visuals	4
More in depth information	1
Software tutorials	1

Q4. Would you want to use it again? Please say why or why not.

1. Yes, but instead of lectures.
2. Yes as reference.
3. No, with all the links become distracting and don't take it in.
4. Yes, to find out more about the various companies' sites.
5. Yes
6. Yes, because it a record of the lectures.
7. Yes, because I like it.
8. Yes, it is good to refer to instead of your notes.
9. Yes, anything, which involves animation, is interesting to view.
10. Yes, allows you to view and then review complex topics repeatedly, until clearly understood.
11. Yes, it is useful to observe animations

Frequency of similar phrases

Yes, as reference resource	4
Yes, is visually interesting	2
Yes, for external links	1
No, links are distracting	1

Q9. Could it be used instead of the lecture? In case you disagree please explain further.

1. No answers
2. Because it does not answer any question or statement.
3. Because you cannot ask questions or ask some things to be clarified.
4. Human element to clarify points and discuss subjects with is important. Good to see other class members sometimes.
5. Lack of physical interaction with fellow colleagues and teacher.

Frequency of similar phrases

Cannot answer questions	4
Lack of physical presence	2

Q10. How would the application need to be changed for use by students studying entirely at home?

1. Chat rooms
2. Real-time communications
3. Chat rooms
4. Computer Conferencing facilities
5. Chat room.

Frequency of similar phrases

Real time communication	5

Programming and Software Engineering
Summative Evaluation
Pre-test

Date.....

Time.....

Student.....

Questions

1. A serial stream of 1000 integer numbers ranging from 1 to 100 is to be analysed by counting the number times a particular integer occurs in the stream. The output of this analysis is to be an array containing a record of the number of times each integer has occurred.
   - Write a logic flow diagram for this process.
   - Write down an appropriate Pseudo code for the programme.
   - Write an appropriate subprogram, which inputs the data and then outputs the result using FORTRAN-77 or else, a programming language of your choice.

2. Write a subroutine which finds the square root of a number, but which gives

$$-\sqrt{|x|}$$

if x is negative.

What are you hoping to learn from doing exercise number 2? Please note down the knowledge or skills you would like to improve in the course of this session.

Programming and Software Engineering
Summative Evaluation
Post-test

Date.....

Time.....

Student.....

Questions

1. A serial stream of 1000 integer numbers ranging from 1 to 100 is to be analysed by counting the number times a particular integer occurs in the stream. The output of this analysis is to be an array containing a record of the number of times each integer has occurred.

- Write a logic flow diagram for this process.
- Write down an appropriate Pseudo code for the programme.
- Write an appropriate subprogram, which inputs the data and then outputs the result using FORTRAN-77 or else, a programming language of your choice.

2. Write a subroutine which finds the square root of a number, but which gives

$$-\sqrt{|x|}$$

if x is negative.

Look back at what you wrote for the pre-test, and note down

(a) what you did learn/revise that you had hoped to:

(b) what you did not learn/revise that you had hoped to:

(c) anything you learnt that was unexpected:

Please respond to all questions by either: (a) entering in the appropriate details; or, (b) Ticking the appropriate box.

Personal Details

Age (in years)

Gender ❑ **male** ❑ **female**

Nationality

How would you rate your computer literacy?

❑ **Very High** ❑ **High** ❑ **Average** ❑ **Low**

How would you rate your acceptance of and general attitude towards new technologies?

❑ **Very Welcome**
❑ **Welcome**
❑ **Not bothered**
❑ **Resistant**
❑ **Very Unsupportive**

About the Application

1. I understood the directions on:

- How to use the instructional material

strongly agree **agree** **no preference** **disagree** **strongly disagree**

- What section to look at next

strongly agree **agree** **no preference** **disagree** **strongly disagree**

- How to operate the application

strongly agree **agree** **no preference** **disagree** **strongly disagree**

2. The application is easy to use for every learner.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

3. The information in the application was clearly presented.

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree, please explain in the box below.

4. Was there enough explanation of the concepts or procedures being described, or do you feel that you need more help in understanding them?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below.

5. Are some lacking details in general?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you agree, please explain further in the box below.

6. Do you feel challenged by the instruction as a whole?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

If you disagree and you feel that the instruction was a waste of time will you please explain why in the box below?

7.What did you like about the application?

8. Which are the most useful features of this application and why?

9. In what ways could the application have done more to help you?

10. Would you want to use it again? Please say why or why not

11. Did you find this a good way of learning?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

12. Is the application an effective learning aid?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

13. Should it be used to support physical lectures?

strongly agree **agree** **no preference** **disagree** **strongly disagree**

14. Should all modules provide similar support?

strongly agree agree no preference disagree strongly disagree

15. Could it be used instead of the actual lecture in the classroom?

strongly agree agree no preference disagree strongly disagree

If you disagree, please explain why in the box below:

16. How would the application need to be changed for use by students studying entirely at home?

Thank you for your valuable help and co-operation.

Table XI.1 PSE Summative Evaluation - Demographics of the Subjects

Subjects	Age	Nationality	Gender	IT Literacy	Acceptance
1	22	British	M	High	V. Welcome
2	24	British	M	High	V. Welcome
3	23	British	M	High	V. Welcome
4	28	British	M	High	V. Welcome
5	31	British	M	High	Welcome
6	21	British	M	High	V. Welcome
7	28	German	M	High	Welcome
8	26	German	M	High	Welcome
9	27	German	F	High	V. Welcome
10	26	German	M	High	Welcome
11	26	German	M	High	Welcome
12	22	Russian	M	High	Welcome
13	25	Russian	M	High	Welcome
14	25	Russian	M	High	V. Welcome
15	24	Russian	M	High	V. Welcome
16	23	Russian	M	High	V. Welcome

Age	Nationality	Gender	IT Literacy	Acceptance
25	British=6	M=15	High=16	Welcome=7
	German=5	F=1		V. Welcome=9
	Russian=5			

Subjects	Pre-test	Post-test
1	6	7
2	7	8
3	7	8
4	8	8
5	6	8
6	7	8
7	5	7
8	6	8
9	6	8
10	5	9
11	7	9
12	5	7
13	6	8
14	8	10
15	8	10
16	8	8

	Pre-test	Post-test
Performance means	6.5625	8.1875

Table XI.2.1 PSE The matrix of Pearson's *r* between pre-test and post-test

	Pre	Post
Pre	1	
Post	0.556524329	1

Table XI.2.2 PSE - Data regarding learning outcomes and its descriptive statisctics

	Pre-test	Post-test
Mean	6.5625	8.1875
Standard Error	0.273385412	0.227646473
Median	6.5	8
Mode	6	8
Standard Deviat	1.093541647	0.910585892
Sample Varianc	1.195833333	0.829166667
Kurtosis	-1.227827764	0.411644617
Skewness	-0.006827725	0.797038173
Range	3	3
Minimum	5	7
Maximum	8	10
Sum	105	131
Count	16	16

Table XI.3: PSE Content analysis of open-ended items included in performance tests

What are you hoping to learn/revise from doing this exercise? Please note down the knowledge or skills you would like to improve during the course of this session

1. Usage of subroutines; Usage of operator 'if'; Usage of math library; Usage of math functions fabs, sqrt.
2. Repeat techniques, which I have mastered.
3. Sqrt; floating points; 'if' operator.
4. Programming in C and Fortran.
5. Usage of library functions; subroutines; 'if' operator
6. Hope to learn to write C code for simple calculations which will allow me to move on to harder examples
7. Numerical operators; Math functions abs, sqrt
8. 'if statement'; usage of subroutines; math functions fabs, sqrt.
9. I hope to learn about the 'if statement' and how to solve square roots of numbers and how to take an absolute value of a number.
10. About library functions/usage.
11. 'if' statement; Mathematical functions such as abs( ), sqrt( )
12. Use of mathematical operations within the C programming language and use of qualified statements
13. Writing and testing own functions using numerical operators.
14. Subroutines; 'if' operator; math functions fabs, sqrt.
15.'if' operator; math library; subroutines
16. math functions abs, sqrt; 'if operator'

Frequency of Similar Words/Phrases

Subroutine/'if"/abs,sqrt/math library	11
C Programming Language/Operators	4
Repeat Techniques	1

Look back at what you wrote for the pre-test, and note down
(a) what you did learn/revise that you had hoped to

1. Usage of subroutines; Usage of operator 'if'; Usage of math library; Usage of math functions fabs, sqrt.
2. Repeat techniques, which I have mastered.
3. Sqrt; floating points; 'if' operator.
4. Programming in C and Fortran.
5. Usage of library functions; subroutines; 'if' operator
6. Improved my C programming.
7. Numerical operators; Math functions abs, sqrt
8. 'if statement'; usage of subroutines; math functions fabs, sqrt.
9. Revise about the 'if ' statement.
10. Using numerical functions
11. 'if' statement; Mathematical functions such as abs( ), sqrt( )
12. Mathematical programming in C and comparison with Fortran
13. Writing and testing own functions using numerical operators.
14. Subroutines; 'if' operator; math functions fabs, sqrt.
15.'if' operator; math library; subroutines
16. math functions abs, sqrt; 'if operator'

Frequency of Similar Words/Phrases

Subroutine/'if"/abs,sqrt/math library	11
C Programming Language/Operators	4
Repeat Techniques	1

(b) what you did not learn/revise that you had hoped to

9. How to find predefined functions
10. Using library functions

(c) anything you learnt that was unexpected

1. Operator '?' could be used instead of 'if'
2. A good connection between the math and programming staff. So, I've learnt some more math.
9. How to overcome a situation without using the abs( ) function.
11. I/O facilities
12. Details on operating systems
13. I learned more about the structure and design of the programming languages

Table XI.4.1 PSE Post-test. Responses to scaled items (a)

Subjects	1a	1b	1c
1	s. agree	s. agree	s. agree
2	agree	agree	agree
3	s. agree	s. agree	s. agree
4	agree	agree	agree
5	s. agree	s. agree	s. agree
6	s. agree	s. agree	s. agree
7	s. agree	s. agree	s. agree
8	s. agree	s. agree	s. agree
9	agree	agree	agree
10	s. agree	s. agree	s. agree
11	agree	agree	agree
12	s. agree	s. agree	s. agree
13	agree	agree	agree
14	s. agree	s. agree	s. agree
15	agree	agree	agree
16	agree	agree	agree

I understood the directions on:		how to use the instructional material	what section to look at next	how to operate the application
Strongly Agree	2	9	9	9
Agree	1	7	7	7
No Preference	0	0	0	0
Disagree	-1	0	0	0
Strongly Disagree	-2	0	0	0
Total score		**25**	**25**	**25**

Total score: -32=strongly disagree, 32=strongly agree

Table XI.4.2 PSE - Post-test. Responses to scaled items (b)

Subjects	2	3	4	5	6
1	agree	agree	disagree	disagree	agree
2	agree	s. agree	disagree	no preference	agree
3	s. agree	s. agree	disagree	no preference	agree
4	agree	agree	no preference	no preference	agree
5	agree	agree	disagree	disagree	agree
6	s. agree	s. agree	disagree	disagree	s. agree
7	agree	agree	disagree	no preference	agree
8	s. agree	s. agree	agree	no preference	agree
9	agree	disagree	disagree	no preference	s. agree
10	s. agree	agree	disagree	disagree	s. agree
11	agree	s. agree	disagree	disagree	agree
12	s. agree	s. agree	agree	agree	s. agree
13	agree	agree	no preference	agree	agree
14	s. agree	s. agree	disagree	disagree	s. agree
15	s. agree	s. agree	disagree	disagree	agree
16	agree	s. agree	disagree	disagree	s. agree

Score		The application is easy for all learners	The information is clearly presented	More explanation is needed	Lacking details in general	I feel challenged by the instruction
Strongly Agree	2	7	9	0	0	6
Agree	1	9	6	2	2	10
No Preference	0	0	0	2	6	0
Disagree	-1	0	1	12	8	0
Strongly Disagree	-2	0	0	0	0	0
Total score		**23**	**23**	**-10**	**-6**	**22**

Total score: -32=strongly disagree, 32=strongly agree

Table XI.4.3 PSE - Post-test. Responses to scaled items (c)

Subjects	11	12	13	14	15
1	agree	agree	s. agree	s. agree	agree
2	agree	s. agree	agree	agree	agree
3	agree	s. agree	s. agree	s. agree	no preference
4	agree	agree	s. agree	agree	disagree
5	agree	agree	agree	agree	no preference
6	s. agree	s. agree	s. agree	agree	s. agree
7	agree	agree	s. agree	s. agree	agree
8	s. agree	s. agree	s. agree	agree	disagree
9	agree	agree	s. agree	agree	agree
10	s. agree	s. agree	s. agree	s. agree	no preference
11	agree	agree	s. agree	s. agree	agree
12	s. agree	s. agree	s. agree	s. agree	agree
13	agree	agree	agree	agree	agree
14	s. agree	s. agree	s. agree	s. agree	s. agree
15	s. agree	s. agree	agree	agree	s. agree
16	s. agree	s. agree	agree	s. agree	s. agree

Score		Good way of learning	Effective learning aid	Support physical lectures	Similar support to all modules	Instead of actual lecture
Strongly Agree	2	7	9	11	8	4
Agree	1	9	7	5	8	7
No Preference	0	0	0	0	0	3
Disagree	-1	0	0	0	0	2
Strongly Disagree	-2	0	0	0	0	0
Total score		**23**	**25**	**27**	**24**	**13**

Total score: -32=strongly disagree, 32=strongly agree

Table XI.5: PSE – Summative Evaluation. Content analysis of open-ended items and optional comments on scaled items

7.What did you like about the application?

- It includes rather deep and profound description of language/Includes description of several OS/Search engine/Video tutorial
- It is simple
- Clear structure/Video
- The fact that everything I need to know is in one application
- Self-learning, could work at my own pace
- Enhance my understanding of the subject without a teacher being present
- Nice introduction to programming
- Very user friendly
- Easy to use
- Help and navigation toolbar are very useful/Clear structure/Video
- Fast information access
- Good on-line electronic books on C and Fortran
- Flexibility, breadth, ease of use, comprehensive
- It was very easy to use as the on screen commands were very simple and precise. Also, the application is structured very well and that also allowed ease of use

8. Which are the most useful features of this application and why?

- Full description of a language (on-line and with a search engine) is particularly useful for searching of information quickly
- C and Fortran solutions are offered in parallel. This is good to see the different structures of both languages/ Permanently visible navigation system/On line compiler/Video solution
- Self learning in a pleasant manner
- The programming examples were excellent/ The on line compiler/Video
- Nicely laid out, links are available in the main window as well as through the toolbar on the left hand side
- The icons on the left side/The compiler/Video
- The toolbar, the search engine and the solution hints that tells you from where to start with a problem/The compiler
- Examples, search engine, on-line compiler, fast information access
- Examples, solutions, search engine, compiler.video tutorial
- Help file, search engine and also the communication channels which prevent the user from becoming isolated and disheartened
- The continuous on-screen instructions. This is so because it made the application very easy to follow, allowimg the user to locate easily where the next step was.

Frequency of similar words/phrases for Q7, Q8

User friendly/easy to use/Simple and clear structure	12
Navigation toolbar constantly on view	10
Video tutorial	7
On-line compiler	6
Programming examples/hints	5
Search engine	5
Fast information access	3

Information available	3
Self-learning in a pleasant way	3
Communication channels	1
Help file	1

9. In what ways could the application have done more to help you?

- More explanation to the problems and solutions
- If solutions in pseudo code could be available
- More worked examples and tasks could be helpful
- Inclusion of exam (past) papers
- More explanation in solutions
- I don't really know if it could have helped any more

Frequency of similar words/phrases

More explanations to the problems	4
Inclusion of past papers	1

10. Would you want to use it again? Please say why or why not

- Yes, I sometimes need to find some specific information about C language and this application is very useful in this case
- Yes, because working with it is an interesting experience
- Yes, I will use it again because of its short and clear structure and the given problems are for different levels of programming experience
- Yes, because of the examples available. Is very good for refreshing and revising
- Yes, it can be used without a teacher being present
- Yes, to help me with programming
- Yes, because it would be for my benefit
- Yes, because it is useful to clarify difficult areas
- Yes, because it allows you to work alone at your own time
- Yes, because it is the best way of independent learning
- Yes, because is very useful
- Yes, because it is much easier to use and comprehend than a book on the subject. This is due to the layout that allows the user to seek a wide variety of information and help
- Yes, because of its simple and clear structure
- Yes, because of the big range of the examples
- Yes, it is really very helpful
- Yes, because of all the features it offers.

Frequency of similar words/phrases

Yes, overall very useful and helpful	9
Yes, you can work at own pace/revise	5
Yes, clear and simple structure	3
Yes, big range of examples	3

15. Could it be used instead of the actual lecture in the classroom?

- Generally yes, but it will be more efficient if it is used as a support to the actual lecture

- I am not sure but I think that it cannot replace the lecture completely. Its better if it supports lectures.
- Lacks support for students with no or negative experience. These students may need regular reassurance that using the self-study package their understanding would be improved.
- I could not imagine the on-line teaching to replace classrooms completely. The interaction between teachers and students in a room is quicker and allows teachers to see individual problems of individual students. However, I think that on-line learning will be the general way in the future.

Frequency of similar words/phrases

No, better as a support to physical lectures	3
No, students with no or negative experience need regular reassurance	1

16. How would the application need to be changed for use by students studying entirely at home?

- More examples
- It is fine as it is
- I think it is O.K as it stands
- Maybe a videophone would help, so that the lecturer and the students can see each other
- More solution hints
- One day introduction session could be helpful
- It can be useful to add some materials about Windows Operating System
- Broader range of problems mainly at the beginning to lead a new user in gently and allow them to gain confidence
- I don't think that this application has to be changed for those students

Frequency of similar words/phrases

It is fine as it stands	3
More content, examples and solution hints	3
One day introduction session	1

Bulletin Board
(URL http://severn.dmu.ac.uk/~nick/guestbook/bare.htm)

Name: Nick Higgett
E-mail: nph@dmu.ac.uk
Comments: National Computer Games Competition with Cash Prizes!!!!!!!!! See http://www.gduk.co.uk/

Name: Nick Higgett
E-mail: nph@dmu.ac.uk
Comments: 24th April Welcome back. I hope you all had a great Easter and are now all ready for the final few laps. Tutorials will be held after the lecture as usual. It is now vital to finalise your group project. P.S. For those doing the on-line lectures I showed a softimage video to the other students just before Easter. If you want to have a look, you can borrow it on Tuesday

Name: drew
E-mail: cousinit@theaddamsfamily.demon.co.uk
Comments: this is a bit of a tangent but, does anybody have some 3dsmax quick start tutorials I could copy because it's doing my head in and I'm starting to cry uncontrollably. Cheers.

Name: Kanellopoulou Natassa
E-mail: natassak@usa.net
Comments: Actually, I have a question for you, Nick. Is it OK if we used Director6 for our illustrations as far as project 1 is concerned? And by the way today's lecture was very interesting.

Name: Kanellopoulos Elias
E-mail: elias.k@diamond.co.uk
Comments: I was very happy reading today's lecture about digital media because it is something that interests me so I had the opportunity to learn something more about this topic.

Name: Nick Higgett
E-mail: nph@dmu.ac.uk
Comments: 10th March Will you all please date all your messages in future as unfortunately this system does not provide automatic dating. Just in case there is any confusion. I will we running the lecture and practical today as normal. I want you to sort out your groups
for the next assignment today if possible.

Name: Ara
E-mail: AraArt@aol.com
Comments: What can I say Maurice??? That is the site I have been looking for, cheers. It has everything. maybe I will just complete my whole assignment now.

Name: Kanellopoulou Natassa
E-mail: natassak@usa.net
Comments: This is really interesting and I just wanted to say that I wish all our modules were like that. Sorry but I missed today's (25th) lecture and practical but I will catch up soon.

Name: Maurice Roach
E-mail: mroach@foobar.co.uk
Comments: here's a site that seems to be quite good for game resources and info http://www.videogamespot.com/ still mail me if you have any info on Martial Arts games. Thanks. maurice

Name: Jamie Ferrar
E-mail: jferrar@hotmail.com
Comments: Nick, I conclusively have to say that having the lecture notes, and all of the information surrounding the module on to the
web. Is definantly the way to go!

Name: jason glenville
E-mail: jeg@webleicester.co.uk
Comments: if your after sites of game producers check out this site it is in deed a gateway!:-
http://www.datascope.co.uk/datascope/gateway.htm its also a good place to look for work in the games industry

Name: Andy G
E-mail: cg_fusion@hotmail.com
Comments: If anyone is interested in 3D stuff then check out http://www.3dcafe.com/ It's got the lot.....

Name: Maurice Roach
E-mail: mroach@foobar.co.uk
Comments: can anyone one remember the first Martial Arts based fighting game they EVER played? If so could you mail me and tell me what platform it was on. Also has anyone found any really good game info site - don't say nintendo orsony or sega or zdnet, etc, i've tried
them. Ara by the way the sure sign of an unsatisfied user is one who is always trying to take down a competitor at any given time. face it man MACs RULE!

Name: Nick Higgett
E-mail: nph"dmu.ac.uk
Comments: Softimage Quickstart tutorials are now available to loan from Janet on the Photocopier on Floor 7. You will need to leave your SU card with her while you are using them.

Name: Nick Higgett
E-mail: nph"dmu.ac.uk
Comments: N.B. This weeks lecture on 24th February will be on Gameplay and Interactivity. This is a swap with week 9. The lecture on on-line gaming will now be in week 9.

Name: Matt Coyne
E-mail: matt@peeldesign.co.uk
Comments: Just thought I would send this again 'cos I couldn't read it before. Must be getting old. I'll need Bifocals soon. PC users [!!@**!! Check out these sites for emulators:
http://ds.dial.pipex.com/dodge/
http://www.proweb.co.uk/~watts/arcade.html
http://www.yahoo.co.uk/Recreation/Games/Video_Games/Classic_Arcade_Games/Emulation/
http://www.datacomm.ch/~camelot/arcade.html
All these and more can be found by typing "PC Arcade Emulators" [include the quotes] at the 'INFOSEEK' search query.

Name: Ara Bozadjian
E-mail: AraArt@aol.com
Comments: http://138.232.233.38/hitman/index.htm

Name: Ara Bozadjian
E-mail: AraArt@aol.com
Comments: For those of you not 'fortunate' enough to have a MAC, here is a URL for downloading some arcade emulators for your beloved PC.

Name: Nick Higgett
E-mail: nph@dmu.ac.uk
Comments: Softimage lessons will be available Tuesdays pm with Dave Prentice. See me after the lecture for details. Also a reminder will all students doing the on-line lectures send me their email.

Name: Maurice Roach
E-mail: mroach@foobar.co.uk
Comments: just thought I'd try this outain't it annoying??? maurice

Name: Maurice Roach
E-mail: mroach@foobar.co.uk
Comments: just submitted the online test and got a "bad request " message returned from a Fujitsu site. see y'all tommorow maurice

Name: Ara Bozadjian
E-mail: AraArt@aol.com
Comments: Dear MR ALex 'I Love My Macintosh' Smith.... Windows is not a machine young sir. Get your bits and PC's right!!

Name: Amanda Gough
E-mail: dmu.ac.uk/bmm6ag
Comments: Congratulations Nick! With seminars to ask any queries, on-line lectures are ideal.

Name: Matt Coyne
E-mail: matt@peeldesign.co.uk
Comments: For anyone who's interested, Activision's web site contains links to 'commercial classics' for the PC [win95]. You can find these at: http://www.activision.com/games/low/classics/atari/index.html Also, if you have a mac there's a great site for those of you who want to look at old/classic games and platforms. It's an emulation page dedicated to the mac [bill gates hasn't found it yet] and is a point of call for as many emulators as there are platf orms [almost]. The address is: http://www.emulation.net OK

Name: Maurice Roach
E-mail: mroach@foobar.co.uk / dreadz1@hotmail.com
Comments: this online lecture thing is quite cool, should have done it sooner.

Name: Nick Higgett
E-mail: nph@dmu.ac.uk
Comments: Can all students who have volunteered to do the on-line lectures only please let me have your email addresses. Please note I will be available on Tuesday after the "real" lecture for group tutorials in the Mac Lab on floor 7.

Name: Morgan Davies
E-mail: morgan_ltd@hotmail.com
Comments: hi Nick, I didn't come to the lecture on Tuesday, due to illness, however it seems that all the info i need is on the website, nice.

Glossary

Browser	A program which allows a user to view hypermedia. The browser gives some means of viewing the contents of nodes, and of navigating from one node to another.
Button	An area within the content of a node which is the source of a link.
Client	A program which requests services of another program. Normally, the browser is a client to a data server.
External link	A link to a node in a different site.
FTP	File Transfer Protocol. A protocol which allows you to transfer files from one computer to another.
Hypermedia	Multimedia hypertext. Hypermedia and Hypertext tend to be used interchangeably. Media other than text typically include graphics, sound and video.
Hypertext	Text which is not constrained to be linear.
Internal link	A link to a node in the same site.
Navigation	The process of moving from one node to another through hypermedia. This is normally facilitated by following links.
Node	A unit of information.
Server	A program which provides a service to another, known as the client. In a hypermedia system, a server will provide hypermedia information to a browser.
URL, URI	Universal Resource Identifier, or Uniform Resource Locator. A means of specifying the Internet access method and location for a particular resource.
VRML	Virtual Reality Modelling Language. A language that facilitates the construction of virtual reality 3D spaces on the World Wide Web.
WWW	World Wide Web is a distributed hypermedia information system which provide linking of information on the network via hyperlinks with documents. It gives access to many types of files, such as text, sound, image, and movie, and provides an integrated interface to information accessed by various methods.

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CyberExam, http://www.vlearning.com

Introduction to Art course, City University, USA, http://www.caso.com/iu/city.html

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