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The Design, Implementation and Evaluation of a Web-Based Learning Environment for Distance Education

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by

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ABSTRACT

In this study, the need was emphasised to investigate the effects of using the Web in teaching students at a distance using a multi-level evaluation framework. A Web-based learning environment was designed, developed, implemented and evaluated for this purpose. Constructivist epistemology provided the basis for developing various components and developing problem-centred and interactive activities. Management, tutorial, interaction and support components were designed to work with each other to construct the learning environment, deliver course content, facilitate interaction and monitor student progress.

A methodology was designed to describe and assess the learning environment in terms of access (standardisation, speed, resources, the tutor and peers), costs (types, structure, factors influencing, etc.), teaching and learning functions (quality of course objectives, materials and resources, learning approach and student achievement), interactivity (quantity and quality of student-tutor and student-peer interaction), user-friendliness (user-interface design, ease of use and navigation design) and organisational issues. The learners were Egyptian first-grade secondary school students (32), assigned randomly, and the topic selected for the course being developed was mathematics. Feedback was obtained from both learners and experts in distance education and on-line learning during the developmental and field-testing of the learning environment. Quantitative and qualitative methods (on-line student and expert questionnaires, students' logs, performance in formative evaluation, content analysis of peer discussions, achievement test and cost-analysis) were combined to gain insights into students' satisfaction with the different instructional and technical features and capabilities of the learning environment, achievement of course objectives in comparison with conventional classroom students, factors influencing their learning and perceptions and the unit cost per student study hour.

The results indicated that although the learning environment and course materials were accessible, interactive, well-structured, user-friendly and achievement was successful for the on-line group, no significant differences were identified between the on-line students and traditional classroom students in overall achievement or achievement of low-order and high-order learning objectives. In addition, it is unlikely any cost saving would be made from shifting to the Internet to deliver instruction and many major factors were found to influence the development and support costs of on-line learning.

LIST OF PUBLICATIONS

Sadik, A. (2000) Wired Class: A Web-Based Learning Environment for Teaching Students at a Distance (*), Poster presented at the Sixth International Conference on Web-Based Learning (N.A.Web), October 14-17, Fredericton, NB, Canada.

Sadik, A. (2000) Tutor's and site facilitator's roles in Wired Class: A Web-Based Learning Environment, Journal of Distance Learning Administration, 3(3), http://www.westga.edu/~distance/jmain11.html

Sadik, A. (2001) Evaluation of a Web-based learning environment for teaching students at a distance, paper presented at CAL 2001 Conference, April 2-4, University of Warwick, UK.

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PART ONE

INTRODUCTION AND REVIEW OF THE LITERATURE

Chapter 1: Introduction

1.1. Introduction

The Industrial Revolution in the nineteenth century was followed by developments in various fields of technology and provided educators with different means for a new era of education. Distance education was one of the main results of this revolution. Distance education is a method of education in which the learner is physically separated from the institution. Therefore, learning materials are often structured in a way that facilitates learning at a distance (Rumble, 1989).

The distance education literature points out many examples of how higher education institutions in many countries used print and post, broadcasting radio and television and other media to deliver instruction. However, although the distance education approach was originally invented to help adults, who could not attend conventional classes, 'distance education methods together with existing conventional systems will converge for the benefit of all learners – not just those we define as adults' (Garrison and Shale, 1990, p. 131). In the last few years, distance education has captured the interest of many elementary and high school students. In other words, adults are no longer the only target of distance education (Dhanarajan, 1996).

The communications revolution, in particular, offered new and different solutions for delivering instruction to learners outside the traditional classes. In the last twenty years, parents' and learners' interest enhanced dramatically as a result of the great advances in audio-visual media, telecommunication technology, which resulted in an increase in the subject areas offered by distance education programmes. By the early 1980s, the rapid developments in computing and information technologies accompanied by easy-to-use, flexible and effective ways of storage and distribution of course materials created a new paradigm of distance education. These features, plus the interactive nature of the computer as an instructional medium for individualised instruction, have attracted distance educators more than any other medium ever and developed the nature of distance education systems to be more effective delivery modes (Gray, 1988).

However, although previous distance education technologies (e.g., broadcasting radio and television, audio and videotapes and teleconferencing, etc.) are popular and appropriate for many situations, they are characterised by many delivery and pedagogical problems (Keegan, 1988). The feeling of isolation from the tutor and peers, lack of support, lack of convenient and effective interaction, lack of strategies for involving learners actively in the programme, difficulty of use and access, slowness of distributing subject material, high delivery or transmission costs and management and evaluation-related problems are the most common problems that characterised these technologies (Keegan, 1990; Bates, 1995; Jones et al., 1996).

The real development in computer-based instruction was established when followed by a revolution in the concept of networking and Computer-Mediated Communication (CMC). Using CMC, interaction between the tutor and distance learners has been established using different forms of computer-based conferencing and students have been able to access a variety of learning resources located in other computers and exchange information with one another (Mcmillan, 1997). CMC has become more popular with the evolution of the Internet and the World Wide Web (abbreviated to WWW or Web). The Internet and the Web are the most popular and growing technology in a long history of using media and technology to deliver instruction to students at a distance. The idea of the Web is to create a system for delivering and viewing documents (called hypertext) containing text, images, audio-visuals media, programs and links to other files, located in other computers connected to the Internet, using a user-friendly graphical interface.

Today, and perhaps for the first time in distance education history, through telephone lines, local networks or channels, learners at home and schools can easily access instructional materials and databases that contain information in different formats, interact with far teachers and peers, share knowledge and experience, co-operate with each other in small or large groups and publish information with low-level costs.

Consequently, educational institutions world-wide are in a rush to establish on-line courses and Web-based virtual classes to deliver instruction and support students at a distance.

According to Powell (2001), '66% of the USA's two-year and four-year postsecondary education institutions provided distance education courses, and another 20% planned to start offering such courses (primarily via the internet) by 2001' (p. 43). However, higher education institutions are not the only sector developing on-line learning; schools are placing more course material on-line to supplement classroom situations or replace classroom instruction to meet student and society needs (Janicki and Liegle, 2001).

Although institutions have invested much in developing on-line environments or using already established commercial platforms, only a few studies have been conducted to investigate the effectiveness of on-line courses based on empirical data (Jung and Rha, 2000). A review of the literature showed that although an enormous number of studies were conducted in the area of on-line education, most of them investigated the effectiveness of Web-based interaction or Internet conferencing on learning, not the entire learning environment (Atkinson, 1992; Fulford and Zhang, 1993; Foley and Schuck, 1998; Graham and Scarborough, 1999; Harris, 1999). Even in those studies that investigated entire on-line environments, student achievement was the most common indicator for evaluation and no other indictors or factors (such as student satisfaction), which may influence students' achievement, were investigated to give a more comprehensive understanding of the effectiveness of Web-based distance education (Lockee et al., 1999).

To promote understanding of the phenomenon of on-line learning, this study attempted to investigate students' perceptions of various aspects of on-line learning environments (such as access, interactivity and user-friendliness), learning outcomes in comparison to the traditional classroom, factors influencing students' on-line experience and the cost-effectiveness of establishing an on-line learning environment.

1.2. Statement of the problem

The lack of evidence of the quality and the cost-effectiveness of on-line learning, inadequate information about the factors that may contribute to students' academic success and satisfaction with on-line learning, in conjunction with the long history of contradictory results of distance education technologies, may lead to inappropriate and costly educational and policy mistakes (Clark and Salmon, 1986). Therefore, the need is emphasised to clarify and evaluate the effects of using the Web in teaching students at a distance using a comprehensive approach and a multi-level evaluation framework (Clark, 1994). This plan might help distance educators to explore the positive features of on-line learning and eliminate weak features, as shown below.

Previous studies in distance education and on-line learning claimed that evaluation of on-line learning needs to provide information about students' reactions to both instructional (e.g., interactivity, quality of teaching, quality of resources, etc.) and technical aspects (e.g., speed, ease of use, ease of access, etc.) of the medium and technology, with an indication of students' achievement of learning objectives and the cost-benefit/savings of implementing the new programme (Fulford and Zhang, 1993; Bates, 1995; Clark, 1994 a; Thorpe, 1998; Lockee et al., 1999; Whalen and Wright, 1999; Jung and Rha, 2000).

Bates (1995), for example, argued that evaluation of distance education technologies should be based on a more generic framework that addresses the various aspects of the medium. He proposed a framework called the ACTIONS model (Access, Costs, Teaching and learning functions, Interactivity and user-friendliness, Organisational issues, Novelty and Speed) to help in analysing and evaluating distance education technologies. In addition, Smith and Dillon (1999) indicated that evaluation of distance education media should consider conceptual attributes of the medium, such as types of interaction supported by the medium (one-way/two-way), bandwidth (amount of information that can be sent from one site to another), realism (providing high realistic images and motions and audio-video rather than abstract symbols) and system interface (access to multiple information resources and control branching).

Second, to conduct such analysis and evaluate an entire on-line course, there is a need to use an already established learning environment or establish a new and reliable on-line learning environment, in which learning can take place and students' learning and experience can be investigated, which is a problem in its own right. Janicki and Liegle (2001) argued that the Web is a relatively new technology and most current offerings of Web-based courses are established by individuals who have authoring skills, 'but are not necessarily knowledgeable about educational concepts'. In addition, Powell (2001) found that:

> 'despite the established base of online courses, online course design and facilitation is still uncharted territory for many college and university faculty. Many faculty members struggle with how to successfully use the available tools and technologies to organize instructional content into well-crafted teaching systems that support learning' (p. 44).

Although an enormous number of guides and articles have been published to help educators to establish on-line learning, 'they do not provide a comprehensive and practical guide to the challenges faculty encounter when designing complex Web modules' (Weston and Barker, 2001, p. 15). On-line learning environments should meet many instructional, structural and technical principles of design and development to be more than information dumping, and to avoid eyestrain from endless text screens, confusing navigation and long download times (Spitzer, 2001).

Specifically, the problem of this study is defined as to establish a reliable on-line learning environment, evaluate its effectiveness using a generic and comprehensive framework and identify factors, which may influence student academic achievement and satisfaction.

1.3. Purpose of the study

The purpose of this study was to establish an on-line learning environment for teaching students at a distance and perform a multilevel assessment of students' reactions to on-line learning, academic achievement and cost effectiveness.

Establishing the learning environment would be achieved based on the answers to the following questions:

1. What is the meaning of distance education?
2. What are the characteristics, advantages and limitations of previous distance education technologies?
3. What are the technical features of the Internet?
4. What are the instructional capabilities of the World Wide Web?
5. What are the essential features of on-line learning environments?

6. What are the elements that should be available in on-line learning environments to serve these features?

7. What instructional design model, or models, is most appropriate in developing an on-line learning environment?

8. How should an on-line learning environment be structured and organised?

However, evaluating the learning environment requires investigating students' perceptions of different aspects of the learning environment, quality of instruction and learning outcomes (Clark, 1994; Bates, 1995). Therefore, the second purpose of this study was to investigate the views of on-line tutors, distance educators, Web developers and subject matter experts on the strengths and weakness of the learning-environment, particularly when students are not able to provide objective feedback. Quantitative and qualitative methods were used to help in exploring what does (and what does not) work, under what conditions and with which students, as well as to identify variables related to students' learning and perception. Quantitative analysis was based on the results of an achievement test, students' demographic information and students' and experts' responses to closed items in the evaluation questionnaires. Qualitative analysis was based on cost analysis, students' and experts' comments and feedback to open-ended questions, students' logs and records and analysis of interaction via discussion boards.

This investigation was mainly guided by Bates' (1995) ACTIONS model. Bates argued that any distance education technology should be described, compared or evaluated in terms of:

1. access (is the technology easy to access? Does it facilitate access to new and high quality teaching and learning resources? Does it facilitate access to the tutor and peers?);
2. costs (what is the cost structure of the technology in terms of fixed costs, variable costs? Is there any cost savings in using the technology?);
3. teaching and learning functions (how efficient are course objectives and content, course materials and resources, presentational features, teaching/learning approach, learning outcomes and time demands?);

4. interactivity and user-friendliness (how do students interact with the tutor, the content and themselves? How friendly is the technology in terms of ease of use, delivery methods, programming, user-interfaces, technical design, navigation and structure?);
5. organisational issues (how well is the learning environment organised? What are the factors that influence students' perceptions and achievements? What are the factors related to students' success?);
6. novelty (how new is this learning technology?); and
7. speed (how long do students spend in learning? Is the system quick?).

In addition, the objectives of this study were to identify instructional and media-related factors influencing students' achievement, perception of on-line learning and instructional activities in the learning environment.

1.4. Significance of the study

This study may contribute to the field of Web-based distance education as follows:

1. Although the comparison approach in media studies is criticised by many researchers (e.g., Lockee et al., 1999; Vrasidas and McIsaac, 2000; Jung, 2000), it is relatively new t o the field of Web-based distance education and useful if it explains how and why the technology is used, and not only to provide the results of such comparison (Smith and Dillon, 1999).
2. Considering the fact that there is little research in the area of Web-based instruction, in general, and for young learners, in particular, this study may assist educators in planning, designing, organising and evaluating quality Web-based distance education in a manner that facilitates learning at a distance.
3. The study used a relatively new evaluation framework to assess the cost-effectiveness of Web-based distance education.
4. A Web-based learning environment was designed, developed and implemented, as a model for developers who may want to develop Web-based courses.
5. A coding system was adopted, which could be used in future studies of asynchronous Web-based learning to assess the quantity and quality of students' responses.

6. The study provided evidence to add to the distance education literature, which suggests that a Web-based learning environment is equally effective as face-to-face education.

1.5. Procedures and overview of the study

Based on the problem and the purpose of the study, as mentioned above, the following procedures were followed:

1. A theoretical study was conducted on:
   - Key issues in distance education, including characteristics, advantages and limitations of previous distance education technologies, the educational relationship in distance education systems, theory of development and evaluation of distance education technologies and costs of distance education technologies (Chapter 2);
   - Technical features of the Internet and the World Wide Web, delivering media via the Web and developing for the Web (Chapter 3); and
   - Instructional capabilities of the Web, models of using the Web in education, theories and types of Web-based learning, cost-effectiveness of on-line learning, elements of on-line learning environments and instructional design for the Web (Chapter 4).
2. A Web-based learning environment was established to offer actual distance education experience for students, as follow (Chapter 5):
   - Participants, course content, learning objectives, appropriate teaching/learning approach and the technical requirements were defined and front-end analysis was conducted;
   - The elements of the learning environment, including tutorials and assessment, support utilities, interaction tools, management and monitoring tools and help and on-line support, were designed and developed; and
   - Developmental testing of the learning environment, including expert appraisal and student usage (September 1999-February 2000), was conducted.

3. The research instruments (including student questionnaire, student achievement test and experts' questionnaire), were planned, developed and piloted, the sample of study selected and preparation made for implementation (Chapter 6).

4. The learning environment was implemented (February and March 2000) and the research instruments administered to collect, analysis and discuss the results of the study (Chapters 7, 8, 9 and 10).

5. Conclusions and implications were drawn from the study in terms of design and development, practice and further research (Chapter 11).

1.6. Delimitation of the study

- **The population:** The population of this study was limited to first year secondary 'language schools' students in Egypt and the sample was limited to students enrolled in the first year at three public secondary 'language schools' in Cairo (El-Maadi Experimental Language School, El-Hadayek Experimental Language School and Hafez Ibrahiem Experimental Language School).
- **The topic of learning:** The topic of learning was the first part of the second semester maths course for first year secondary 'language schools' in Egypt.
- **Teaching method:** Two teaching methods were used in this study; traditional classroom/face-to-face instruction (for the control group) and Web-based instruction (for the treatment group).

1.7. Limitations of the study

The present study is a preliminary investigation of the effectiveness of teaching students at distance and had many limitations, as follows.

1. The study included only one on-line class, due to the small sample available for the study. The decision of the Ministry of Education in Egypt and district administrators as to which school within the district would participate affected the number and the location of schools selected for the study.
2. Since quantitative analysis was limited due to the small sample, the results may not be generalised beyond this specific population of students.

3. The number of male and female students enrolled in Grade 1 in the selected schools and classes led to unequal numbers of male (76.92%) and female (23.08%) participants. The small percentage of girls might affect their level of participation in the on-line environment and limit the interpretation of results to this specific population of students.
4. The time spent by students in on-line learning was only eight weeks. This relatively short time might not allow them to get enough experience with the new features of the on-line learning environment (e.g., interactive content and tools, distance tutor and classmates, etc.) and provide a wide range and objective feedback at the end of the field-testing.
5. A post-test only control group design was implemented due to the difficulty of examining students prior to the study. This limitation was treated in the research design.
6. Control and treatment group students were taught by different teachers, which may have had an impact on students' learning.
7. The analyses of students' records were done by the researcher, and some degree of subjectivity is hence inevitable.
8. Experts' and students' perceptions and achievement were measured as experienced only throughout the learning environment designed in this study.

1.8. Definition of terms

In this study, many operational variables and instructional and technical terms are used. These variables and terms are defined as follows.

- **Asynchronous interaction:** Asynchronous interaction is time-independent and does not require real-time dialogue. It allows the tutor and learners to send and receive messages at any time (for example, using e-mail or discussion boards), without the need to immediate response and give them the chance to read, reflect on their own ideas (Liaw and Huang, 2000).
- **Bandwidth:** Bandwidth is the capacity of communication channels to carry and transfer data among users at any given second. This capacity is limited and depends on the connection type.
- **CGI Scripts:** CGI (Common Gateway Interface) is not a programming language in itself but a collection of protocols that allows Web clients (browsers) to run programmes on a

Web server and receive their inputs again. CGI scripts in conjunction with HTML forms can respond to the user's inputs and generate appropriate pages for the user's entries.

- **Discussion boards (bulletin boards):** Discussion boards are virtual place at which users can post and read others' messages. These messages might be sent via e-mail or directly using discussion input forms.
- **HTML:** HTML (Hypertext Mark-up Language) is the major language of the Web. It is the set of 'mark-up' symbols or 'tags' inserted in ASCI Files, at certain places in a text, to deliver documents via the Web and present them using a Web browser. HTML tags tells the Web browser how to display (font, colour, margin, spaces, etc.) the elements of a page (texts and images).
- **Hypertext:** Hypertext is an approach to organise and access information on the Web. In hypertext documents, information is stored in a network of nodes connected by links. These nodes may contain plain text, graphics, audio-video clips, programs or other or other types of information (Balasubramanian, 1994). Hypertext pages are the essential component of the Web and provide a non-sequential method of accessing information.
- **Hypermedia:** A hypermedia system is a hypertext system with links to various forms of media such as images, graphs, sounds, movies and other objects, such as Java applets.
- **Interactivity:** Interactivity is a descriptive term used to describe student communication with the tutor (via e-mail, chat, on-line tests, etc.), peers (via discussion boards, e-mail, chat, personal pages, presentation boards, etc.), course content (on-line quizzes, form inputs, etc.) and user-interface (menus, navigation aids, hyperlinks, buttons, etc.).
- **Java:** Java is a general-purpose, client-side and cross-platform programming language, developed by Sun Microsystems, designed to deliver and run applications via the Internet. Java applications are small size files, called applets, which can be downloaded and run in the user's machine.
- **JavaScript:** Java Script is a cross-platform Web scripting language, developed by Netscape Communications. JavaScript code is inserted directly into an HTML page and run in the Web browser.
- **Experimental Secondary Language Schools:** Experimental Secondary Language Schools (14-17 years), are a relatively new type of public secondary schools in Egypt

established in the early 1990s. These schools constitute about 10% (about 1000 schools) of secondary schools in Egypt. The government founded Experimental Schools to teach the national curriculum in English. They are called experimental because the Ministry of Education's statute did not grant it the right to establish language schools, but gave the Secretary for Education the right to experiment.

- **On-learning activities:** Learning activities refer to all tasks students are required to accomplish on-line, including logging-in and logging-out, contacting the tutor and peers in the on-line class, search and access Web resources, publishing course-related work, etc.
- **On-line tutor:** On-line tutor is a descriptive term used to refer to the human instructor who is responsible to monitor students' tracks and records, respond to students' questions and provide appropriate feedback, suggest learning activities, maintain and develop course materials and tests as appropriate, maintain and encourage students to participate in class activities and assess students' progress.
- **Students' perceptions:** Students' perceptions of on-line learning experiences refers to results of students' answers to questionnaire items solicit information about students' satisfaction with the instructional and technical design of the learning environment.
- **Students' records:** Students' records is a descriptive term used to refer to the course documents in digital format (HTML, TXT and MS Access MDB format) produced by the learning environment as a results of students' entries or participation in instructional activities (e.g. discussion boards and tests).
- **Students' responses:** Students' responses refer to the student behaviour in the learning environment, including responding to e-mail messages, discussion boards and on-line quizzes and tests.
- **Synchronous interaction:** Synchronous interaction is real-time interaction similar to telephone dialogue or audio-video conferencing systems. Many protocols are available on the Web (such as chat) for conducting real-time conferencing.
- **WYSIWYG Editor:** WYSIWYG (What You See Is What You Get) editor is a tool for designing and editing hypertext pages without the need to learn HTML. It allows developers to see what the hypertext page looks like while it is being created. Developers

can easily enter text and add images, tables, form fields or other display elements to Web pages.

Chapter 2: Issues in Distance Education

The Industrial Revolution in the nineteenth century was followed by developments in various fields of technology, which provided educators with various means for a new stage of education. Distance education was one of the main results of this revolution. Broadcasting and communications technology offered educators new and different solutions for adapting and delivering instruction to learners outside the traditional campus. Learners' and parents' interests were enhanced dramatically as a result of the great advances in audio-visual media and telecommunication technology, which resulted in an increase in the subject areas offered by distance education institutions.

In response to this interest, distance education became one of the formal means of education for those who could not attend schools or universities for cultural, economic, social or geographical reasons. Since designing instruction for distance education requires understanding the meaning of distance education and its objectives, the stages that distance education passed through, the media and their characteristics, and the main issues in distance education, as reviewed in the distance education literature, are reviewed in this chapter.

2.1. Defining distance education

The importance of defining the meaning of distance education is that it may provide a good starting point to recognise its elements. First, there is some confusion among distance educators as to the correct definition of this term. A review of the term 'distance education' in the literature showed that the two terms 'distance education' and 'distance learning' have been used almost interchangeably and there is an overlap between them. This reflects the continuing debate among distance educators as to which term should be used. Many distance educators (Moore, 1973; Holmberg, 1977; Rumble, 1989; Moore and Kearsley, 1996) use the term 'distance education' to mean a systematic approach involving the learning environment, educators and separated learners. Three important definitions of distance education are offered by Holmberg (1977), Rumble (1989) and Moore and Kearsley (1996). These definitions are supported by many distance educators.

Holmberg (1977) offered one of the common definitions of distance education that is both simple and comprehensive. He defined distance education as follows:

> 'a term that covers the various forms of study at all levels which are not under the continuous immediate supervision of tutors present with their students in lecture rooms or the same premises, but which, nevertheless, benefit from the planning, guidance and tuition of a tutorial organisation' (p. 9).

In a concluding discussion on distance-education-related issues, Rumble (1989) proposed a similar definition of distance education, which can be summarised in two main points:

1. Distance education is a method of education in which the learner is physically separated from the teacher by space and time.
2. Distance education materials are often structured in ways that facilitate learning at a distance.

Recently, Moore and Kearsley (1996) stated a definition that reflects the recent developments in distance education technology. They defined distance education as:

> 'the family of instructional methods in which the teaching behaviours are executed apart from the learning behaviours, including those that in a contiguous situation would be performed in the learner's presence, so that communication between the teacher and the learner must be facilitated by print, electronic or other devices' (p. 197).

According to Rumble's definition, the learning materials are important elements and should be designed to promote effective learning for the learner at a distance. However, Moore's definition highlights, for the first time, the need to establish direct interaction between the learner and the teacher. More specifically, Garrison and Shale (1987) believe that mediated communication between the teacher and students 'is a necessity'. Therefore, they proposed what they called 'the essential criteria' for characterising the distance education process. 'An assumption underlying these criteria is that an educational experience requires two-way communication between teacher and student' (Garrison and Shale, 1990, p. 26).

These criteria are:

1. Distance education implies that the majority of educational communication between (among) teachers and student(s) occurs noncontiguously.
2. Distance education must involve two-way communication between (among) teacher and student(s) for the purpose of facilitating and supporting the educational process.
3. Distance education uses technology to mediate the necessary two-way communication (Garrison and Shale 1987, p. 11, in Garrison and Shale 1990, p. 25).

In conclusion, it is noted that many key features characterise distance education as understood from the definitions above:

1. The separation of teacher and learner;
2. The separation among learners;
3. The use of one medium (or more) to deliver the subject matter (e.g., print and post, broadcasting and tapes, etc.); and
4. The use of a communication channel to facilitate interaction and support learners (e.g., post, telephone, teleconferencing, etc).

2.2. Key issues in distance education

To understand the factors that affect distance education systems, this section sheds light on some of the common and important issues in distance education as reflected in the literature. These issues are distance education media and technologies, the educational relationship in distance education, interaction in distance education, the effectiveness of distance education for learning and the costs of distance education systems.

2.2.1. Media and technology in distance education

Bates (1995) and Thorpe (1998) suggested that the term medium means a particular way (or ways) of representing knowledge associated with a form (or forms) of communication. This medium can be carried by different delivery technologies. For example, text, as a medium for representing language and conducting communication, can be carried using different kinds of technologies such as books, tele-text systems, audio-graphics and CD-ROMs. In other words, the medium's role is to represent the knowledge in a specific way and technology's role is to modify and deliver the medium to the audience.

As mentioned above, the development in distance education relies on the development of media and technology. During the last four decades, media and technologies have developed to deliver instruction and to facilitate interaction between the tutor and students at a distance. Broadcasting radio and television, teleconferencing, interactive video, satellite telecommunications and computer technology are used to deliver the subject matter, promote student-teacher interaction and support students at a distance. Distance education technologies have evolved from print-based and one-way broadcasting to multimedia and two-way interactive technologies. Through the use of audio and videotapes, laboratory kits, telephone, video conferencing and interactive courseware, new educational opportunities are offered and many subject areas are delivered effectively for students at a distance (Holmberg, 1995).

Many attempts have been made (e.g., Nipper, 1989; Romiszowski, 1993; Bates 1995; McIsaac and Gunawardena, 1996; Stenerson, 1998) to analyse and describe distance education technologies. These attempts agree that distance education systems can be classified into three generations. The first generation is called the correspondence generation, in which distance education depends on printed materials and post services to send and receive instruction and contact learners. However, with the development in media, instruction came to be delivered through audio- and video-cassettes and even computer programs. This phase is characterised by the lack of direct interaction between the tutor and students and slow transmission. In addition, programmes are characterised by a deliberately integrated multimedia approach, with learning materials specifically designed for self-learning (e.g., courseware).

In the second generation, one-way technologies (e.g., radio, TV and audio-graphic systems) are used to deliver instruction, reach very wide and far areas (e.g., satellite) and enrich presentations. Lastly, in the third phase, two-way and interactive communication media, with full and flexible access to instruction and human tutor, are used to encourage direct interaction between the tutor and students and among students, either individually or in groups.

A review of the literature reveals that many features characterise distance education technologies. For example, Rowntree (1995) indicated that the ability of the medium to conduct interaction (one-way and two-way or asynchronous and synchronous), deliver multimedia presentations and support group-based learning are essential features for effective distance education systems. In addition, Forsyth (1996) added more important criteria to be used in analysing and comparing technologies. He analysed media according to their multimedia capabilities (e.g., text-based, audio, audio-visual, etc.), the ability of the medium to reach a wider range of students, speed of delivery and costs.

However, stating another point of view, Turok (1975) claims that distance media should meet a formula of features of distance education technology. This formula prescribes that media should be interactive, cost-effective, flexible, able to reach a wide range of students, learner-based and flexible. In view of these different approaches, the need was highlighted for a generic framework based on the analysis of various criteria to describe, compare and use technology in distance education.

Accordingly, Bates (1995) suggested a generic framework called the ACTIONS model (Access, Costs, Teaching and learning functions, Interactivity and user-friendliness, Organisational issues, Novelty and Speed) to help in analysing and selecting the appropriate distance education technology. Recently, Zlomislic and Bates (1999) applied this model to assess the telelearning systems at the University of British Columbia and the Ontario Institute for Studies in Education of the University of Toronto (2000). These studies are two of six case studies in the NCE-Telelearning project entitled Developing and Applying a Cost-Benefit Model for Assessing Telelearning.

Access is usually the most important criterion for deciding on the appropriateness of a technology for distance education (Bates, 1995). Distance education programmes should consider the target audiences as well as their locations and the availability of equipment they need to access learning. However, the availability of technology is not enough. The costs of implementation is also a strong discriminator between technologies. Bates indicated that:

> 'there are some clear cost differences between technologies in open and distance learning. Print and pre-recorded instructional television (lectures) [for example], appear to be the lowest cost one-way

technologies. A combination of print and audio cassettes appears cost-effective for large courses' (Bates, 1995, p. 4).

Table 2-1: Bates' ACTIONS model for describing and using distance education technologies

Features	Questions
Access	- How accessible is a particular technology for learners? - How flexible is it for a particular target group?
Costs	- What is the cost structure of each technology? - What is the unit cost per learner?
Teaching and learning	- What kinds of learning are needed? - What instructional approaches will best meet these needs? - What are the best technologies for supporting this teaching and learning?
Interactivity and User-friendliness	- What kind of interaction does this technology enable? - How easy is it to use?
Organisational issues	- What are the organisational requirements, and the barriers to be removed, before this technology can be used successfully? - What changes in organisation need to be made?
Novelty	- How new is this technology?
Speed	- How quickly can a course be mounted with this technology? - How quickly can materials be changed?

Although the effectiveness of the medium is one of the most common issues in the literature, Bates believes that 'teaching and learning issues are less strong as discriminators than access or costs, partly because of the flexibility of different media and technologies, and the ability of teachers and learners to make the best of any given situation' (p. 6). However, Bates stresses the importance of technology that offers different types of interaction (Table 2-1). For example, he found that two-way communications media are useful tools for students and allow them to interact easily with the tutor and with other students.

Recently, Smith and Dillon (1999) proposed a framework for defining and comparing the variables of alternative distance education technologies. The importance of this model is that it was originally proposed to compare between distance education and classroom learning. In addition, it considers recent attributes (e.g., types of interaction, bandwidth and system interface), which make it more suitable when attributes of interactive technology (like the WWW) are considered. These variables are categorised into three groups: realism/bandwidth, feedback/interactivity and branching/interface. The categories of this model with their description, attributes and media that represent them are represented below (Table 2-2).

Table 2-2: Analysis of media attributes (adapted from: Smith and Dillon, 1999)

Category	Description	Media	Attributes
Realism/ Bandwidth	- Realism is the concept that reflects the relative concreteness of a medium - Bandwidth refers to how much information can be sent from site to site	Images, motions, films and Video-conferencing	- Provide high realistic symbols and images - Richer and immediate learning experience - Support and activate cognitive processing
Feedback/ Interactivity	- Interactivity fundamentally involves two-way communication, the opportunity for dialogue between the tutor and students and among students - Feedback to indicate the possibility of asking and answering questions	Telephone, e-mail and discussion boards	- Correct misunderstanding and reinforce correct learning - Enhance meaning - Promote high-order learning (e.g., problem solving) - Motivate learners
Branching/ Interface	- Branching is a characteristic of instruction in which the sequence of instruction is determined by prior response - Interface refers to seamless access to multiple information resources	Interactive CD-ROMs and the WWW	- Provide individual instruction - Offers immediate educational experience - Learners gain greater control over content - Increase learner autonomy

In the light of the ACTIONS (Bates, 1995) model and Smith and Dillon's (1999) framework above, examples of media and technologies used in distance education will later be analysed with regard to their advantages and limitations.

2.2.2. The educational relationship in distance education

Conventional education is characterised by a direct relationship or face-to-face interaction between the teacher and students. Teachers prepare lessons, discuss with students, manage the class, select the needed technology, suggest activities, assess students and provide reinforcement. In other words, the teacher can play an essential role in facilitating learning and supporting students. Although distance education is recognised by the separation between the tutor and learners, this does not mean, however that learners have complete control over learning. With the development in media and distance education theory, an important role can be played by distance tutors to enhance learning and support learners.

Sherry (1996) indicated that the distance tutor needs to suggest learning resources, deliver the instruction, determine the degree of interaction and select the appropriate form of assessment. Moreover, Trentin and Scimeca (1999) argued that the role of the distance tutor may be as important as that of the course designer. They suggested that although experts assume a leading role in course design, they have to be supported by distance tutors. For example, the tutor can decide the type of material and communication to be used, suggest the human resources to be involved and translate the course objectives into activities.

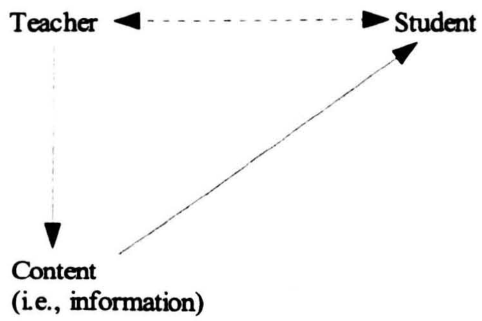
Ferguson (1996) emphasises the role of the distance tutor by distinguishing between two components of distance education environments: the subject matter and the dialogue. He argued that the dialogue during learning is the tutor's responsibility. According to Ferguson, the importance of the dialogue between the tutor and students lies in its importance for activating the use of new knowledge and facilitating assessment of students' progress. Sherry (1996) indicated two main approaches be used by distance tutors to interacting with students over a distance:

1. The distance tutor may visit the distant site, or students may take a trip to a central site.
2. The distance tutor may use technology (e.g., telephone, e-mail or discussion boards) to interact and support students.

To conduct a non-contiguous dialogue and effective relationship between the tutor and students and encourage them to exchange information and ideas 'we must have a broader application of the communicative process and of the technology needed to support the interaction between the teacher and student appropriately' (Garrison and Shale, 1990, p. 33).

To recognise the relationship between the distance tutor and students, Shale and Garrison suggested a model of the educational relationship in distance education expressed in terms of communication (Figure 2-1).

Figure 2-1: The educational relationship in distance education in the absence of two-way communication technology (Shale and Garrison, 1990, p. 36)



In this model, the teacher generates the content to be delivered by the medium to the student. According to Garrison and Shale (1990), the 'negotiation of meaning' closes the communication loop and 'is supported by a different medium from that used to deliver the content' (p. 36). However, with the development in technologies that deliver the content and facilitate two-way communication at the same time (like the WWW), the same medium can be used to distribute the content and facilitate interaction, allowing the model above to be represented as follows (Figure 2-2).

Figure 2-2: The educational relationship in distance education using two-way communication technology

In this model, the learner can interact with the teacher directly and transmit or receive information in both directions (e.g., read the content, answer questions, submit an assignment, receive feedback, etc.). For example, in the absence of two-way communication technology that transmits the content and the dialogue, at the Open University instructors use one-to-one telephone calls and audio conferences to monitor students' progress and solve course-related problems. Wyld and Eklund (1997) advised that a paper-based study guide could be used together with a communication channel (like the telephone) if dialogue is to be conducted.

2.2.3. Interaction at a distance

Researchers always emphasise the importance of interaction in the learning process (Ritchie and Newby 1989; Harris 1999). Interaction is defined as a process that happens between the learner and the learning environment, in which the learner takes a more positive role (Berge, 1997). This environment includes the tutor, students and the learning content. Interactivity has been described as a key to success in traditional classroom to enhance learning and motivate learners (Fulford and Zhang, 1993; Wagner, 1994; Flottemesch, 2000).

Considering the definitions of distance education above, McIsaac and Gunawardena (1996) argued that that the isolation of distance students is determined not only by distance and time but also by the dialogue between the learner and the teacher, interaction with peers and the design of instruction. Fulford and Zhang (1993) stated that 'since teachers and learners are not in the same room, subtle interactions through body language are lost and learner perceptions of amount of interaction may be altered' (p. 8).

In a distance education context, studies found that students who enrolled in programmes that support and encourage interaction have highly positive attitudes toward learning and higher levels of achievement than others in one-way systems (Ritchie and Newby, 1989; Comeaux, 1999). In this regard, Garrison and Shale(1990) highlighted the relationship between the dropout rates in a distance education system and its interactive capabilities . They argued that:

> '[...] improving the quality of the educational process through increased two-way communication is likely to have the most significant impact upon the effectiveness of learning and in turn is likely to raise completion rates in distance education' (p. 128).

Holmberg (1990) believes that the ability of the medium to conduct interaction between the tutor and students is the essential criterion in selection among distance education technologies. He pointed out that any distance education medium should be able to provide the tutor and students with means of bringing about their experience, create rapport between them and offer opportunities for discussion.

McIsaac and Gunawardena (1996) indicated three constructs that affect students' attitudes and achievement at a distance: transactional distance, learner control and social context. These constructs are mainly affected by the concept of interaction. Moore (1989) provided a framework for studying interaction in distance education by defining three types of interaction:

1. Learner-content interaction, which occurs between the learner and the learning content to bring about changes in the learner's understanding, perspective or cognitive structures. Trentin (2000) believes that the quality of learning materials has an enormous effect on achieving this type of interaction.
2. Learner-instructor interaction, which occurs between the learner and the instructor to motivate and support the learner and allows for clarification of any misunderstanding.
3. Learner-learner interaction, which occurs between one learner and another learner, with or without the presence of an instructor.

Eaton (1997) agrees with Moore in defining these types of interaction. However, he described them as two general types: individual interaction and social interaction. Individual interaction happens between the learner and the learning material. However, social interaction happens between two or more learners concerning the learning material and may involve the instructor.

Stating another point of view, Hillman et al. (1994) noted that the earlier typologies of interaction failed to take into account the interaction that occurs when a learner uses 'intervening' technologies to communicate with the content. Therefore, he suggested a new type of interaction called 'learner-interface interaction', for example, sending and receiving messages using a specific e-mail program or dealing with the graphical user interface of operating system. According to Hillman et al., this new type is responsible for facilitating students' acquisition of skills needed to participate effectively.

Holmberg (1990) defined learner-content interaction (individual interaction) as a 'one-way traffic' in distance education systems. This one-way traffic is common in the earlier types of technology (e.g., printed materials and broadcast). However, using two-way technology (e.g., video-conferencing and the WWW), 'two-way traffic' can take place between the tutor and students. In this regard, Berge (1996) believes that while in earlier distance education programmes it was possible to conduct interaction only between the instructor and students, it is possible now for distance education students to interact with one another.

Garrison (1990) emphasised the role of interactive media and technology in conducting both types of interaction. He argued that without using these technologies, distance learning 'degenerates' into the correspondence generation of independent study in which the student is isolated. To achieve social interaction in education programmes, usually a real-time (synchronous) communication technology (e.g., telephone and video conferencing) were being used. However, with the development in communication technology (like the Internet), these kinds of interaction do not necessarily require real-time communication. Interaction can be independent of time (asynchronous), using communication tools (e.g., e-mail and discussion boards).

The type of interaction used in any distance education system depends on the nature of the communication system (synchronous or asynchronous), the kind of interaction (individual or social) that is needed, the number of learners (small groups or large groups) and costs. For example, Trentin (2000) highlighted the importance of group size in the success of the learner-learner interaction in distance education programmes. He argued that:

> 'the more the communication is directed toward socialization and sharing of ideas and experiences, the larger the discussion group may be, Conversely, the more the communication is directed toward collaborative study, the more limited group numbers need to be (Trentin, 2000, p. 20).

However, implementing interactive technology, like the WWW, and its components is not enough. Since distance education is characterised by the isolation of the learner, it means less involvement and fewer possibilities to ask questions. To solve these problems, Trentin (2000) suggested that:

> 'One of the key ingredients for raising the quality of an online course is strong interaction between the players in the process; organized in full-fledged virtual classes, the participants must obviously respect

schedules and deadlines if a collaborative working strategy is to be successful' (p. 20).

Many suggestions have been offered in the literature showing how to conduct successful interaction between the learner and the content, the tutor, peers and the user interface. For example, learner-interface interaction can be stimulated by instructional activities (e.g., computer games and informal chatting sessions) that help the learner become comfortable with the technology (Hillman et al., 1994). In addition, student-to-tutor and student-to-student interaction can be constructed and fostered using various strategies such as group-based collaborative projects, presentation boards and tutor questioning using interactive communication tools such as e-mail and discussion boards (Anderson, 1987; Moore, 1989).

2.2.4. The effectiveness of distance education

A debate in the educational technology literature about the effect of the distance education media on the 'learning outcomes' is reflected in the writing of Adams and Hamm (1988), Clark (1994, b), Jonassen et al. (1994), Kozma (1994) and Vargo (1997). The debate presents two opposing viewpoints. On the one hand, the medium used to deliver an educational programme can affect only the efficiency of delivery, not the outcomes of the learning. For example, television can facilitate reaching a wide range of learners (using cables or satellite) and reduce the time of learning (using audio-visual presentation). However, there are no significant differences between the results of students who learn by television and others who learn in traditional classes.

On the other hand, the medium can have an impact on the learning outcomes apart from its capabilities as a delivery medium. For example, using television affects students' performance and attitudes. In addition, television is easy to access and can reach thousands of students outside the class. A review of the literature showed that the majority of studies agree with the first point of view (that using the medium can affect only the efficiency of delivery, not the outcomes of learning). For example:

1. Schramm (1977) claims that the instructional strategy, rather than the medium, influences the learning process.

2. Adams and Hamm (1988) note that the instructional approach affects the development in learners' achievement. However the medium affects only the interaction between learners and the medium.
3. Clarke (1994) emphasises that media and their attributes have an important influence on the cost or speed of learning, but only the use of adequate instructional methods influences learning acquired.

However, stating another point of view, Morrison (1994) raised the criticism that studies 'do not allow researchers or those interpreting the results to determine how much of the variability is due to the teaching strategy and how much is due to the medium' (p. 42). Jonassen et al. (1994) believe that the debate about the effectiveness of media should focus not solely on the effectiveness of the media on learning outcomes, but also on the process of learning, the nature of the learning environment and the features that support this learning. Kozma (1994) provided another useful point of view. He claims that research should consider the ways in which the medium can be used to influence learning for particular students, tasks and situations. From a similar point of view, Vargo (1997) has agreed with Kozma by claiming that the system should concern the learning process rather than the influence of the medium. He believes that systems use various methods and media in complex social settings and all these components work together to yield learning outcomes.

Many studies were conducted to compare the effectiveness of distance education technologies on learning compared the achievement of distance education students with conventional classroom. The majority of these studies (e.g., Beare 1989; Ritchie and Newby 1989; Graham and Scarborough, 1999; Johnson et al, 2000) have shown that distance education students achieve better than, or at least similar to, conventional classroom students and distance education courses could be designed to be as effective as conventional on-campus education.

Souder (1993), for example, conducted a 'natural experiment' to examine the relative effectiveness of distance education compared to traditional classroom. The distance education course was delivered via satellite-based teleconferencing system. The results of evaluation obtained from assignments, term papers and questionnaire indicated that distance learners can perform as well as or better than traditional learners. He concluded that 'this study adds to the burgeoning evidence that distance learners should not be viewed as disadvantaged in their learning experiences' (p. 50). Similarly, Wisher and Priest (1998) compared between the performance of on-campus students and distance students using written achievement tests. He found that although the percentage of distance students (93%), who received their learning via audio tele-learning system, that reached criterion in the achievement test was significantly higher than the on-campus group (85%) there was equivalence in the graduation rate between the two groups, since all students ultimately passed the course.

However, although the distance education literature indicated that distance education is as effective as, or better than, conventional education systems, the effectiveness of distance education versus conventional education remains an on-going subject of debate and is affected by many variables (e.g., characteristics of learners, objectives of the programme, length of the study and technology of delivery) that require more investigation.

2.2.5. Costs of distance education technology

Since distance education relies on technology to deliver instruction and support the learner, it can be argued that a great part of its cost is that of technology (e.g., equipment, materials, operation, etc.). Costs vary between institutions according to the type of technology and programme. Curran (1991) and Bates (1995) noted that institutions that use the cheapest forms of technology do not provide support for students and encourage interaction. However, others (non-conventional systems) use expensive technology in which tutorial-style interaction is usually incorporated. In other words, the costs of distance education programmes depend on the choice of media. There are forms of distance education which involve personal tutoring (using telephone, for example) and others are based on textbooks only as a self learning approach (Rumble, 1999).

However, Rumble (1989) highlighted that many factors affect the costs of distance education technologies. For example:

1. The period over which costs are compared.
2. Inflation rates and changes in currency exchange rates.
3. The length of the study period.
4. The number of learners.

The literature reflects many different ways and approaches for looking at the costs of distance education technology. Thomas (1988), for example, used the 'value-added' approach to evaluate a computer-based conferencing system (as a two-way communication system). He argued that the advantages of such a programme should receive more attention than the costs. Jamison et al. (1978) used 'cost functions' to evaluate and compare the total cost of different radio and television projects (e.g., The Nicaraguan Radio Mathematics Project, The Mexican Radio Primaria and the Stanford Instructional Television System). He recommended that educators should pay more attention to the average cost of these systems and media (as shown below).

Bates (1991) broke down technology costs into three components, as an approach to understanding the cost structure for each technology. These elements are:

1. Production: which includes the costs of designing and developing teaching materials.
2. Delivery: the costs of each delivery medium which is used to get materials to distance students (e.g., post mail, telephone rent, television transmission, etc.).
3. Support: which includes the administration, facilitators' and tutors' salaries.

Overall, Jamison (1977), Wanger (1982), Markowitz (1987), Curran (1991) and Bates (1995) distinguish between different types of costs of distance education technology: fixed costs, variable costs, average cost and direct and indirect costs. Fixed costs are the initial costs of purchasing the equipment. These costs do not depend on the size of audiences or number of courses in the programme. However, variable costs depend on the size of audiences and number of courses in each programme (e.g., costs of teachers, materials, etc.). Production costs can be considered as variable costs as they depend on the costs of designing, developing and producing the course. However, delivery costs vary according to the medium. For example, in broadcasting, delivery costs are the costs of transmission, while in tapes the delivery costs are the costs of mail.

Average cost is the cost of a programme for each student per study hour. Marginal costs are the costs of adding one or more units of output to the system. Curran (1991) suggests a simple function to calculate the marginal cost for student per hour as follows:

$$MC = TC(N+1) - TC(N)$$

where:

MC is the marginal cost per student per hour

TC (N+1) is the cost of the system after adding a new unit

TC (N) is the cost of the system

Jamison (1977) argues that the total cost function can be approximated using the fixed and the variable costs per student from the following formula:

$$AC(N) = \frac{F}{N} + V$$

where:

AC (N) is the cost per number of students

F is the fixed cost

N is the number of students

V is the variable costs

Jamison emphasised that the above function gives a reasonable approximation to the cost behaviour of an instructional technology system, making it possible to find the cost for each student, taking into account the fixed and the variable costs, which may not remain constant. Considering Wanger's calculation (1982) of the average cost of any system (the total cost divided by the units of output), and Jamison's earlier function (1977), Bates presents the following function that gives the dollar cost per student (students being the unit or the unit of output for distance education) contact hour for an educational technology system, as follows:

$$\$ = \frac{t}{h \times n}$$

where:

\$ is the cost per student contact hour

t is the total of the variable costs

h is the average of studying hours

n is the total number of students who studied the course.

Bates argues that this function may be useful for estimating the costs before a project begins, or for evaluating the costs and benefits of a whole system.

Rumble (1997) pointed to other important types of costs related to distance education technology. These costs are direct costs, indirect costs and overhead costs. According to Rumble's approach the total cost can be explained and calculated as below (Table 2-3).

Table 2-3: Total costs of educational technology system

Costs	Elements	Example
Direct costs	The costs of designing, producing and distribution.	The costs of rough materials, machines, developers' salaries, mail, etc.
Indirect costs	The costs that cannot be directly attributed to the production.	The costs of equipment the students use to run the teaching materials (e.g., computers, TV)
Overhead costs	Costs other than direct and indirect costs	Like the selling and administrative costs.
Total costs = Direct cost + Indirect cost + Overhead cost		

The various earlier approaches for finding the cost of educational technology systems in general can provide a good background for developers to understand the cost-related factors that affect the selecting and developing of these systems. More importantly, these approaches can contribute in minimising the additional or unimportant stages associated with the delivery or presentation of teaching materials for distance students. Considering the earlier approaches for defining costs, Jamison et al. (1978) suggested a cost function that can estimate the total cost of using broadcasting. This function has been given as follows:

$$TC = C_C + C_P + C_T + C_R$$

where:

C_C = central costs (costs of research, planning and start up the programme)

C_P = programming costs (production equipment, facilities, etc.)

C_T = transmission costs (transmission operation and equipment)

C_R = reception costs (receivers, power, etc.)

Using recent technologies which have the ability to accomplish high-level objectives of interaction and support for distance education accompanied by high fixed costs, these costs tend to fall due to the long time of use and the number of learners who can be reached world-wide (as by television and satellite).

2.3. Media and technologies used in distance education: Advantages and limitations

This section sheds light on various types of electronic media used in distance education. These media are radio and television broadcasting, telephone, videoconferencing and computer and networking. However, other types of media are discussed under these headings. For example, audio and videocassettes are discussed under broadcasting as a solution to the limitations in using live programmes. The characteristics, advantages and limitations of these media are discussed in the light of Bates' (1995) ACTIONS model and Smith and Dillon's (1999) framework above.

2.3.1. Radio and television

In the 1930s, educational radio programmes were introduced, adding instruction by radio to the usual array of print materials and correspondence by post (Halliwell, 1987). Although educational radio and television began decades ago, they are still the most popular medium. There are several major reasons why broadcasting should continue to play a major role in distance education, as reflected in the literature:

1. 'The broadcast element includes constituents which are unique to the medium and which provide experiences not easily gained by other means' (Robson, 1974, p. 213).
2. Broadcasting reaches audiences that other forms of education do not reach;
3. Compared to other media, radio is extremely flexible, has a dramatic effect and can stimulate the imagination of learners (Heinich et al., 1993).
4. With the development in communications satellites, radio and television can reach a long distance and use extra numbers of channels, with their potential for two-way signal carriage (Kent, 1969; Bates 1984; Halliwell, 1987; Bates, 1995).

However, although radio and television broadcasting is a flexible and easy to access technology, instruction goes in one direction, from the tutor to the audience and the medium does not support transfer of information in the opposite direction (Cronje, 1996). Braun (1962) found that these programmes had no significant effect, when compared with traditional instruction, unless they were used in situations where they were integrated with other activities (e.g., problem-solving in mathematics) in a learning situation with an active role for the learner.

Spencer (1996) reviewed studies in TV instruction and concluded that 'over a wide range of subjects, there is no difference between class lectures and TV instruction' (p. 22).

The following points summarise the limitations of broadcasting as reflected in the literature, in the light of ACTIONS (Bates, 1995) and Smith and Dillon's (1999) framework.

1. Broadcasting does not have many of the features available in printed materials, as an old fashioned medium, such as learner control and self pace (Gunawardena and Dillon, 1992).
2. Although broadcasting is considered as a powerful tool for bringing the real world into the classroom, programmes often lack strategies for involving learners actively in the programme or in cognitive activities (Schwier, 1987; Krendl and Watkins, 1988).
3. Certain types of experiences cannot be transmitted by broadcasting, such as face-to-face contacts and abstract ideas that need interaction and deep explanation, like mathematical concepts (Costello and Gordon, 1965).
4. In terms of cost-effectiveness, Bates (1995) indicated that the costs of production, equipment and transmission per hour are very high in comparison with other media.
5. Bates (1984) criticised radio saying that it is difficult for students to talk, practise skills or understand difficult points unless teachers integrate broadcasting with other learning activities.

As a result of the limitations of radio and television, many solutions were suggested to overcome them. These solutions include using audio- and video-cassettes and two-way interactive radio/television to give the learner more control and to facilitate interaction between the teacher and students. Heinich (1993) pointed out that instructors (and students too) resist media that have to be used according to a rigid pre-set schedule. The advantage of cassettes is that they allow students to control and discuss the material as often and for as long as they wish (Brown, 1984). Audiocassettes afford learners control over instruction because they can play, stop, forward or rewind the tape. In addition, they offer flexibility in the way they can be used (e.g., at home, school, etc.) and they are easily accessible to students, since they are cost-effective (McIsaac and Gunawardena, 1996).

With the low-cost of audio and videocassettes players, and their flexibility in use, Crooks and Kirkwood (1990) argued that videocassettes can achieve learning more effectively than television, due to the often inconvenient transmission times of broadcasting. Moreover, cassettes can increase the amount and level of interaction between learners and the learning materials and give more opportunity for human interaction (Bates, 1984).

2.3.2. Telephone and audio conferencing

The use of the telephone in distance education was a result of the limitations of broadcasting as one-way medium. The main reason for using the telephone medium is to establish a direct connection between the teacher and students at a distance. Using the telephone, individually or in groups, students can gain learning experiences by interaction with the tutor, receiving information, feedback or asking for immediate support. Using the telephone takes two forms (Robinson, 1990): one-to-one telephone tutoring (teacher-to-student) and small-group audio-conferencing (students-to-students). The purpose of the first form is to provide students with human support. However, the purpose of the second form is to link students together for helpful dialogue and to socialise the learning process. McConnel and Sharples (1983) argued that the telephone can overcome many contact problems between students and tutors, whether in one-to-one links or in small group conferencing.

A review of the literature showed that telephone-based courses use three main techniques: voice mail, documents exchange using fax and audio teleconferencing. Using additional equipment, a voice message (or messages) can be stored for distance students to access at any time/anywhere. Voice mail has added many functions to the telephone and its uses in distance education. Some of these functions are as follows:

1. Allowing connection to electronic grade book programmes.
2. Ability to check on a student's progress which is known as 'homework hotlines'.
3. Obtaining test schedules.
4. Checking attendance records (Lucas, 1994).

Fax seems to be a suitable choice for distributing printed materials. Using fax, the tutor can send course materials, homework and feedback. At the same time, students can submit their assignments or send their questions for more explanation. Graphic exchange over the telephone has many advantages for distance education, for many subjects (e.g., mathematics), such as fast transmission of printed materials (text and graphics) and ease of access, since it uses the telephone line which is available at schools and homes (Robinson, 1990).

Audio conferencing occurs when more than two telephones are linked together at the same time. Telephone conferencing enables students to interact directly with the tutor or experts, exchanging experiences or ask questions. Using loudspeakers, the telephone can link learners in a small or large groups. A conference can consist of students at their homes or in study centres (Kember and Murphy, 1994).

Idrus (1993) agreed with Robinson (1990) on the effectiveness of using the telephone for tasks which involve information transmission, problem-solving and generating ideas, giving and receiving information, asking questions and exchanging opinions. Idrus believes that telephone can be as effective as face-to-face teaching and in some cases more effective than correspondence.

Although the equipment needed for using the telephone in distance education is already available, albeit at different levels, the telephone machine and fax have many limitations. Some of these limitations are as follows:

1. Telephone tutorials do not allow full interaction between teacher and students, unlike face-to-face instruction. Prepared materials have to be delivered by print or audio-tapes to the learners in advance (Kember and Murphy, 1994).
2. Conference calls require special equipment known as a conference amplifier or conference bridge. This equipment is necessary to avoid the loss of power that would be caused by connecting a large number of telephones in parallel (Open University Course Team, 1976).
3. Students do not make extensive use of the telephone and they usually prefer direct contact to telephone dialogue (Gunawardena and Dillon, 1992).
4. Most science courses are heavily dependent upon visual representation, particularly these that contain graphs, formulae and diagrams. These subjects need additional visual media besides the telephone (Robinson, 1981).
5. The absence of visual presentation requires some adaptation in communication behaviour, particularly among groups of students in audio conferences (Robinson, 1990).
6. Individual calls are costly in time and money for the tutor and students (Choat, 1983).
7. Although the telephone is very common, audio teleconferencing usually requires the student to travel to a nearby study centre, with a consequent loss of independence (Garrison, 1990).

As a result of the limitations of telephone and audio teleconferencing, a new generation of solutions has been found. The main objective of this generation is to conduct audio-video/real interaction between the tutor and students, with visual capability.

3.3.3. Audio-video teleconferencing systems

Audio-video teleconferencing as a communication system among people, located at two or more different places, provides audio-visual live interaction between the learner and the teacher and among a group of learners (Rao, 1994). The literature reveals that there are various systems of audio-video teleconferencing. These systems vary from simple audio-graphic systems to full two-way audio-video systems. Each system has its own advantages and limitations.

- Audio-graphic teleconferencing

Audio-graphic teleconferencing is a two-way real-time interaction system. It provides an opportunity for immediate responses to questions and interaction among the participants in the discussion (Idrus, 1993). Audio-graphic teleconferencing combines still-picture transmission with audio teleconferencing. Several different devices can be used to send pictures and graphics over the same telephone lines (Heinich et al., 1993).

- Audio-low-scan TV teleconferencing

Audio-low-scan TV teleconferencing takes two forms: telewriting and teletext. Telewriting systems add graphics to audio-conferencing and allow for the live transmission of writing and drawing by telephone between two or more screens (Heinich et al., 1993). However, teletext is broadcasting system for displaying text and graphic on any TV set with special teletext decoder. Zorkoczy (1984) argued that a degree of interaction was added using response terminals to allow the learner to select specific pages, answer questions or determine the waiting time. Furthermore, the recent models of teletext support dynamic images and sound as well as static images. In addition, two-way audio can be added to a teletext system to add interactivity to the system. Bacsich (1984) pointed out many technical advantages of teletext systems, such as low cost, fast response and a simple user-interface.

- CYCLOPS

CYCLOPS was developed in the Open University in 1976, as a solution to one-way television broadcasting. The most important feature of CYCLOPS is its ability to be linked by voice via telephone line. Using CYCLOPS, students and tutors can write and send drawings to each other (McConnel and Sharples, 1983).

- Telematics

Oliver and Reeves (1996) described telematics as synonymous with interactive television. The telematics system is a one-way television that transmits instruction from teacher to students. Interactivity between teacher and students is established through a free call-back telephone enabling students to communicate directly with the teacher during broadcasting.

- Full audio- video-conferencing

Simply, two-way audio-video teleconferencing is a fully interactive television system. It supports two-way communication using audio and video between or more two groups. Sites are connected using telephone lines, local network or satellite. A powerful and attractive attribute of video teleconferencing is that participants are able to hear and see each other and the teacher. Garrison (1989) believes that 'if students can see the teacher and the teacher can see them, then the educational transaction at a distance is virtually identical to that in a traditional classroom setting' (p. 74).

Although audio-video teleconferencing systems can provide real-time and visual interaction simulates face-to-face interaction, they still too have many limitations to be widely used in distance education. The major limitation of audio-video conferencing systems is that it needs to be associated with other forms of materials (such as printed materials). These materials need to be distributed to students to use during or after conferencing. In addition, many technical problems still face full video-conferencing systems, such as bandwidth capacity. The high rate of visual signal and the transmission rate cause performance degradation in both audio and visual conditions. Satellites can be used to reduce the transmission time of audio- video-conferencing, but teaching with satellite requires skills and sensitivity in student interaction.

Heinich et al. (1993) agree with Bates (1984) on the high cost that still faces the production and delivery of teletext systems. Furthermore, Oliver and Reeves (1996) report that with the high cost of these systems, students rarely work together and most communications are between individual students and the teacher. In general, teaching at a distance using conferencing has two limitations: it is not time independent and restricts the type of content that can be delivered.

2.3.4. Computers and networks

By the early 1980s, the rapid developments in computing and information technologies began to create a new paradigm of using computers in education. A new generation of storage and distribution of course-related information in new, flexible and effective ways was created. These features, plus the interactive nature of the computer as a learning environment for individualised instruction, have attracted distance educators more than any other medium ever, and moved distance education away from static, one-way systems to new and effective delivery modes (Gray, 1988). Heinich et al. (1993) set out many of the interactive capabilities of the computer that gave it prominence at that time. For example, it allows students to learn at their own pace, enables personalised responses and reinforcement, and is effective with special learners.

As a learning device, the computer has a number of outstanding possibilities to communicate, support and control other devices. For example Barker and Yeates (1985) found that computers can facilitate data archival, retrieval and dissemination, offer a variety of data-capture techniques, facilitate control of external devices and of learning progress and generate sounds and graphical effects.

In distance education settings, Lehman (1995) highlighted the importance of course delivery using courseware. He indicated that computer-based instruction can replace many traditional media of distance education using instructional software, which can be supplied to distance students using diskettes. Since delivery is an important element of distance education programmes, the development in storage devices has had a significant impact on the use of computers in distance education programmes (Jones and Kirkup, 1992). The high capacity of CD-ROMs and the availability of CD-ROM drives in most students' machines, in particular, have encouraged designers to store an enormous amount of text, graphics, audio, and full-motion video clips in a single CD-ROM, and distribute courses to students at home (McIsaac and Gunawardena 1996).

Computer-based distance education packages range from static electronic pages to show the content (e.g., text, images and audio) as an electronic book with a passive role for the learner, to intelligent courseware capable of dealing with the learner individually and involving him/her in a real learning environment that responds to his needs and problems. In this regard, Swann (1997) noted that:

1. Different educational computer packages allow different levels of interaction.
2. There is variation in the quality of presentation.
3. There are differences in the accessibility of information within programmes and the depth and quality of information presented.

The development in educational computer applications, accompanied by dramatic development in communications technology, was followed by a revolution in the concepts of networking and Computer-Mediated Communication (CMC). A network is a communication system that allows two or more computers to communicate and exchange information with one another using a variety of networks (e.g., Local Area Network and Wide Area Network) (Hiltz, 1994). Networking allows teachers and students to share resources on their computers or to access information located in other computers or networks (e.g., database, library, etc.). In addition, it enables distance education tutors to operate and manage students without the need for additional delivery or communication media (Thomas, 1988).

CMC is the most popular form of using networks in distance education. Using CMC, the interaction between tutors and distance learners has been established using various forms of computer-based conferencing (audio, video and text conferencing) (McMillan, 1997). CMC allows distance learners to exchange messages with the tutor or other learners on the network. Basic CMC usually takes one of the following forms:

1. Electronic mail: to send and receive messages between two computers in the network.
2. Computer conferencing: which is based on text, still images, audio or video and may run synchronously or asynchronously.

This revolution in the networking concept led some educators to claim that the era of computers is over and that the most significant technological advances will come from networks (Calbreath, 1999). The concept of internal and wide networks was still limited until the mid 1980s. At this time, a new comprehensive networking phenomenon was established world-wide. This new phenomenon is the Internet, which is known as the global network of networks. However, it would be unjust now to consider the Internet just as an unlimited network (see the next chapter).

Although the literature has discussed far more advantages in using computers and networks in education than disadvantages, research has identified some disadvantages. Poor courseware, unreliability, self-management, cost effectiveness and the lack of human interaction are the main problems, which have been mentioned. Among the most considerable disadvantages commonly reported is that shown by Kennedy (1996). He argued that:

> 'Harnessing the power of the computer calls for new ways of examining how the computer can help in learning. Today's courseware has not yet reached its potential to fill this need and often it attempts to engage students through drill and practice'.

Furthermore, Kirkpatrick and Cuban (1998) claimed that as the earlier technologies have failed to meet public expectations, most courseware reaches for lower-order rather than higher order thinking skills. Davies and Inman (1995) found that there are two main limitations of most courseware available today: poor quality and the unreliability of CAI, derived from the fact that learners are usually at a loss with programmes that behave unexpectedly.

In a distance education context, Barker and Yeates (1985) and Drury (1996) pointed out an important problem associated with using courseware for teaching students at a distance, called the 'transferability problem'. This problem arises for a variety of reasons, such as media and hardware incompatibility (as between disks and drivers), the need for continuous updating and inadequate documentation and technical support. In addition, Gunn (1997) pointed out two main challenges that face the use of computers in teaching students at a distance today: students may not be able to study alone with CAI programs and they may encounter repeated problems as they work at their own pace.

In terms of learning effectiveness, Roblyer (1989) reviewed 38 articles and 44 dissertations on computer-based instruction (between 1980 and 1987) focusing on the impact of microcomputer use in specific areas and with specific kinds of students. He calculated effect sizes for each study, summarised them across studies and compared them in a number of areas. In addition, he examined the effectiveness of computers at certain grade levels, with certain types of content, with certain types of students and in relation to students' attitudes. He concluded that 'an overall finding was that computer applications had a statistically significant positive effect ($p<0.05$) in a majority of the areas examined' (Roblyer, 1989).

By virtue of CAL's advantages and limitations, the need for a new form of environment that involves the human teacher (rather than simulating the behaviour) has arisen. Barker (1985) recommended that because a significant part of the teaching process involves much more than information retrieval, courseware should be designed to implement the intelligent behaviour of human teachers. These features and others are available on the Internet and the World Wide Web.

2.4. A theory of development and evaluation of distance education technologies

The above review of distance education technologies shows that the development in technologies has focused on production and distribution of instruction using audio and video to reach a wide range of learners. This development began with no or minimum interaction, less possibility to access instruction and low cost, allowing it to be more accessible (e.g., radio and television, audio- and video-cassettes). Accordingly, technologies were developed to enrich presentations, individualise instruction, speed transmission and provide multimedial content. Examples of these technologies are audio-graphic systems, audio-video conferencing and computer programs.

These technologies enhanced learner-control over instruction and allowed real-time interaction between the tutor and students and, for the first time, between the learner and others on the course. More recently, a dramatic development in computing and networking has occurred. This development in computing and networking technology has shaped a unique paradigm of access to instruction, characterised by easy and unlimited access to information, real-time or delayed interaction, flexible learning and learner-based instruction. The development in distance education media and technologies is characterised by three models: the correspondence model, the tele-learning model and the information and networking model.

- **The correspondence model (1890s-1960s)**

This is the earliest model of distance education and used to package and deliver instruction for isolated students. Basically, 'correspondence study has meant the exchange of lessons by mail. [...] however, there are many new approaches to course work and although mail is still the prime means of exchanging lessons, technological advances are being introduced'(The Dominion Bureau of Statistics, 1971, p. 287). However, the correspondence model does not mean simply delivering textbooks with other media. Perraton (1982) indicated that correspondence education is distinguished by three features: the use of a variety of different media, its structure and its system for feedback. In this model, 'two-way communication between students and teachers separated by distance only became practicable with the advent of railways, and a relatively fast and efficient postal service ' (Powell et al., 1999, p. 86). Mail was used by students to send their questions and assignments and receive feedback and comments from the tutor. Due to the low speed of interaction, particularly for students at a long distance, interaction between the tutor and students was scarified in many cases.

Although this model 'represents an opportunity for students to study when and where it is convenient and in a low-cost manner, most of the limitations of correspondence study are associated with the delayed form of communication' (Garrison, 1989, p. 56), the difficulty of maintaining motivation and high drop-out (Wedemeyer, 1971). Enrichment of the learning process by adding more student-centred activities, offering local centres for group-based learning and discussion, motivating students to contact the tutor and others in the course, speed communication and using other interesting media (e.g., radio and television) would reduce these problems.

- **The Tele-learning model (1960s-1980s)**

In the correspondence model, the aim is to make instruction easily accessible in a low-cost and efficient manner. However, distance education is 'more than an efficient method of making information available to learners' (Garrison, 1989, p. 64). Therefore, the tele-learning model aims to distribute on-campus instruction using one-way media (e.g., broadcasting radio and television) with two-way communication technologies (e.g., telephone and teleconferencing). Radio was the first technology that characterised this model. In this regard Perraton (1982) pointed out:

> 'studying by correspondence alone, for example, is almost a byword for boredom. Radio programs to support correspondence lessons offer a stimulus and a sense of personal concern to an isolated student. At the same time the content of the radio program can reinforce the content of the print, and it may be possible to use each medium to present that part of the content for which it is most appropriate' (pp. 5-6)

Following radio, television broadcasting brought about a revolution in distance education by transmitting face-to-face style of instruction to homes and schools. In addition, the availability of satellite has increased accessibility and reached far locations in a cost-effective way (Wisher and Priest, 1998).

Although broadcasting is a very popular and appropriate technology for developing countries (Keegan, 1988), the most important problem of broadcasting, as realised by the Planning Committee of the British Open University, is that 'the amount of learning materials required to meet the needs of a full range of degree courses would be too great to cover by broadcasting alone' (Bates, 1988, p. 228). The real development in this model occurred when communication, as the 'second element' of distance education, was enhanced by using audio and video tele-conferencing (Holmberg, 1990). However, although the major benefit of tele-conferencing is its ability to overcome the isolation of distance students (Dymock and Hobson, 1998), the major disadvantage of tele-conferencing is the pedagogical and technical experience and skills needed to use it.

- **The information and networking model (1990s-)**

The lack of convenient and effective interaction for independent learners has always been a weakness of the tele-learning model of distance education (Bates, 1991) while access to course-related information and resources is a common problem facing distance students in the model (Kirkwood, 1998). The potential of information and networking technologies is that they combine media (e.g., text, hypertext, images, video, etc.) and technologies (e.g., interactive CD-ROMs and the WWW) to represent knowledge and facilitate student-content and student-peers interaction effectively (Westera, 1999).

This model implies 'a more generic approach to teaching and learning, in cont rast to the largely one-way flow of packaged knowledge and instruction from teachers to learners' (Kirkwood, 1998, p. 231). For example, interactive CD-ROMs have the power to individualise learning as they allow the learner to explore, search and interact with the content and user-interface effectively. Moreover, the Internet provides access to a vast amount of up-to-date information, offers the ultimate interactive learning experience and encourages collaboration and discussion among distance students (Rose, 1999).

The WWW, specifically, has become the most popular and easy to use service of the Internet and provides access to most Internet services (e.g., e-mail, desk-top conferencing, FTP, etc) and resources (e.g., text databases, multimedia and hypermedia archives, etc.) with no limit to the number of students. Currently, the WWW is increasingly used in distance education for communication, conducting discussion, delivery of courses, searching for course-related information and evaluation of students.

Considering the characteristics, advantages and disadvantages of distance education models, it can be said that many key features been driven the development and success of media and technologies:

1. Time of interaction (synchronous/asynchronous)
2. Type of interaction (student-student, student-teacher, student-content and student-machine)
3. Learning style (support group-based learning/individual learning only)
4. Flexibility (anytime/anyplace)
5. Speed (delivery/feedback/development)
6. Cost-effectiveness
7. Multimedia support
8. Use as a stand-alone medium

9. Learner-control

10. Ease of use

11. Ease of access

The above features of distance education technologies are categorised into five categories with their contribution to distance education (Table 2-4). These categories and their features are considered as a generic framework for evaluation of distance education technologies.

Table 2-4: A framework for describing the features of distance education technologies

Criteria	**Feature**	**Contribution to distance education**
Time of communication	- Asynchronous - Synchronous	Distance education can be time-independent (e.g., video-cassettes) or time-dependent (e.g., broadcasting television). Both of these two types are useful and required to deliver instruction and motivate and support students.
Type of interaction	- Student-teacher - Student-student - Student-content - Student-technology	The ideal distance education technology should facilitate two-way interaction between the tutor and learners, among learners, between the learner and the learning materials and between the learner and the machine or technology that delivers instruction.
Learning style	- Individualised - Group-based	Often, distance education happens in individual settings. However, recent trends in distance education encourage social and group-based learning using on-line discussions and collaborative projects. Distance education media need to support both of these styles.
Instructional	- Multimedia - Stand-alone	Traditional media whether visual only (e.g., printed materials) or audio-visual (e.g., video-conferencing and TV) have many limitations in presenting knowledge. Recent technologies integrate text, audio, animation and video (e.g., computer-based multimedia applications and the WWW) to enhance the learning experience, allowing them to be used without need for the support of other types of media.

Criteria	Feature	Contribution to distance education
Cost	- Cost effectiveness	The unit cost of a medium is affected by its fixed cost, variable cost, capital cost, recurrent costs, marginal cost, etc. High variable costs for a medium, for example, increase the unit costs per hour and discourage decision-makers from selecting it and learners from continuing in their learning. At the same time, stand-alone media (e.g., the Internet) avoid both the course provider and the learner having to pay for communication, sending and receiving feedback and access to learning resources.
Organisational issues	- Ease of delivery - Ease of access - Ease of use - Speed - Flexibility	Media, whether old or new, should be simple enough and available to access at homes or schools, easy to use by educators and students to deliver and receive instruction, fast enough in terms of transmission and updating of content, etc.

Applying the above model to evaluate radio, for example, shows that radio:

1. Supports synchronous learning only since students have to attend the class at a specific time to listen to the programme.
2. Does not support student-student, student-teacher, student-content or student-machine interaction.
3. Is not suitable for group-based learning.
4. Can be accessed at any place.
5. Is characterised by the speed of development and transmission of programmes. However, questions and feedback require a long time to be sent.
6. Has very high fixed, capital and recurrent costs. However, variable cost is very low. At the same time, receiving instruction is less costly.
7. Uses audio only to deliver instruction.
8. Is not a stand-alone medium and should be used with other media (e.g., print and post).
9. Is not student-centred and students have no control over the transmission of the programme.
10. Is easy to be installed and used at home or school.
11. Is easy to access at home or schools, since it requires nothing more than a radio receiver.

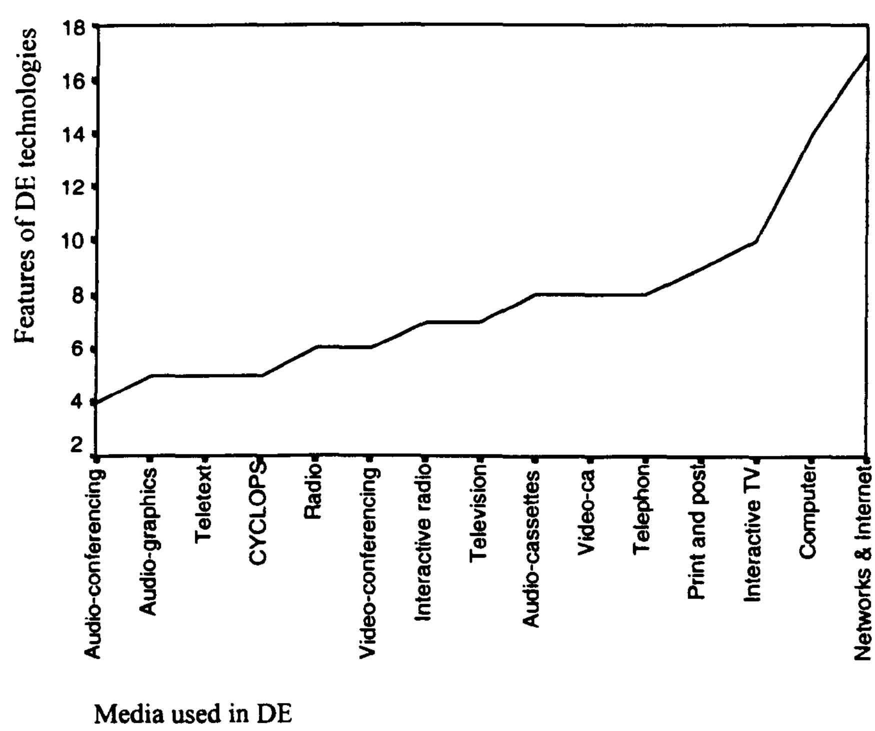
Table 2- 5: A framework for looking at distance education technologies

Category	Feature	Print and Post	Radio	Interactive radio	Audio-cassettes	Television	Video-cassettes	Telephone and fax	Audio-conferencing	Audio-graphic	Video-conferencing	Teletext	CYCLOPS	Interactive television	Computers & CD-ROMs	Networks & the Internet
Time of interaction	Synchronous		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓
	Asynchronous	✓			✓		✓	✓					✓		✓	✓
Type of interaction	Student-student							✓	✓		✓					✓
	Student-teacher			✓				✓	✓	✓	✓	✓	✓	✓		✓
	Student-content	✓		✓						✓					✓	✓
	Student-machine				✓		✓			✓				✓	✓	✓
Learning style	Group-based	✓							✓		✓			✓	✓	✓
	Self-based learning	✓			✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Flexibility	Anytime	✓			✓		✓								✓	✓
	Anyplace	✓	✓	✓	✓	✓	✓	✓						✓	✓	✓
	Ease of access/use	✓	✓		✓	✓	✓	✓						✓	✓	✓
Speed	Development	✓	✓	✓	✓										✓	✓
	Feedback			✓							✓			✓	✓	✓
	Delivery		✓	✓		✓		✓			✓	✓	✓	✓	✓	✓
Instruction	Stand-alone medium														✓	✓
	Multimedia support					✓	✓							✓	✓	✓
Cost	Low cost	✓	✓		✓	✓	✓								✓	✓
Total		**9**	**6**	**7**	**8**	**7**	**8**	**8**	**4**	**5**	**6**	**5**	**5**	**10**	**14**	**17**

This evaluation shows that radio gets 6 points out of 17. This means radio fulfils only 35 per cent of the features that should characterise distance education technology. In addition, the majority of media (11 out of the 15 revised) meet less than 50% of the features. However, print and post as traditional media get a relatively high score (53%) in comparison with recent media (Table 2-5). Lastly, this framework shows that the Internet and the WWW meet all the criteria that should be available in distance education media and technology to be used successfully at a distance.

This simple analysis reflects that the majority of technologies used in distance education do not satisfy many of the criteria of distance education technologies, as reflected in the literature. These media and their characterises are graphed below (Figure 2-3).

Figure 2-3: Characteristics of media and technologies used in distance education



Media used in DE

This graph shows that:

1. A dramatic development happened in distance education media and technologies to fulfil the requirements of distance education. This development is not time-based but depends on the features of media and technologies.
2. Although most of the recent media may seem to be perfect solutions for distance education or 'third generation' technologies, they do not possess most of the characteristics required

of distance education (e.g., flexibility and cost-effectiveness). At the same time, approaches that are considered as traditional (e.g., print and post) can be used successfully, since they fulfil more than 50% of these criteria.

3. There is no one medium better than other; every medium and its technology has its own features and these media should be selected and used according to the need of the programme, tutors and students (e.g., the needed type of interaction, costs, etc.).

For example, although video-conferencing, in comparison with print and post, is a two-way interactive medium, encourages interaction between the learner and the tutor and between the learners and others, is suitable for group-based and collaborative learning and fast in sending and receiving feedback, it does not facilitate student-content and student-technology interaction, is not easy to be used by all tutors and students, is not easily accessed at any time and from any place, needs to be supported by other types of media and is not cost effective.

Similarly, although the development in computers and CD-ROMs has offered learner-centred, self-paced and sophisticated multimedial solutions for learners using flexible storage solutions, a common drawback is the isolation of learners from human tutoring. Therefore, an important breakthrough in computing has been shaped by the networking and computer-mediated communications concepts. The unprecedented growth in networking technology has yielded a wide range of powerful and wide networks and has led to the world-wide international network known as the Internet.

As the earlier breakthrough in computing has yielded the Internet, the second remarkable breakthrough in the Internet was the World Wide Web protocol. The World Wide Web has evolved new channels of delivery that have encouraged educators to present materials in ways that did not exist a few years ago. In addition, it has offered many tools to conduct asynchronous/synchronous interaction between the tutor and learners and among learners themselves.

2.5. Distance education for the benefit of school students

Although many sectors call for the development and spreading of distance education, a review of the literature showed that in the last few decades, most distance education programmes have focused on adult education, rather than students at the earlier stages. The largest use was for 'short courses to help farmers and small businesses adapt to new technologies' (Fulton, 1992).

According to the NCES (National Centre for Education Statistics) (1998), 'among potential audiences for distance education courses, professionals seeking recertification and other workers seeking skill updating or retraining were targeted by more institutions than were other types of individuals'. A survey on distance education courses offered by education institutions indicated that 88 percent of institutions targeted professionals seeking recertification, skills updating or retraining (NCES, 1998)

A recent survey of adult education (National Institute for Literacy, 2000) reveals that educators are increasingly viewing distance learning as a delivery mechanism that can reach adults who are unable to attend traditional adult education classes due to work or family commitments, lack of transportation or other obligations. The essential features of adult and continuing education are the age of learners and their responsibilities (e.g. job and family). The freedom from time and social constraints offered by distance education programmes expands access to education for these learners.

The majority of programmes target adult learners, enabling them to continue in their studies through access to degree studies programmes. A remarkable example in this case is the British Open University. According to its 1998 factsheets, more than 200,000 students were registered with the Open University during the academic year 1998 and 80 per cent of them were in employment (Open University, 1999). Another example in the UK is Aberdeen University in Scotland, which offers local study centres located throughout the Highlands and Islands for adult learners. Using a telephone, an electronic writing pad, a monitor and a loud-speaker telephone, the learner can contact live teachers and access a set of part-time courses (McLean, 1998).

Disabled adults, in particular, are natural users for distance education. According to the Open University factsheets (1999), about 5 per cent of all its students are disabled. Disabled students who are unable to benefit from on-campus education, even if they are within reach of an education institution, can use distance education as an alternative way of on-campus education (Owston, 1997).

In general, distance education attracts and has many advantages for adults. It can eliminate travel and moving problems, reduce costs and offer a flexible mode of learning. In addition, text-based systems, captioned videotapes and computers with multimedia capabilities can overcome many of the problems of disabled students (e.g., deaf and blind).

However, although the distance education approach was originally invented to help adults, who could not attend conventional classes, 'distance education methods together with existing conventional systems will converge for the benefit of all learners – not just those we define as adults' (Garrison and Shale, 1990, p. 131). In the last few years, distance education has captured the interest of many elementary and high school students. In other words, adults are no longer the only target of distance education (Dhanarajan, 1996). Lehman (1995) found that there are many problems that encourage students and schools to move to a distance education approach. For example, in many situations, students have to travel to the school site or cannot access class sessions after they have occurred. At the same time, schools need to overcome problems challenging them, such as lack of trained teachers or the increased numbers of students.

In elementary education, distance education programmes are used to reduce costs, provide new types of courses or engage others who cannot attend the class (Moore and Kearsley, 1996). Many programmes are now available for students at elementary and secondary schools, using different kinds of media. For example, the UOP system is an Internet-based distance education system provided by the University of Phoenix in USA (Swenson, 1995). Students can access the school or university library, participate in discussions, attend on-line classes, submit assignments and exchange messages. This programme emphasises collaboration among students and encourages them as active participants.

Traditionally, schools participate in these programmes using radio, television or video-conferencing allowing students to exchange knowledge and interact with one another in a social context. Using the Internet, schools can conduct development programmes for students and teachers, integrate a wide range of materials into classroom projects and allow students to communicate with other Internet users. For example, Kirby (1998) indicated that in the United States, formal federal support for elementary and secondary distance education began with the initiation of the Star Schools Program. In 1998, the congress passed the programme to provide funding for the support of improved instruction in mathematics, science and foreign languages to students, using distance education technologies.

To meet both the short-term and long-term educational demand, many countries world wide have begun to establish and distribute courses and classes for young learners at home. Within distance education, 'cyberschools' are a new type of virtual schools that offer courses and classes conducted electronically and are less costly (Jones, 2000). An example for this type of schools is the Cyberschools. According to the founders of Cyberschools [*], this type of virtual learning offers accredited primary and high school level credit courses over the Internet, intended to expand a student's face-to-face course choices. Cyberschool currently offers tens of online courses that are asynchronous, individualised and self-paced.

Owston (1997) referred to three growing areas where distance education attracts students and parents and provides an alternative to conventional school. These areas are home schooling, alternative schooling and extension course delivery. For many geographic, political or religious reasons, many parents prefer to educate their children at home. Alternative virtual schools enable students to access quality learning materials and contact peers and tutors. The third area (extension courses) is the most growing, practical and famous use of distance education in the primary and secondary education sector. Usually, students at secondary schools and their parents are seeking for complementary courses in basic sciences (e.g., maths and science) and languages (particularly second languages) to improve learning or compensate for the lack of quality education at schools.

Considering the target audience of this study, today, young learners have the choice to attend a traditional classroom or the virtual classroom, or at least choose among thousands of courses available world-wide (Hamza and Alhalabi, 1999). Recent technology like the Web facilitates joining virtual classes or access to course related information, interaction and exchange of information with others.

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[*] Cyberschools available on the Web at http://www.cyberschool.k12.or.us

Conclusion

The above review shows that, first, distance education is not a new concept and has a long history of development, allowing it to be one of the formal means of education for those who cannot attend on-campus education. However, students in the earlier distance education systems faced many problems, which discouraged them to enrol in off-campus classes or complete their programmes. A review of the literature showed that most these problems were technology-related barriers, such as the lack of face-to-face interaction, lack of support and tutor feedback, low-speed of delivery of instruction and difficulty of access the technology (such as tele-conferencing).

Second, the development in media and technologies used in distance education emphasised the need to identify features that should be met by distance education technologies. The importance of this formula highlighted the need to use a comprehensive framework to analyse and describe distance education technologies. In his ACTIONS model, Bates (1995) argued that distance education technology should be described, compared or evaluated in terms of access, costs, teaching and learning functions, interactivity and user-friendliness, organisational issues, novelty and speed. In the light of this model, previous technologies used in distance education have been reviewed and the advantages and limitations of each medium highlighted. This evaluation framework may provide a comprehensive guide to realising the technical and pedagogical advantages and limitations of the Internet and help in designing and evaluation of a Web-based learning environment for teaching students at a distance, according to the purpose of this study.

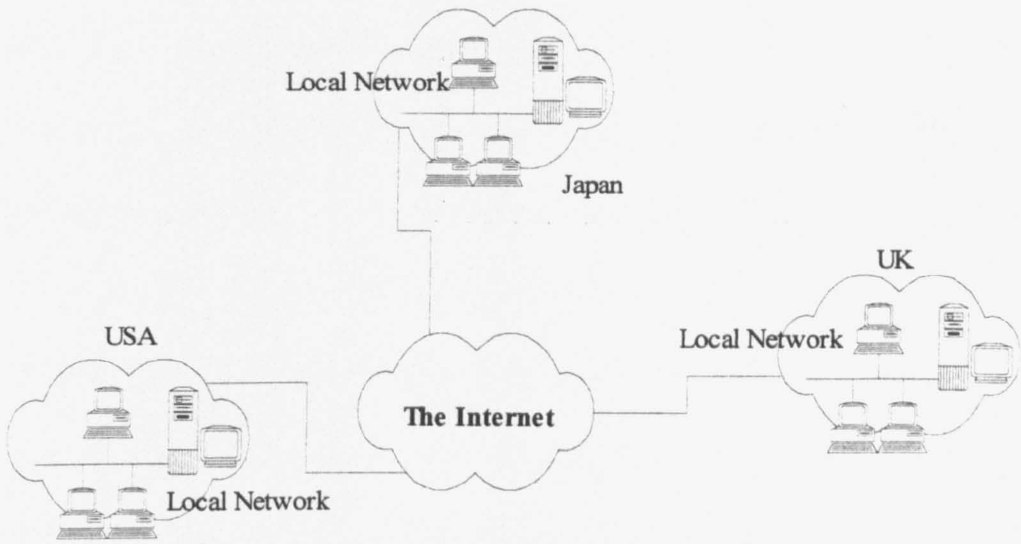
Based on the issues reviewed in this chapter, the key technical and pedagogical features of the Internet, as the basis of on-line education, are reviewed in the next two chapters.

Chapter 3: Internet Technology as the Basis of On-line Education

In the previous chapter it was found that the concept of internal and wide networks was still limited until the end of the 1980s. At this time, a new comprehensive networking phenomenon was established world-wide. This new phenomenon is the Internet and the World Wide Web. A review of the media and technologies used in distance education (Chapter 2) showed that although the majority of these technologies did not meet the basic criteria that should be available in distance education technology (e.g., interactivity, multimedia support and accessibility), the Internet and the WWW might meet all these criteria. This point of view highlighted the need to review some technical features and capabilities of the Internet (e.g., accessibility, user-friendliness, interactivity and delivery of media) in the light of the previous chapter to see whether it is appropriate to deliver and access instruction or not. In the light of this review, learning via the Internet, in a distance education context, is reviewed in the next chapter (Chapter 4).

The Internet was developed during the Cold War in the 1960s by the United States government. The objective of the government was to develop a means by which computers could be linked, communicate and exchange information. For political and financial reasons, academic institutions and commercial organisations got involved in developing and financing this network. By the end of the 1970s, many universities and organisations were involved in using it for academic and commercial purposes. However, the real growth of the network began in the early 1980s when universities world-wide began to connect their local networks to the Internet (Figure 3-1). By the end of the 1980s, thousands of universities, research institutions, companies, governmental offices and persons were already connected to the Internet.

Figure 3-1: The International Network: the Internet



3.1. Internet connection: Types and requirements

Users can access the Internet directly using a computer working as a host or using a terminal that is connected to an Internet host. Terminal connection is the more common and cheaper means whereby educational institutions connect their students to the Internet. Terminals can be connected to host computers in two ways: hard-wired connection and dial-up connection. In hard-wired connection, users get connected to the Internet host using permanent cables. This type is suitable for big institutions, in which hundreds or thousands of students can access the Internet for a long time during a day. However, this type of connection is costly and restricted by the school building or university campus (Schurman, 1999). Dial-up connection can be established over a telephone line and modem allowing students who have computers to access the Internet from home (Figures 3-2a and 3-2b).

Figure 3- 2 a: Cable connection

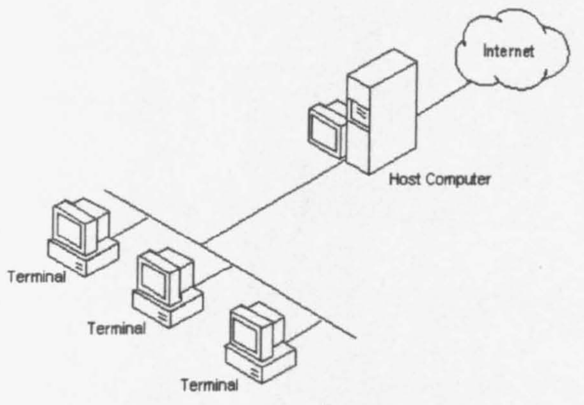
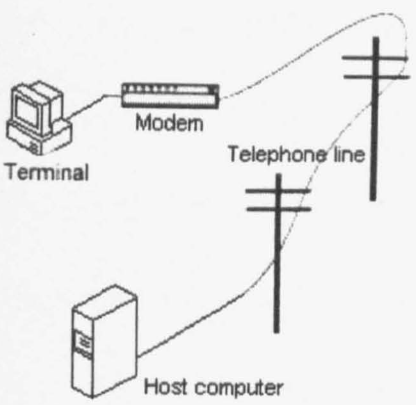


Figure 3-2 b: Dial-up connection



Internet access needs three types of requirements: computer requirements, connection requirements and software requirements (Micco and O'Neil, 1996). A personal computer with sufficient memory and enough disk space, rather than high-speed computer, is needed to run a Web browser and connection software to download and upload (Sweet, 1999). In addition, a modem and a telephone line are required to access from home, even if they are slow in comparison with other high-speed access options, as shown below (Dodd, 2000).

For large educational organisations and schools, there are multiple transmission media or technologies that can be used to provide high-speed Internet access. These include cable, an enhanced telephone service called digital subscriber line (DSL), ISDN lines, satellite and fixed wireless (Kruger and Gilroy, 2001). ISDN lines (Integrated Services Digital Network) are used in the same way as a regular telephone but unlike regular analogue telephone lines, they provide high-speed, crystal clear voice reception and data transfer rate of 64 Kbps. This is far superior to what is offered with a standard telephone and dial-up modem (Farwell, 2000). Using satellite technology, users can get very high-speed Internet access anywhere, even in remote or isolated areas. Although ISDN (Integrated Services Digital Network) and fixed wireless are the fastest options today, dial-up access through an analogue modem is the most reliable and widely available access option at the present time (Dodd, 2000).

The speed of access to the Internet mainly depends on the type of Internet connection and the bandwidth of the network that provides the service. At the same time, getting access to the Internet requires installing and configuring software. Fortunately, commercial Internet service providers usually provide software for their accounts (Phelps, 1998). Dial-up software, Internet protocols (e.g., TCP/IP), a Web browser (e.g., Internet Explorer and Netscape Communicator) and an e-mail client (e.g., Eudora and Outlook Express) with the capability to send attachments are the essential software needed to access the Internet and benefit from its services (Anderson, 1998). IP protocols are used to transfer packets of data over the Internet. Computers require Internet Protocol/Transmission Control Protocol to get connected, communicate with one another and break information up into packets (Gillies and Cailliau, 2000).

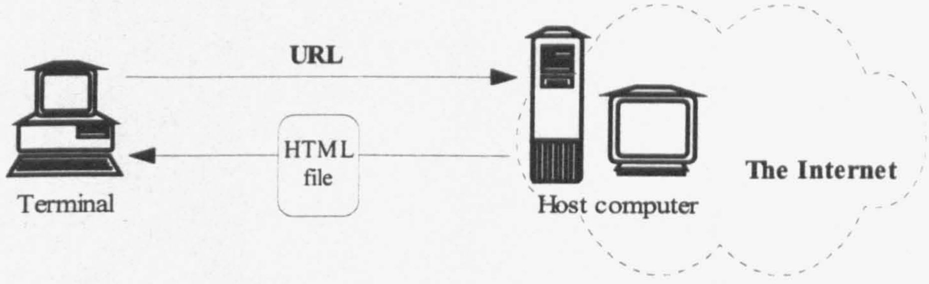
3.2. The Internet and the World Wide Web

The World Wide Web, or the Web, is the most common side of the Internet. It mainly depends on graphical user interface software to show the content of files located in other computers (or servers). This software is called a Web client or 'Web browser'. Browsers have many features that characterise them, such as a consistent graphical interface, the ability to display hypertext documents in a variety of fonts and layout elements, support to media elements (e.g., graphics, sound and movies) and the ability to support plug-in technology for different purposes (Hughes, 1993).

On the Web, every document has a unique address called the URL (Uniform Resource Locator). This address indicates the computer (Web server) in which the document is resident and the directory (or the subdirectory) which determines the full path of the file. Viewing a document on the Web requires a viewer called a 'Web browser' or 'Web client'. When the user enters a specific URL, the Web server replies with the contents of the document. The browser's role is to format the contents and display them whether, HTML ASCI text or multimedia components. Using Web browsers, the user can access, browse and view the documents located in the Web server easily and without the need for special skills.

Hughes (1993) explained the relationship between the client and the Web server in three steps: the user types the address of a server connected to the Internet, the Web server connects to the server specified by a network address and the server responds by sending the text and any other media within that text (HTML file) to the user client. The relationship between the Web browser and Web server is represented below (Figure 3-3).

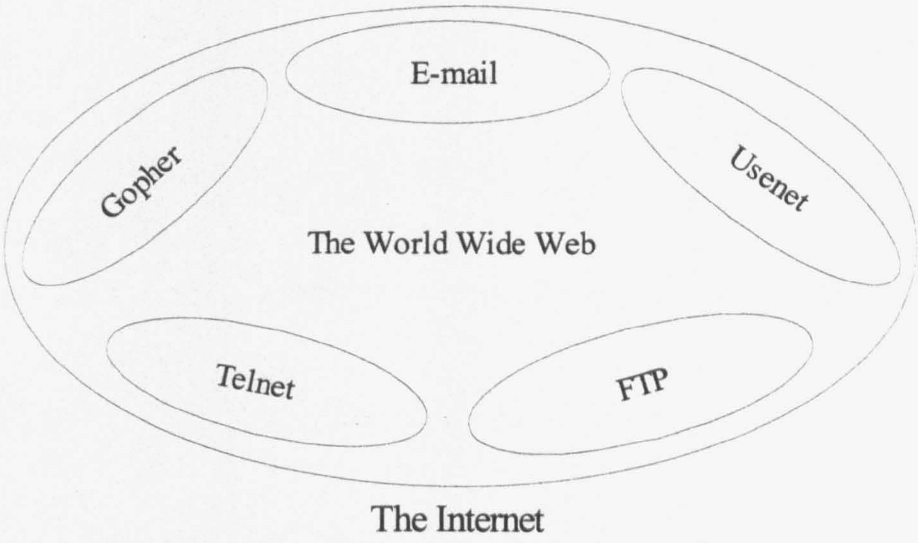
Figure 3-3: The relationship between the client and the server on the Web



There is a wide variety of browsers available in the market for viewing the Web. The two most famous browsers are Netscape Navigator (or Netscape Communicator as released recently) and Microsoft Internet Explorer. Although the objective of these browsers is the same and the documents they can show are similar, these browsers are not similar in their capabilities and features. Netscape Navigator, for example, does not support ActiveX and VB Scripts, while Microsoft Internet Explorer supports most of the Dynamic HTML tags and features.

Today, almost all Internet protocols now are accessible via the Web. These include e-mail, FTP, Gopher, Telnet and Usenet. Using the Web browser (Figure 3-4). E-mail, for example, as one of the primary and most popular applications on the Internet, has now become accessible via the Web. Using HTML forms within CGI scripts and a Web browser, users can read and send their e-mail messages to any e-mail address without the need for additional software.

Figure 3-4: Internet services and the World Wide Web



In addition, new applications for the Web have arisen with the development of Web authoring and publishing tools. Educational publishing, for example, is one of the most rapid applications in its development. A wide range of publications is now available on the Web, ranging from abstracts of publications to full text journals and encyclopaedias. Moreover, HTML forms and CGI scripts provide two-way asynchronous and synchronous interaction on the Web allowing Web, documents to move beyond their former static nature.

3.3. Delivering media via the Web

Web pages can contain texts, still and animated images, audio, video, programmes and scripts such as Java applets and CGI scripts. However, writing Web pages depends mainly on the Hypertext Mark-up Language (HTML).

3.3.1. Text and hypertext

In the earlier stages of the Web, designers developed Web pages by writing the source code of the pages using HTML tags, which requires programming skills and was very time consuming. In the last few years, many simple as well as sophisticated HTML authoring tools have become available for designing, planning and writing Web pages. Using these programs, designers can concentrate on designing and managing pages, rather than writing the code. Hypertext documents are simply ASCII text files that have been marked up with standardised tags. These tags provide information about a document's structure (e.g., title, headings and paragraphs) and format (e.g., bold, italic and colour) (Barry, 1998). In hypertext documents, nodes can take textual format, graphical format, which depends on graphical display such as an overview map, or a combination of textual and graphical format. Balasubramanian (1994) distinguishes between two types of links in hypertext documents:

1. Sequencing links, which allow the designer to define the reading sequence through the content. In other words, users can read only the content that is determined by the sequencing link. The disadvantage of this type is that it constrains the reader's navigation through the document.
2. Exploration links, which allow the user to explore more related materials. This type allows unconstrained access to the content (Balasubramanian, 1994).

Pilto (1998) described sequencing links and exploration links as unidirectional links and bi-directional links. The designer uses unidirectional link to control the user's movement through the content. However, a bi-directional link allows the user to activate the link from either end. This type of links presents different options to the user (Figure 3-5 a and 3-5 b).

Figure 3-5 a: Sequencing design of hypertext (Pilto, 1998)

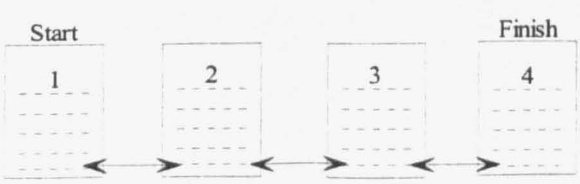
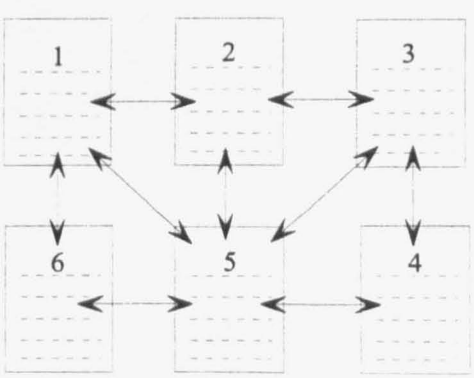
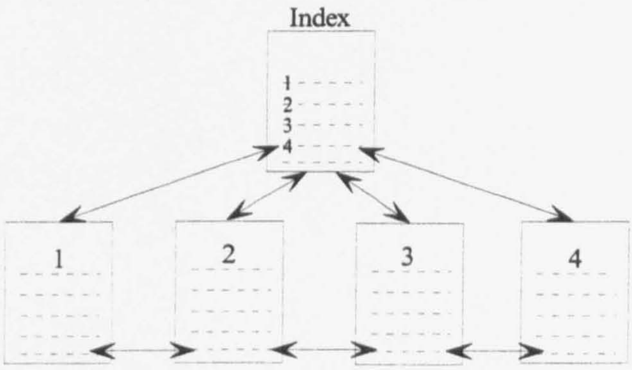


Figure 3-5 b: Exploration design of hypertext (Pilto, 1998)



When users follow hyperlinks, they often need to return to some previously visited node. Most hypertext systems support this through backtrack links. Backtracking depends on the user's movement, i.e. the order in which he/she visited the nodes (Nielson, 1995). Tissue (1996) described another type of navigation on hypertext called 'indexed design' (Figure 3-5 c). If a user gets lost in the middle of a series of documents, he/she can return to the main index or home page. This design is very important in avoiding the 'lost in the cyber' problem, as shown below.

Figure 3-5 c: Indexed design of hypertext (adapted from Tissue, 1996)



However, not all series of Web documents are suitable to be formatted in hypertext format. To determine whether an information-based application is suited for hypertext or, in other words, whether hypertext is important to use in providing the information, Shneiderman (1989) argued that there is a need for a large body of information, this information should be organised into numerous fragments related to each other and access to information a fraction at a time is needed. These rules mean that if the body of information is relatively small, it should be displayed as a whole block or page. However, if the amount of information is relatively large but its parts are non-related, it should be displayed in another style such as databases or electronic documents [(*)].

Hypertext has many technical and pedagogical advantages that encourage educators to deploy it in education, they have two unique features. First, it provides a consistent graphical user interface and allows the learner to click on a link, select among many options in a menu or enter information to a form. Second, hypertext files can be generated from text files in many different

[(*)] Electronic documents is a common term on the Web, popularised by the emergence of Adobe Acrobat Documents. Using Adobe Acrobat Reader, the user can read or download a whole document as a one file. Adobe Acrobat (PDF) files retain the original page layout in the documents.

formats (e.g., Word Documents and RTF). At the same time, hypertext documents can be converted to any type of files (Balasubramanian, 1994; Barnes, 1994).

However, although, in some cases, hypertext is the only mechanism for delivering information to students, Hammond (1991) argued that using hypertext with students revealed a number of problems. First, if the volume of information is large and the learner is unfamiliar with the subject, he/she may get lost. Second, novice learners may find it difficult to gain an overview of the material and how the parts of the knowledge base are related. These two problems may be crucial in instructional applications, if they are not considered. Therefore, designers need to avoid an excessive number of different choices and to maintain a balance between the different type of navigation styles via the Web.

3.3.2. Graphics, audio and multimedia

Because graphics and audio files usually have large size, compression is the initial issue usually considered in producing and delivering multimedia applications via the Web. This issue becomes more important with the need to deliver graphics and audio to Internet users who have limited bandwidth and computer speed to reduce file size and so avoid excessively slow dial-up connections. Therefore, many techniques have been applied to reduce the size of audio, graphics and audio-video files for smooth transmission via the Web. Two types of compression are available, lossless and lossy (Denton, 1999). Simply, lossy algorithms re-create an image file that appears to be identical to the original, although the two files are very different at the bit level. Because the Web is a multimedia platform, lossy compression may be more suitable than lossless compression, which ignores this human effect (Denton, 1999).

One of the most common techniques that uses lossless algorithms to reduce the size of graphics is the GIF (Graphics Interchange Format) standard, invented and developed by CompuServ in 1980s. 'The GIF defines a protocol for the online transmission and interchange of raster graphical data in such a way that is independent of the hardware used in its creation or display' (Wu and Irwin, 1998). Since it uses lossless algorithms, GIF is suitable for 8 bit/256 colour and stylised images (e.g., line drawings and images which contain a limited number of colours) and is widely used and supported by Web browsers (Vanzyl, 1995).

Other appropriate compression standards that use lossy algorithms are JPEG (Joint Photographic Experts Group standard for still images) for still images and MPEG (Motion Pictures Expert Group) for moving images. JPEG is an excellent choice to deal with real photographs through networks. However, MPEG is targeted for video compression on the Web and video services over networks (Wu and Irwin, 1998). In comparison between GIF and JPEG compression standards, Denton argued that although JPEG offers high compression rate and quality images, it does not support transparent backgrounds in Web browsers because of slight background variations.

Multimedia is defined as 'the integration of text, audio, graphics, still images and moving pictures into a single, computer-controlled, multimedia product' (McCarthy, 1989, p. 26). Today's multimedia systems are characterised by the integration of audio, interactive images, video and graphical user interfaces. Irrespective whether such access to multimedia tutorial would lead to better performance, multimedia tutorials help students to work at their own pace, support interaction, communicate dynamic information more accurately and help students visualise phenomena that cannot be seen (Bennett and Brennan 1996).

However, although the capability of integrating different types of media on one computer has encouraged a rush to develop multimedia systems, one of the main problems that challenged multimedia providers and educators was the time lag between invention of multimedia solutions and their use. Producing multimedia CD-ROMs, distribution, purchase of multimedia capable machines and updating low-speed CD-ROM drives (primarily speed and storage capacity) were the most common problems associated with the use of multimedia objects at home and in schools (Noacco, 1995).

Today, many of these drawbacks are eliminated by the easy access Internet and platform-independent technologies. In the last five years, the Internet has offered a good ground for multimedia presentation and vehicle of multimedia objects to a huge learner using great capabilities (Flynn and Tetzlaff, 1998). Other problems such as the large size of multimedia objects, interactive and live multimedia presentation are being solved with the rapid development streaming applications and desktop conferencing.

Streaming audio/video can be used in the language lab, school libraries, for storage and delivery of classroom lectures. Multimedia players allow users to stop and start the stream anywhere, jump to another part of the stream and watch half of a film on one occasion and the second part on another (Hunter, 1999). Desktop or Internet conferencing is a very common form of one-to-one or group communication, which allows users to interact at a distance without the need for additional communication media.

Basically, establishing a videoconference via the Internet requires at least two computers connected to the Internet. Each computer requires a video camera, sound card with a microphone and speakers and conferencing software (e.g., Microsoft NetMeeting and CUseeMe Pro). The conference can be one-way video, two-way audio or two-way audio and video. At the same time, it can be one-to-one or group conferencing, involving more than two sites (Schiller, 1993). Internet connection can be established using analogue connection (modem and telephone line) or using digital networks (such as ISDN and MPEG2 Satellite TV transmission). Although the first option is fairly cheap for individuals who have Internet access at home and schools, the quality of video in poor. However, ISDN and satellite connections provide high quality audio and video transmission, albeit at high cost (Wheeler, 1999).

The major advantage of Internet conferencing is that it plays an important role in maintaining the interpersonal relationship and 'complements speech by the real-time transmission of moving pictures' (Bogen, 1997). Atkinson (1992) highlighted the beauty of Internet conferencing when he pointed out the problem of incompatibility between conventional video conferencing systems. One of the major benefits of Internet-based conferencing over conventional teleconferencing system is Internet-based compatibility between machines and the flexibility of location it offers. Students can participate in discussions from all over the world using their own personal computers (Foley and Schuck, 1998). According to Buxton (1997), recent Internet conferencing enables students to listen to different parallel conversations, make comments and share documents.

Microsoft NetMeeting is one of the most popular desktop conferencing packages. It has many outstanding features that have characterised Internet conferencing in the last few years. For example, it has a Whiteboard to type on and present graphics to users, users can use a conference as a keyboard chat session and it supports file transfer protocol (FTP) allowing users to exchange files while they are conferencing.

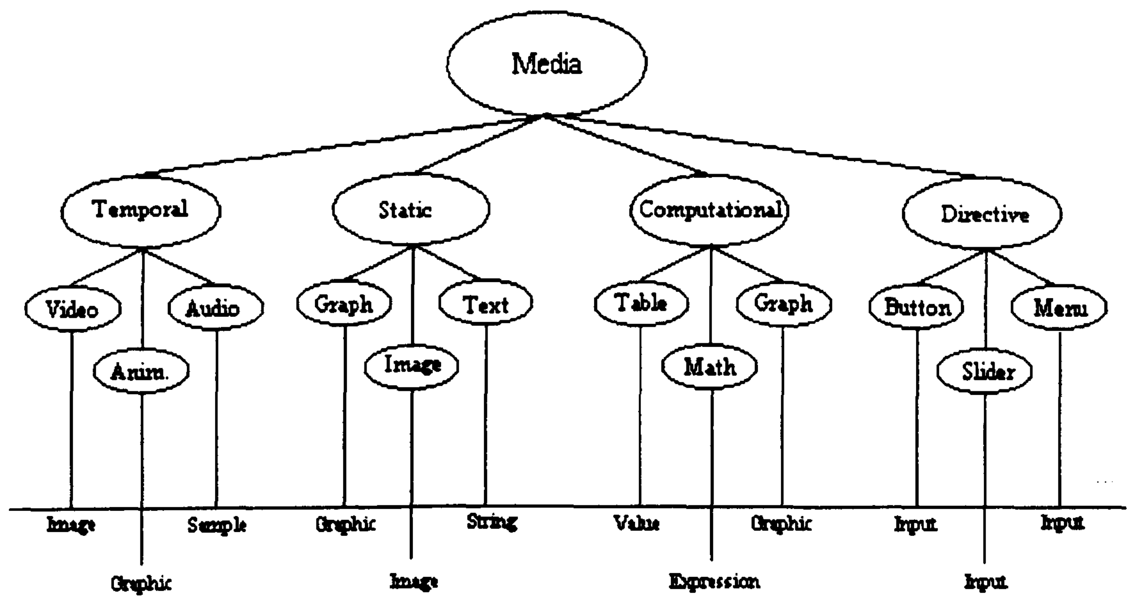
3.3.3. Hypertext and multimedia: Hypermedia

Although the hypermedia approach is not a new concept in education, the Web has offered a good ground to exploit this concept. Basically, a hypermedia system is a hypertext system with various links to other forms of media, such as animations, interactive graphs, audio, movies and other recent objects. Using interactive objects (such as Java applets, ActiveX and server-based scripts) with multimedia supports a new type of dynamic and interactive presentation that is better than a static description with figures. Eklund (1995) and MacKinnon (1997) emphasise the differences between traditional media and hypermedia systems by describing hypermedia as a non-linear method for organising and displaying information in the form of text, graphics and video.

Nielson (1995) goes beyond the traditional concept of hypermedia as a structured document of hypertext and multimedia. He described it as a method for integrating three technologies: publishing, computing and broadcasting. He believes that hypermedia provides the opportunity to publish information, control information and interact with the content and makes it easy for anyone to access information easily anytime/anywhere (broadcasting). In addition, Redmond and Sweeney (1997) noted that the single biggest difference between television and hypermedia is interactivity. Television programmes have a fixed length. However, a hypermedia production is as long as it is viewed by the user.

Watters (1996) suggested a media hierarchy for the multimedia classes that are available in hypermedia applications on the Web (Figure 3-6). Besides the traditional two classes which he called temporal (audio, video, animation, etc.) and static (text, graphic, images, etc.), he added two types of Web-related media. These two classes are called 'directive' and 'computational'.

Figure 3-6: Media class hierarchy with primitive types (Watters, 1996, p. 6)



Watters believes that although these two additional classes are already integral parts of hypermedia systems, they are not generally included as media object classes. These additional media classes reflect a growing trend towards the integration and interoperability of data and computing functionality. Computational objects include tables, mathematical expressions and graphics objects. Directive objects, such as menus, buttons and slider bars and dialogue boxes, combine data presentation functions with user input functions and facilitate interaction by the user.

Alexander (1997) and Marchionini (1988) pointed out that there are many pedagogical characteristics of hypermedia systems that have great potential for learning and teaching. They argued that hypermedia enables designers to store diverse formats of information with easy access and supporting links to other kinds of materials, offers high levels of learner control, facilitates and formalises human interaction and helps learners to define information format according to their own needs, which are often unique to each individual learner. Becker and Dwyer (1994) believe that increased learner control is one of the benefits of implementing hypermedia in instruction. They found that an increased sense of control increases students' motivation to learn.

Dede and Palumbo (1991) indicated that learners might create different pathways through the hypermedia application. In addition, Sweany et al. (1996) explained that in hypermedia environments, learners can decide which topics they view, in what order they will view the topics, how the topics are related and how long they will spend on each topic.

However, the interactive nature of hypertext and hypermedia environments reveals that the successful use of hypermedia systems depends upon the design and creation of appropriate non-linear information. Hammond (1991) describes two types of user control which tend to feature in hypermedia: control over the sequencing of the materials which the learner sees, and control over the types and sequencing of learning activities; such as reading information, taking tests, solving problems or trying interactive demonstration. Barker (1993) suggested that information structures in hypermedia must be designed in a way that allows the learner to choose the direction in which he/she wishes to proceed through the knowledge.

However, although there are many benefits for learner control in hypermedia environments, Sweany et al. (1996) showed that learners become overwhelmed with the number of choices available to them and 'lost in hyperspace', not knowing how they arrived at their current location or how to get back. Furthermore, Cho (1995) found there are many reasons why a learner-controlled medium may sometimes not be effective. He argued that learners may have insufficient knowledge about the new content and therefore cannot make the best decisions about which concepts to study, they may not have the appropriate metacognitive ability to control learning process or they may not understand how to integrate their prior knowledge into the learning process (Cho, 1995 in Sweany et al., 1996).

3.4. Developing for the Web

Although the Web is able to deliver texts, graphics, audio and video effectively, as shown above, the possibility of distribution and offering pages of information to learners may not be enough. On the Web, the learner's role needs to be more than clicking on links and moving from one page to another, since the ideal learning environment is one in which learners take an active role by participating in such activities as submitting responses, and receive feedback (Gagne et al., 1988; McAlpine, 2000; Smith-Gratto, 2000).

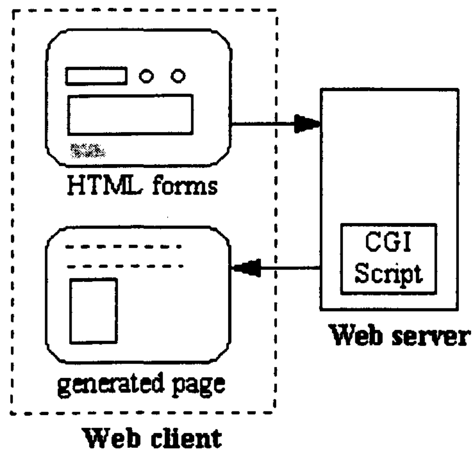
Earlier computer-assisted learning programs, which are similar to the Web in nature, provided many active mechanisms and support that encourage the learner to undertake an active role by selecting from multiple choice questions, practising solving some problems, conducting an experiment, analysing a graph or developing his/her language skills. However, the standard HTML features are not enough to make the Web in-line with interactive courseware, developed using high-level and sophisticated programming languages (e.g., Visual Basic and C++) or professional authoring tools (e.g., Authorware and ToolBook Instructor). For many reasons (commercial, educational, entertainment, etc.), many Web-based solutions have been invented in the last ten years to activate the Web and add more control and interactivity to its pages. These solutions have been reflected in the emergence of server-based and client-based programming languages and environments such as CGI scripts, Java Script, Java, ActiveX and VRML.

CGI (Common Gateway Interface), for example, is a collection of protocols that allow Web clients (browsers) to execute programs on a Web server and receive their inputs again. The need for CGI has arisen to meet the requirements of HTML forms which require data entry by the user. CGI scripts in conjunction with HTML forms can respond to the user's inputs and generate appropriate pages for the user's entries. CGI allows the computer to pass information back to the Web server. The information can then be processed and saved. All of this is fast, automatic and transparent to the user (Dickinson, 1997). The conceptual working of form-based CGI query is described by Zhanshou (1998) as follows:

1. The user enters and submits information using a HTML form.
2. The browser sends the data to the server.
3. The server runs a specific CGI script (its name is included in the HTML form).
4. The CGI script processes data and sends outputs back to the Web server, which in turn passes it back to the browser (Zhanshou, 1998).

These steps are represented below (Figure 3-7).

Figure 3-7: The relationship between CGI scripts and the Web browser



A CGI script can be programmed to perform a variety of tasks on the Web. For example, in conjunction with HTML forms, CGI scripts can be used to provide search information. Many search engines and directories (e.g., Altavista and YAHOO!) return a list of potential documents found (Barry, 1999). In addition, CGI scripts can be used to run many common applications on the Web, such as e-mail, discussion boards, surveys and evaluation of learners' entries.

However, although CGI scripts perform many functions on the Web, it is not enough to simulate many conventional computer applications, such as multimedia presentations and complex mathematical operations. Therefore, client-side and platform-independent languages have been developed to run as applications in the user's machine by downloading them from the server. An example of these languages is Java programs or 'Java applets'.

Java applets can run on any computer with any operating system and allow developers to build applets to run within the Web page by referencing the code in the HTML code. Java has many features, which make it a favoured language for the Web. It is an object-oriented, interactive, distributed, secure, portable, high performance, multi-thread, dynamic language and suitable for all purposes (Kamthan, 1999). In addition, it can display graphics, play audio and video files. These features enable the provision of high-level and sophisticated programs for learners, similar to those of previous CAI applications with the touch of interaction between the teacher and students via the Internet. In the distance education context, Java can be used in many ways, such as designing communications channels for interaction (such as chat rooms), providing self-assessment tests, and providing help and support tools, such as graphical mathematical calculators and scientific simulators.

ActiveX is another client-side programming approach, similar to Java language, and provides a framework for building software components that can communicate with one another. ActiveX has been developed as a tool for building dynamic and active Web pages and distributed object applications. When a user visits an Active X Web site, Active X controls are downloaded to the user's browser (Sheldon, 1998). ActiveX controls can perform an enormous number of tasks, such as computations and communication.

Today, active scripts (e.g., Java Scripts and VB Scripts), Java applets and ActiveX controls in combination with standard HTML form what is known as Dynamic HTML or DHTML. DHTML is a relatively new approach to creating highly visual, animated and interactive Web pages. A DHTML page 'includes menu items that change colours when the mouse moves over them, a chunk of text that slides across the page, or images that users can manipulate on-screen' (LaChance, 2000).

However, although the above programming languages and controls require sufficient experience in designing and programming on-line materials, in the last five years, developing Web pages, or sites, has become a relatively easy task, particularly with the development in Web editors. These editors are tools that work as word processors, enabling Web pages to be created even without writing the HTML code behind the page. There are many Web editors available, which vary in their features and capabilities. The recent generation editors, known as WYSIWYG (What You See Is What You Get) editors can be used to create and manage Web sites without the need for a HTML or programming background. However, developing sophisticated sites requires developers who are experienced enough in HTML. The actual benefit of WYSIWYG editors for developers is that they save the time in writing HTML code and direct the attention of developers toward more important tasks, such as planning and developing user-friendly interfaces, effective branching approach, interactive multimedia elements and efficient content.

One of the most recent and powerful WYSIWYG editors released in the last few years is Microsoft Front Page. The Microsoft Front Page is a tool for creating, designing, and editing World Wide Web sites. Developers can add text, images, tables, form fields and other elements easily to Web pages, letting the Front Page editor generate HTML tags, including extensions such as cascading style sheets, frames and ActiveX Controls and display them as they would appear in a Web browser. FrontPage, as a powerful HTML editor, includes many features [(*)] that recommend it for use in developing the HTML code, such as dynamic HTML support, easier hyperlinks, enhanced form creation, improved table editing and WYSIWYG frames page editing.

However, although Front Page is considered as the cutting-edge in HTML authoring environments, it is not enough to develop interactive and sophisticated Web-based learning environments. Even authoring tools of Web-based courses (e.g., ToolBook Instructor and Authorware) are very limited in their possibilities and do not offer a high degree of flexibility and wide range of strategies for developers. Although some packages (like ToolBook Instructor) offer a built-in programming language for developers (e.g., Open Script for ToolBook Instructor) they are still far from finding a solution to problems already solved using CGI scripts, Java applets and Java scripts, as shown in Chapter 5. The development of more sophisticated Web applications requires using additional support tools (e.g., photo editors and drawing tools) and high-level programming languages (e.g., C++ and Visual Basic) to add features such as interaction, communication, feedback, user control and tracking.

3.5. The availability of the Internet at schools

Today, perhaps for the first time in media history, through telephone lines, local networks or satellite links, students at schools can access Web pages and databases that contain information in different formats, exchange electronic messages, share knowledge and experience, co-operate with each other in small or large groups, publish information for others and update it easily. In developed countries substantial progress has been made towards achieving the target for every school to have Internet access. In the United Kingdom, over 80% of primary schools, more than

[(*)] These features are obtained from help documents of MS Front Page 98.

90% of special schools and nearly all secondary schools were connected to the Internet in 2000. In each school type, the most common form of access is via a computer network connected to the Internet using an ISDN connection (Table 3-1). E-mail was the most common means of electronic communication used in all schools (Department for Education and Skills, 2000). The Government's aim is that up to 75% of teachers and 50% of pupils should have their own personal e-mail addresses by 2002.

Table 3-1: Connection to the Internet (Department for Education and Skills, 2000)

Internet connection	Primary	Secondary	Special
Percentage of schools connected to the Internet:	86%	98%	92%
Estimated number of schools connected to the Internet	15,600	3,500	1,100
of which through:			
stand alone computer using a modem	38%	32%	35%
computer network using a modem	9%	8%	8%
computer network using an ISDN2 connection	59%	77%	69%
computer network using a leased line	5%	10%	5%
computer network using a broadband connection by cable	22%	21%	26%
computer network using a broadband connection by satellite	1%	-	-
computer network using a broadband connection by microwave	1%	1%	-
other	2%	2%	1%
Average number of internet access points per school: 2000	8	54	10
Average number of internet access points per school: 1999	4	26	5
Average number of internet access points per school: 1999	2	12	2
Percentage of schools who had their own Web site: 2000	34%	62%	31%
Estimated number of schools with a web site: 2000	6,200	2,200	370
Percentage of schools who had their own web site: 1999	21%	54%	22%
Estimated number of schools with a Web site: 1999	3,800	1,900	270

In addition, according to the Internet in Secondary Schools Survey (Jervis and Steeg, 1997), the majority of Internet at English schools used by staff is for research (93%), downloading curriculum materials (71%) and downloading software (55%). The connection is used for private e-mail in 75% of schools. For pupils, individual research accounts for 80% of use, followed by directed class research (46%), class e-mail projects (41%), undirected class research (35%) and private e-mail (28%) (Jervis and Steeg, 1997).

In the United States, a recent survey of Internet access conducted by the U.S. Department of Education (2000) indicated that public schools in the United States have nearly reached the goal of 'connecting every school to the Internet'. The percentage of public schools connected to the Internet has dramatically increased from 35% in 1994 to 95% in 1999. In 1999, the majority of schools (63%) used dedicated-line network connections, 14% used dial-up connections, and 23% of schools used other connection types, including ISDN and wireless connections to offer high-speed Internet access suitable for access multimedia and real-time interaction effectively (U.S. Department of Education, 2000).

However, although Internet access varies dramatically across countries, Internet access in developing countries is expected to rise at a faster rate than in developed countries during the next 10 years. In developing countries, the number of schools which have Internet access is being increased dramatically, particularly with the increase of the Internet's popularity, reduction in hardware and software costs and growing development telephone infrastructure (The World Bank Group, 2000).

In 1997, the World Bank launched the WorLD Program (World Links for Development) to connect many secondary schools in developing countries [(*)] to the Internet. The WorLD Program has provided sustainable solutions for mobilising the equipment, training, educational resources and school-to-school partnerships required to bring students and teachers in developing countries into the Internet (World Bank Institute, 2000). As part of its work, the WorLD Program has conducted a comprehensive technical needs-analysis of each of its participating countries to create tailored connectivity packages that are adaptable to local circumstances. To set-up Internet connection, four models were proposed according to the country's location, telecommunications infrastructure and number of students (Table 3-2).

[(*)] These countries are Botswana, Brazil, Cape Verde, Cambodia, Chile, Colombia, El Salvador, the Gambia, Ghana, India, Indonesia, Laos, Mauritania, Mozambique, Paraguay, Peru, Philippines, Senegal, South Africa, Sri Lanka, Turkey, Uganda, Vietnam, West Bank / Gaza and Zimbabwe.

Table 3-2: World Bank classroom set-up models (WorLD Program, World Bank Institute, 2000)

Option	Specifications
1. Computer Lab	10 computers networked in LAN with a dial-up connection using a 33.6 modem, proxy server separate computer for teacher use
2. Computer Lab Plus Library Access	10 computers networked in LAN with a dial-up connection using a 33.6 modem proxy server With a separate computer for teacher use common library
3. Classroom Access	12 computers networked in LAN with a dial-up connection using a 33.6 modem, proxy server with a separate computer for teacher use library common access and 3 classrooms with 4 computers
4. Full Internet Connection	12 computers networked in LAN with a leased line connection with router proxy server, a separate computer for teacher use library common access 3 classrooms with 4 computers

In Egypt, for example, Internet connection was piloted in 150 secondary schools in 1996 by the Ministry of Education. In 1997, the Ministry of Education commenced an extensive and ambitious programme to connect all secondary schools in the region to the Internet (Al Atraqchi, 1998). By 2000, about 50% secondary schools had been connected to the Internet. Since the majority of these schools are located in urban areas, mobile services in the form of fully-equipped vans provide access to those out of reach school districts were used around the region (Ministry of Education in Egypt, 2000). Currently, schools in many developing countries around the world, which have no LAN to connect computers, use telephone lines to access the Internet. The principal problem is still the cost of phone calls (Lederman, 1995); however, schools have found some ways to minimise the costs, such as using key telephone systems or PBX systems from which telephone lines are controlled or run to specific computer (Lucas, 1994).

Conclusion

This chapter has shed light on the Internet and the World Wide Web and their technical capabilities, to find out whether or not they are the right medium for delivering instruction at a distance. It is noted that the Web, as the most popular protocol, holds a lot of promise as a distance education medium. Via the Web,

1. Access to information is available from anywhere and at anytime;
2. Interactive materials can be developed and delivered by virtue of hypertext and modern programming languages, such as CGI scripts and Java, and Java Scripts;
3. Dynamic, student-centred, user-friendliness and standard applications can be developed and make accessible to exploit a long history of experience in developing computer-based instruction; with student-tutor and student-peers Interaction that can be achieved using asynchronous and synchronous methods with no extra requirements, except a computer and telephone line.

However, although these features indicate that the Web is a useful instructional medium, the successful use of the Web requires finding out how educational developers can exploit these capabilities to design and deliver instruction for students at a distance. Distributing instruction via the Web is more than making information and traditional materials accessible via the Web. Using the Web in education may need to go beyond the basic use of the Internet to the development of virtual learning environments, in which students can participate and take an active role in the learning process. More attention should be paid to the Web as a learning environment, its educational capabilities and adapting instruction for its use than its technological features. These issues and others are investigated in the next chapter.

Chapter 4: Web-Based Learning

In the last few years, the Internet and World Wide Web have given new impetus to educators and computer-aided instruction designers attempting to design and develop interactive, intelligent and human-based courseware. In the last ten years, the Internet began to provide learners with a new and wide range of learning opportunities and experiences (Wise, 1996). Hites and Ewing (1997) and Huang (2000) described the Web as a powerful tool that facilitates interaction and distributes instructional resources globally. They drew attention to the development in Internet use in distance education by instructors and students who have begun to use e-mail, discussion groups and on-line resources to enhance interaction and expand instruction. The Web has many of the features of audio-visual media (e.g., text, image, sound and video clips) as well as the ability to support interaction between the learner and others. Asynchronous communication technology, as shown below, is one of the unique features of the Internet. It is able to support learning, as information is presented in a range of formats that are suitable to students' abilities and needs.

This chapter sheds light on research and key issues in Web-based education, such as the pedagogical potential of the Web and instructional design for on-line education.

4.1. Instructional capabilities of the Web

Since the Web was invented for information exchange and collaboration among scientists and academic institutions, it offers the same potential for teachers and students. The Web has the ability to contribute to solving many traditional educational problems such as the lack of resources and information, the need to facilitate interaction among teachers and students, encouraging students to work in collaborative groups and reaching isolated schools and students (Mason, 1998).

Takle et al. (1996) indicated that in Web-based learning, the student can learn at his/her own pace, engage in remedial opportunities and have access to enriching opportunities and group discussion. Wyld and Eklund (1997) and BECTA (the British Educational Communications and Technology Agency) (1998) have defined many educational advantages of the Web that encourage educators to use it. They argued that the Web is an easy to use, cost-effective, interactive two-way medium, a rich information source and a global publishing medium. In terms of interactivity, the Web offers many ways of interaction via e-mail, chat and discussion groups. Resources on the Web include databases, software, illustrated guides, libraries catalogue and galleries. In addition, the Web is a cost-effective publishing medium that allows educators to publish courses and projects (Wyld and Eklund, 1997; BECTA, 1998).

Russell (1995) pointed out that although the Web was developed as a system for distributing information among scientists into a more general multimedia tool, its use as a search tool has increased enormously. The number of documents available on the Internet is growing dramatically and every day thousands of Web pages in all fields of knowledge are uploaded to Web servers. Green (1997) indicated that the Web is a single source, multimedial and interesting source of information. He argued that it is a single source because it allows students to do their search in thousands of Web servers from one location. In addition, it is multimedial since it is, unlike traditional books and journals, capable of providing information in different forms.

However, stating another point of view, although the Internet is a global, easy-to-access library, and likely to yield more up-to-date information, the traditional library is likely to yield higher quality and more accurate results than the Web (Ryder, 1996)(Table 4-1). Green (1997) pointed out that not all Web-based resources are suitable for school students and many students have not the skills to evaluate the quality and the accuracy of on-line resources and find appropriate materials.

Table 4-1: A comparison between traditional libraries and the Internet (adapted from Ryder, 1996)

Feature	Traditional libraries	The Internet
Schedule	A library is constrained by limited hours of operation.	The Internet is not constrained by schedule. It is as available with a personal computer and a modem.
Location	A library has a fixed location. Most communities have at least one library but rural communities are specially constrained.	The Internet is not constrained by proximity. It is accessible anywhere that electronic communication is possible.
Holdings	Library holdings are constrained by past acquisitions and current budgets.	The Internet holdings are growing daily, although at the present time, resources on the Internet are fundamentally constrained by copyright.
Accessibility	Library resources are accessible depending on the location of the book and availability.	Electronic texts on the Internet are available instantly.

McKenna (1994) pointed out that the Internet has great potential to work as a global library to help learners and to facilitate access to information. He suggested that libraries can use e-mail to contact isolated students, and connect them to remote computer resources to browse other library catalogues, access commercial database services or download software programs and encyclopaedias.

In distance education settings, Saltzberg and Polyson (1995) indicated five main attributes that encourage distance educators and students to use the Web, flexibility, ease of use, ease of development, ease of access to resources and ease of dissemination. They explained that teaching and learning via the Web are not confined by space or time. Web browsers integrate all types of Internet resources and protocols in one easy to learn and user-interface. Developing instructional materials for the Web is a relatively easy task and can be done quickly and unlike printed resources, once materials are posted, information is easily updated and disseminated.

Wagner (1995) believes that the essential advantage of using the Web is its ability to arouse students' interest in learning and interaction. In addition, it encourages educators to use communication techniques in sharing ideas and developing new relationships, not just locally but world-wide. Overall, Owston (1998) highlighted the contribution of the Web to distance education from the perspective of three questions: does it increase access to education, does it promote improved learning and does it reduce the costs? (Owston, 1998). Although Owston believes that the Web shows strong promise in all these three areas, he argued that the promise is rooted in how the Web is used, not solely in 'hypothetical advantages'.

In conclusion, the Web has several unique educational capabilities for education, in general, and for distance education, in particular. It has the potential to reach students world-wide, offers hypermedia capabilities, is place and time independent, is easy to use, is cost-effective, provides rich information source and is globally accessible. The Web offers an appropriate environment for establishing interaction with the tutor and other students, the content and elements of display. It has most of the features required to set up collaboration among students and between students and the teacher to implement Web-based activities as a part of the learning process.

4.2. Research in Web-based distance education

Although there is a growing interest in offering courses via the Web for remote students, reviewing the distance education literature has shown that research in Web-based distance education accounts for a small portion of this literature. The vast majority of this research has been hypothetical, theoretical or descriptive rather than empirical. The aim of these studies was to investigate the features and capabilities of the Web in order to apply them in designing and developing future Web-based distance education programmes (e.g., Berge, 2000; Miller and Miller, 2000; Spector and Davidsen, 2000; Weston and Barker, 2001). Jung and Rha (2000) found that although numerous studies have explored various aspects of on-line education, 'only a few attempts have been made to investigate the effectiveness of online education based on empirical data' (p. 57).

The most extensive literature review on Web-based distance education was conducted by Jung (2000), in association with the American Center for the Study of Distance Education. She reviewed the Web-based distance education literature (62 studies) between 1997 and 1999 based on the transactional distance theory published in four refereed journals and concluded that:

> 'Most of these studies have focused on the effective design of Internet-based education using the various technical features of this technology. The pedagogical features of Internet-based education have been also discussed, and effects of the Internet on learning, participation, and attitude have been investigated in several studies. In addition, there have been a few papers that report on the cost-effectiveness of the Internet-based education'.

Jung summarised the results of her review according to the research methodology and focus of the study, as shown below (Table 4-2). The results showed that only 26% of these studies adopted quantitative or qualitative, true or quasi-experiments for their research methodology, while 31% of these studies reported the design and development approaches implemented in developing Web-based educational systems. Out of sixty-two studies, 52% focused only on Web technology as a stand-alone medium, without involving any other technology. Jung expressed the criticism that although the majority of these studies reported the design of research, design of interaction and learners' satisfaction and achievement, few of them explained the pedagogical approach or theory employed in learning, how learning happened and why it happened.

Table 4-2: Classification of Web-based distance education research by methodology and focus (adapted from Jung, 2000)

Classification	Category	Number (Percent)
Methodology	Developmental studies	19 (31%)
	Experiments	16 (26%)
	Evaluation studies	15 (24%)
	Ideas and positions	12 (19%)
	Total	62 (100%)
Focus	Internet-based education in specific	32 (52%)
	Internet-based education along with other technologies	17 (27%)
	Computer conferencing in general	13 (21%)
	Total	62 (100%)

Based on Jung's comprehensive framework of review, a further review of developmental, empirical and evaluation studies was conducted in the present study to review research in Web-based education. Basically, the studies reviewed fall into three major categories: developmental studies, evaluation studies and ideas and positions studies. Examples of the first two categories were reviewed in this section. However, ideas and positions research is reviewed in the rest of this chapter.

4.2.1. Strengths and weaknesses of on-line instruction

The most common type of developmental studies in Web-based instruction was conducted to investigate the strengths and weakness of the design of on-line environments. One of the earlier studies was conducted by Heath (1997) who designed, developed and evaluated the strengths and weakness of a 'virtual' online classroom. The purpose of Heath's study was to suggest a model to be followed in further development research. Heath surveyed and interviewed twenty college students, as well as experts, to gather suggestions and critiques to be used in future design of virtual classes.

The results revealed that most students favoured the user-friendly design of the user interface and a straightforward navigation system. However, the major weakness was found in the design of discussion boards that require reading, jumping forward and back, thinking and posting. In addition, the results emphasised the importance of instructor's participation, the need to reduce the number of threads per discussion and the need to prepare students to learn and interact on-line.

Another approach to conduct more beneficial research in Web-based distance education is the use of longitudinal studies. Lockee et al. (1999) pointed out that:

> 'The collection of data over time can provide a more accurate perspective, whether through qualitative case studies rich in descriptive information, or more quantitative time-series analyses, which may demonstrate patterns in certain variables' (p. 39).

An example of this approach is the study conducted by Graham and Scarborough (1999) over two years at Deakin University in Australia. In their empirical study, they compared the potential and benefits of on-line learning to the traditional methods. Students were allocated to a traditional method group and a FirstClass (*) group. The traditional method involving printed course notes, phone contact with staff, assessment via assignments and final exams. FirstClass provided students with asynchronous and synchronous communication tools and facilitated access to on-line resources and sharing files. Analysis of results was based on overall final exam grades, questionnaires administered over a two-year period and interviews with the staff. The findings showed that although the performance of 60% of on-line students improved in the second year of the programme, compared to 40% of students not adopting CMC in their study, and access to the lecturer is a great potential benefit to on-line learning, the need to keep up to date with fortnightly exercises 'reduced the flexibility' of on-line distance education. In addition, Graham and Scarborough concluded that measuring learning outcomes using only final grades in evaluating on-line learning systems is limited and fails to recognise the actual benefit of interactive learning, flexibility and collaborative learning activities.

4.2.2. Costs of Web-based distance education

Few exploratory developmental studies in Web-based distance education have investigated the full direct costs or costs and benefits of Web-based distance education. The aim of these studies was to investigate the several key design elements that should be considered in costing Web-based distance education. Two comprehensive case studies were conducted in this area by Whalen and Wright (1999) and Zlomislic and Bates (1999). The purpose of these was to develop a cost-benefit methodology to be considered in analysing and understanding the costs of Web-based distance education projects.

Whalen and Wright (1999) conducted a case study to analyse and compare the cost and evaluate the effectiveness of training courses provided by Bell Online Institute in Canada. They developed and delivered three courses on four different learning platforms (WebCT, Mentys, Pebblesoft and Centra Symposium). Their methodology divided project costs into fixed capital costs and variable operating costs. According to Whalen and Wright, fixed costs analysis helps to 'determine whether the high fixed costs associated with providing learning in

(*) FirstClass® is an on-line learning environment designed to deliver course materials, facilitate interaction and manage students at a distance.

a technology-enabled format are justified in comparison to the costs of traditional classroom' (p.30). These costs include licence fees for learning platform software, costs of hardware (server and clients), costs of course development (including instructional design, the production of text, graphics and multimedia, software development and course testing) and developers' salaries. However, variable costs are the tuition fees, training costs, usability testing costs and travel costs.

The results of cost-benefit analysis showed that although Web-based education seems to have higher fixed costs than the traditional campus, the total cost per student was offset by lower variable costs due to two reasons: the reduction in course delivery time and the potential to deliver courses to a wider range of learners without additional costs. However, to make savings and recover high the fixed costs, Whalen and Wright emphasised the need to consider three variables in developing and delivering on-line costs. These variables are the number of students per course, multimedia objects in the content and the live presence of the instructor during delivery. A sufficient number of students and limited multimedia elements and instructor presence could offset the high total cost of the course. Lastly, Whalen and Wright (1999) argued that this methodology could provide more comprehensive understanding of the cost benefit of on-line learning and be used in conducting future cost-benefit studies of Web-based distance education.

Using a similar, but more generic, methodology, Zlomislic and Bates (1999) developed and applied a cost-benefit model for assessing Web-based learning at the University of British Columbia (UBC). The methodology developed in their study was based on Bates' (1995) ACTIONS model, as described in Chapter 2 above. Cost measures assessed in this study include capital and recurrent costs, production and delivery costs and fixed and variable costs. Benefits include learning outcomes, student/instructor satisfaction, increased access, flexibility and ease of use as well as other 'value added' benefits (e.g. reduce traffic and pollution and the potential of new market). Both quantitative and qualitative techniques were used with a sample of 80 university students. Cost findings revealed that:

1. Start-up costs were higher than anticipated;
2. Students thought the course was worth the money it cost them to take it; and
3. On-line courses can be cost effective, especially when marketed internationally.

Regarding benefits, it was found that:

1. Students were able to access instructors and experts;
2. Access to on-line courses was flexible in terms of time and place;
3. Students were satisfied with the course materials, the user-friendliness of the design, individualised tutor feedback and peer interaction; and
4. Development and delivery of courses can be made very quickly (Zlomislic and Bates, 1999).

Zlomislic and Bates claimed that this cost-benefit methodology allowed them to take a detailed look at the distance education project, provided an accurate approach of measuring the costs of on-line courses in a real context and could be very useful in conducting future cost-benefit analysis of similar projects.

4.2.3. Students' perception and performance

Another common area of research in Web-based distance education is investigation of the effectiveness of online delivery of course materials in students' perception and learning outcomes, especially in comparison with the traditional classroom. Schlough and Bhuripanyo (1998) developed a Web-based instruction programme for graduate students at the University of Wisconsin-Stout. After eight weeks of interaction with the on-line content, the students (n=22) were asked to rate several statements using a five point Likert scale. Students cited organisation, relevance and accuracy of content as strengths of the course and provided positive feedback regarding the effective and attractive design of graphics and illustrations. On the other hand, lower scores were given for navigation and control over the program, instructional format of the course and peer interaction.

In addition, in a comparison between an on-line course and an equivalent course taught in a traditional face-to-face format Johnson et al. (2000) found that on-line distance education could be designed to be as effective as traditional instruction. The overall mean rating of the traditional class was 3.47 (SD = .60) and the mean rating for the on-line class projects was 3.40 (SD = .61). The results of this study showed student satisfaction with their learning experience to be slightly more positive for students in a traditional course format, although there was no significant difference in the quality of the learning that took place.

More recently, Gagne and Shepherd (2001) have supported the common finding of non-significant differences between Web-based distance education and conventional classes (conventional face-to-face lecture mode) using a well-described true experimental design, with a relatively larger number of students. The same course was delivered in the traditional format and via the Web. According to Gagne and Shepherd, the on-line course allowed students to engage in synchronous (chat) and asynchronous (e-mail and forums) interaction to communicate with the instructor and with each other. They were given their own workspaces where they could exchange files with the instructor and with each other. To enhance comparability, the same text, syllabus, assignments and examinations were used in both classes. Moreover, the same lecturer taught both groups.

Analysis of variance was used to investigate how much the two classes differed from each other and how much the students' demographics (e.g., work experience, academic background, etc.) within the classes differed. The findings indicated that the performance of on-line students was similar to that of those in the on-campus course. Furthermore, Gagne and Shepherd concluded that although students' perceptions of the course were similar, on-line students indicated that they were less satisfied with the presence of the on-line instructor than the traditional class students.

4.2.4. Non-comparative studies

While the above studies compared the effectiveness of the Web with a traditional class or other media, there are a few non-comparative studies that concern or examine factors that may be related to successful on-line learning and students' satisfaction or how students with different learning styles perform in Web-based distance education. For example, Shih et al. (1998) designed and developed two stand-alone Web-based courses, which they tested on 78 university students. The purpose of this study was to identify relationships among student learning styles, learning strategies, patterns of learning and achievement. An on-line questionnaire including a learning strategies scale, a patterns of learning scale and demographic questions was designed and posted on the Web for this purpose. In addition, students completed a learning styles test. The results of this study indicated that learning styles, patterns of learning toward Web-based instruction and student characteristics did not have an effect on students' achievement.

Also, Jiang and Shrader (2001) conducted an exploratory study to investigate many factors that might contribute to students' academic achievement and satisfaction with an on-line environment provided by Western Governors University. These factors are pre-assessment results, interaction with the mentor, number of on-line courses taken and demographic profile (e.g., age, gender, age, current position, etc.). Participants in this study were 120 students enrolled in a Master's programme. They learned via direct interaction with on-line course materials and the mentor using e-mail, listservs and threaded discussions. The researchers developed a questionnaire to reveal students' satisfaction with the programme and used the results of pre-assessment and raw count of students' messages. Using correlation analysis and multiple regression analysis, the researchers found that:

1. Students' overall satisfaction was high, with a mean score of 3.18 on the four-point rating scale. They felt most satisfied with the flexibility of time and place provided by the on-line course;
2. Only student-mentor interaction had a significant relation with students' satisfaction and academic progress.
3. The various demographic variables did not bear any significant relationship with satisfaction and academic progress.

Jiang and Shrader found that the more the students communicated with their mentor, the more motivated they were and the more academic help they obtained from their mentor, therefore they progressed faster and were more satisfied with on-line learning.

One final interesting study was conducted by Carey (2001) to examine the effect of practice tests and feedback strategies on academic achievement and motivation in Web-based instruction. Forty-five undergraduate students enrolled in a Web-based assessment for teachers course participated in the study. All practice tests and feedback were contained within the Web site and there were a total of 42 practice tests embedded in the instruction. To create the two different practice test strategies, Carey divided the course Web site into two separate models. In the first model, questions related to the current instruction were presented, and students were directed to answer the questions using their own paper. They were then directed to check their answers against the feedback by scrolling down the web page. However, students were not forced to answer questions in order to receive feedback. In the second model, students took the practice tests using a test administration program, and they submitted their answers for the grading program. The program returned information about whether each item was correct or incorrect, as well as the total percentage of correct scores. Students were not forced to take the practice tests to continue through the instruction; but they could access feedback only by answering the questions.

The students were randomly assigned to either the self-scored or the computer-scored testing and feedback strategy. The findings showed that:

1. The computer-scored practice test group performed significantly better than the self-scored practice test group on both the midterm and the final examinations. In addition, the students in the self-scored group achieved at relatively the same levels on both the midterm and final examinations, while the students in the computer-scored practice group improved their achievement level between the midterm and the final.
2. The two groups were not significantly different in their ratings of their attention to practice and feedback materials.
3. There were no significant differences in the two groups' ratings of their confidence in performing course objectives or their satisfaction with their efforts during the course.

Carey argued that students' performance improved and was supported by the enhanced perception of the relevance of the practice and feedback, because students provided their own structure in the course and created their own interpersonal dialogue. He recommended that 'research should continue in strategies for narrowing the transactional distance for less mature learners'.

Summary of developmental and evaluation research in Web-based distance education

The above review of literature shows that developmental studies take one of three forms defined by Richy and Nelson (1996). These forms are:

1. Performing instructional design, development, evaluation activities and studying the process of distance education at the same time;
2. Investigating the impact of someone else's instructional design and development; and

3. Studying the instructional design, development and evaluation process as a whole, or a particular component (Richy and Nelson, 1996).

In evaluation studies, it was found that both the internal efficiency and the operational efficiency of the programme, as defined by Lam and Paulet (1991), are considered. Internal efficiency refers to 'the learners' achievements, the number of learners who successfully complete the courses or programs, and perhaps, the degree of satisfaction with the learning experience' (Lam and Paulet, 1991, p. 54), while operational efficiency refers to whether the revenue to the institution is sufficient to allow it to continue to offer the same programme for a long time or not.

In both developmental and evaluation studies, a research design was implemented to obtain and analyse research data (e.g., true or quasi-experimental, quantitative or qualitative, etc.). In addition, evaluation measurements, such as learning outcomes, students' overall satisfaction, costs and benefits of the system, media attributes, implementation issues and factors associated with students' achievement and perception were implemented to examine the effectiveness of the Web in distance education.

In almost all of the above developmental and evaluation studies, first, on-line students performed as well as students in traditional classrooms and had the same attitudes toward the course. However, some factors might influence students' performance and perception. These include gender, age, academic experience, computer skills, student-instructor interaction and motivation. Second, research emphasised the role of the human contact in motivating and enriching students' experience. Third, although these studies pointed to increased interest and motivation to learn via the Web, they did not indicate:

1. the quality of student-student and student-tutor interaction and how this can affect students' performance;
2. the quality and ease of access to Web resources;
3. the potential of branching and user-interface capabilities of the Web (Smith and Dillon, 1999);
4. the best ways of integrating asynchronous interaction with the on-line learning; and
5. the technical support needed to deal with and learn via the Internet.

Moreover, in all these studies, participants were mature learners (undergraduate, graduate or higher education learners) and no study investigated the Web-based distance education process with younger or school students. Therefore, further research is required to investigate approaches for designing and implementation of on-line learning for younger learners using appropriate learning theories and instructional design approaches.

Lastly, although most of the studies reviewed in this section were comparison studies, which have been criticised recently (Lockee et al, 1999), such studies could play an important role in providing distance educators with extensive experience in designing and implementation of the Web and the factors that could affect learning in a variety of settings, 'but only if those factors are adequately defined' (Smith and Dillon, 1999, p.20). These factors and how they may relate to students' learning are discussed in the next sections.

4.3. Models of using the Web in education

A review of the literature has shown that the Web is utilised at different levels and in many ways. Rice et al. (1998), for example, argued that the Web could be used as a communication medium, search tool or publishing medium. Lowther et al. (2000) defined five levels of Web use in education. These levels vary from using the Web as an informational and supplemental source of course information, beside face-to-face instruction, to a sophisticated and integrated virtual learning environment for teaching students at a distance (Table 4-3).

Table 4-3: Levels of Web use in education (adapted from Lowther, 2000, p. 135)

Level	Description
Level 1: Informational	Provides course-related information to the student such as syllabus, course schedule, contact information, etc.
Level 2: Supplemental	Provides course content information including notes and handouts, presentations, etc.
Level 3: Essential	Provides most, if not all, of the course content information on-line.
Level 4: Communal	Provides all course content information as well as limited student-student and student-instructor interaction.
Level 5: Immersive	All of the course content and course interactions occur on-line.

However, according to Parson (1997), these functions could be implemented in the educational context in only three different levels:

- Web pedagogical resources;
- Web supported instruction; and
- Stand-alone instruction.

When the Web is used as a secondary source of information, students are encouraged to locate on-line course-related information and to expand their experience via reading, evaluating and exchanging these resources. However, in Web supported instruction, students use the Web to suggest assignment subjects, work on collaborative projects or conduct discussion. As a stand-alone learning environment, the Web deliver course materials and facilitate access to resources, facilitates interaction between students and the tutor and provides exams. This level seems to be the most suitable model to use in a distance education context for students who are not in direct contact with the tutor, peers or learning resources.

As a distance learning environment, Dalgarno (1995) argued that the Web encourages students to undertake such activities and provides them with feedback as they do so. Meanwhile, Sherry and Wilson (1997) emphasised the importance of integrating three important components in Web-based learning environments. These components are learning resources, student support and collaboration among learners. They argued that these requirements need to be implemented in various ways in the Web, whereby students, instructor and experts can participate, communicate and discuss related issues.

Koutoumanos et al. (1996) indicated three requirements for stand-alone learning via the Web. These requirements are mainly related to the availability of the course materials and the method of interaction with the student's responses, as follows:

1. The educational material must be widely available and able to be accessed by students;
2. The environment must provide students with a means of submitting questions and receiving feedback from the tutor; and
3. The environment must facilitate administrative tasks (Koutoumanos et al., 1996).

Khan (1997) pointed out that the Web, as an approach for delivering instruction for students at a distance, has many attributes that could be integrated to create a meaningful learning environment. He described a Web-based instruction environment as:

> 'a hypermedia-based instructional program which utilizes the attributes and resources of the World Wide Web to create a meaningful learning environment where learning is fostered and supported (p. 6).

In his definition, Khan (1997) pointed to many unique features and components associated with the Web as a distance education environment. The most obvious features are interactivity, supporting hypermedia applications, supporting individualised as well as collaborative learning and flexibility in time and place. However, communication approaches and knowledge sources are the main components that structure the environment. These features and their components are summarised below (Table 4-4).

However, although it seems that at the high-level of using the Web, students may work independently in isolation from the teacher and rely on the Web to access course information and resources, the Web requires a tutor/facilitator who has good experience in dealing with the medium itself (Berge, 1996; Beaudoin, 1990). Nevertheless, the tutor's role is not as a deliverer of information but as a monitor of students' activities and facilitator of learning. He/she suggests activities and encourages learners to discuss, seek for information, share knowledge and work co-operatively (Robinson, 1981; Sadik, 2000). Berge (1996) pointed out more pedagogical and social roles of the on-line tutor. Pedagogical roles are related to the teaching function, such as encouraging learners to participate in the class activities, inviting visiting experts, requesting responses and providing feedback. However, social roles (e.g., motivating and introducing students to interact with each other and building a sense of community) are necessary to promote human relationships and activities. In addition, Shotsberger (1997) pointed out many ways by which on-line tutors could encourage learners in stand-alone Web-based instruction. Examples of these ways are publishing materials that emphasise learner involvement, posting messages to promote conversation, assigning varying roles to students, such as presenter and discussant, and encouraging smaller work groups to accomplish tasks.

Table 4-4: Features and components associated with Web-based learning environments (adapted from Khan, 1997, pp. 11-18)

Feature	Components	Function
Interactive	Communication tools (e.g., E-mail, chat and videoconferencing)	The Web has many two-way interaction tools that enable students to interact with the teacher, site facilitator, experts and themselves without the need to use additional tools. The importance of this feature is that it enables teacher to provide support, feedback, and guidance via both synchronous (e.g., chat, conferences) and asynchronous (e.g. discussion board and e-mail) communications.
Hypermedial	HTML, graphics, sound, text, sound, movie, Java applets, etc.	The Web environment enables designers to incorporate a variety of multimedia elements (e.g., graphics, audio, video, animation) with hypertext to establish a hypermedia system. Hypermedia features enable students to explore materials in libraries, museums, and databases in different formats effectively.
Active Learning	Search engines, communication tools, HTML form, etc.	The interactive components on the Internet like Web-based forms, which depend on learner participation, in addition to the communication tools and search engines have changed the role of the learner from recipient to participant.
Devices, place and time independent	Browsers, plug-ins, HTML, etc.	Students can enrol in a Web class from any place in the world, far from the teacher and their peers(distance-independent) using different types of hardware and software (device independent) and they can access the class at any time (time-independent).
Online resources	Databases, search engines, directories, etc.	The Web provides instant access to different types of online resources in different formats. This feature provides instructors with access to information sources that enable them to incorporate recent information and examples into their courses.
Personalised	E-mail, chat, Web-based forms, etc.	The Web establishes a student-centred learning environment. The hypermedial organisation allows material at different levels of detail or difficulty to be made available to students without imposing a pre-determined path for them to follow. Students can create individual paths to master the desired goals, moving at their own speed and retrieving information.
Collaborative Learning	Video conferencing, discussion groups, presentation boards, etc.	The Web environment has all the capabilities to facilitate co-operative learning, which extends beyond the classroom. The Web environment has the capabilities to create collaboration, conversation, sharing, discussions, exchange, and

Feature	Components	Function
		communication sessions among students that promote active and interactive learning from multiple perspectives.
Online evaluation, feedback and reinforcing	HTML forms, e-mail, discussion boards, JavaScript, CGI scripts, etc.	The Web has a facility that allows students to submit exams to the instructor or the on line institution depending on interactive testing through HTML forms processed by server-based CGI scripts or client- side JavaScript. Students' quizzes, assignments, exams and projects can be stored on a database and graded, then the appropriate feedback sent to each student individually.

In conclusion, in stand-alone learning environments, the online teacher needs appropriate experience in tutoring and supporting students at a distance, and a clear view of the learning objectives, appropriate teaching methods and learners' abilities. In addition, such learning requires an on-line tutor who has the ability to maintain course materials, upload and download files to and from the Internet, deal with the different file formats, manage e-mail messages and other communication protocols and promote student collaboration.

4.4. Theories of on-line learning

Over the last three decades, the use of technology in education has developed rapidly. Technologies vary from tools to facilitate the role of the teacher and enrich the presentation process, to systems offering flexible and active learning environments that engage the learner in an active and collaborative experience. Since the design of Web-based instruction should be based upon sound learning theories (Reeves and Reeves, 1997), Web developers need to find an approach that meets the many concepts in instructional design of recent technologies. The main feature of these technologies, like the Internet, is the change in learner's roles from a passive recipient to an active participant.

Three main schools of thought have emerged concerning instructional design. These schools depend on the concepts of three approaches known as behaviourism, cognitivism and constructivism. Behaviourists are concerned with observable cause and effect relationships and view learning as a sequence of stimuli and response actions in the learner (Conway, 1997). A stimulus is provided (such as a short presentation of content) then a response is demanded via question. Feedback is given as to the response and positive reinforcement is given for correct responses (Reeves and Reeves, 1997). In contrast, cognitivists focus on cognitive processes, such as retention and recall of prior learning (McMahon, 1997). Objectivist philosophy holds that 'information in the external world is mind-independent and can be characterised in objective, concrete terms which are transmitted or communicated from the instructor to the student' (Bannan and Milheim, 1997, p. 382). However, the behaviourist and cognitivist theories are challenged by constructivist theories and models which recognise that social context, roles and relationships are central to learning (Jones et al., 1993). Sells and Glasgow (1998) summarised these three paradigms and their characteristics, as shown below (Table 4-5):

Table 4-5: Instructional paradigms and their characteristics (adapted from Sells and Glasgow, 1998)

Theory	Behaviourism	Cognitivism	Constructivism
Nature of learning	Change in overt behaviour due to conditioning	Programming of new rule for information processing	Personal discovery based on insight
Types of Learning	Discrimination, association and changing	Short-term sensory storage, short-term memory, long-term memory	Problem solving
Strategies	Present and provide for practice and feedback	Plan for cognitive learning strategies	Provide for active, self-regulating and reflective learner
Media	Variety of traditional media and CAI	Computer based instruction	Responsive instruction

In a study by Eric and Lincoln (1992), the researchers asked, 'how do we educate the new child raised in a world of instant information, where interactive technologies have led them to believe they can act on the world with the press of a button?' Their study showed that using the current communication technologies and the features of constructivist philosophy can enable learners actively to construct their knowledge, rather than absorbing ideas spoken at them by others. 'Constructivist theory explains learning as an active process in which the learner builds knowledge and understanding from individual experiences' (Smith-Gratto, 2000, p. 230). Additionally, constructivist epistemology assumes that construction of knowledge depends on the interaction between the learner and others in the learning environment, and an active engagement in problem-solving situations (Oliver, 2000).

Gagnon and Collay (1998) suggested four epistemological assumptions, which they called 'the heart of constructivist learning'. They believe that knowledge is physically constructed by learners who are involved in active learning, symbolically constructed by learners who are making their own representations of action, socially constructed by learners who convey their meaning to others and theoretically constructed by learners who try to explain things they do not completely understand (Gagnon and Collay, 1998). These four assumptions imply that learners need to be engaged in active learning situations that stimulate them to construct their own meaning and knowledge. These situations should involve problem-solving activities and facilitate peer interaction.

Lefrere (1997) argues that the aspirations of constructivist approaches to teaching are laudable, and indicated many advantages of constructivism, which can be exploited in on-line learning. He indicated that constructivism encourages students to take responsibility for their own learning and become problem solvers, frames tasks using terms with connotations of higher-level thinking, such as classify, analyse, predict and create and encourages students in experiences that might challenge their initial hypotheses and then encourage discussion both with the teacher and with one another (Lefrere, 1997).

Consequently, many studies have begun to look into the Web as an optimal learning environment that has many capabilities to exploit the concepts of the constructivists, as concluded below.

1. Strommen and Lincoln (1992): Accomplishing educational practices that follow from constructivism and nurturing learners' cognitive abilities requires a supportive environment, like the Web, in which they can create their own ideas, both individually and collaboratively.
2. Bannan and William (1997): While the design of objectivist lessons may be represented by posting the content and questions from the instructor to the learner, Web-based constructivist design would include many opportunities for the learner to analyse, organise and structure information, evaluate and contribute information.

3. Harper and Hedberg. (1997): The flexibility and freedom of the Web environment suggests that the user is operating entirely within a constructivist framework. The Web enables the learner to work in a group or individually. The group provides a discussion forum for suggestions, ideas and debate and feedback. In the meantime, the Web encourages the learner to work individually and display motivation.
4. McMahon (1997): In many respects, the Web is an ideal forum for constructivist learning, and despite its limitations, offers some interesting opportunities. The Web, as a communication medium, has strong potential for social interactivity.
5. Smith-Gratto (2000): 'If one considers both definitions of constructivism, the Web can be considered primarily a constructivist environment, because learners move through materials on the Web and construct individual understandings of the material they encounter'. In addition, 'students can also engage in conversations with others during the information-gathering and problem-solving processes' (p. 228).

The above studies agree that constructivist principles appear to be suitable for designing learning for Web-based environments. The Web supports social interaction, problem-solving activities and accessing and verifying information, and allows the designer and learners to define the scope of learning in a flexible manner. However, although the above review may give the impression that this research agrees with the tenets of constructivism, there is no doubt that no single teaching approach suits all types of subject matters and learners. Web developers should consider more than one theory to accommodate the differences among learners.

4.5. Interaction via the Web

Often, teaching with earlier media is content-centred, time dependent and characterised by the lack of collaboration among learners (Chapter 2). However, the Web environment facilitates interactive learning, which is still difficult to achieve or manage in the conventional classroom, using one-way media (such as broadcasting) or even using the latest generation courseware (such as interactive CD-ROMs). One of the important factors that have encouraged educators to use the Web in distance education is its ability to engage students in an interactive learning experience. The Web provides many mechanisms to facilitate dialogue between the learner and the course content and between the learner and others (Fisher, 2000).

First, Brown (1997) argued that the possibility of designing the Web around a series of topics and in hypertext format allows the learner to decide what information to access and what path to follow. Since student-centred learning enables students to learn according to their abilities, they can study and practise new concepts more deeply or spend less time on concepts that are already understood (Powers and Guan, 2000). In addition, Eaton (1997) pointed out that one of the main advantages of online active learning is giving the learner control over the context, content and sequence of learning. He defined five different types of control over Web-based learning and their function to be considered in designing learning for the Web (Table 4-6). He indicated the learner's control over the page content and hyperlinks and his/her ability to read or jump over texts as context control and content control. However, he called for the ability to choose among presentation formats that cover the same subject or concepts (display control).

Table 4-6: Types of learner control (Eaton, 1997)

Type of control	Function
1. Context control	To give the learner control over the text density, optional links to additional resources, concepts and examples.
2. Content control	To control the selection of the content which is suitable for the learner to learn.
3. Sequence and pace control	To allow the selection of subjects, selection control allows the learner to determine the path through the subjects or topics, according to learning objectives related to the overall course.
4. Display control	To allow the learner to choose one of several formats that cover the same subject or concepts (syllabus, exercises, etc)
5. Feedback control	To allow the learner to either defer to computer-controlled feedback or select options on the feedback mechanism.

However, having access to a rich information source like the Internet and the freedom of the learner to search and determine his/her pathway through the content is not the only type of interaction available on the Web. Via the Web it is possible to conduct human (student-student and student-tutor) interaction by virtue of Web-based interaction methods (Huang, 2000). Harasim (1990) described interaction as a critical variable in learning. He believes that learners construct their own knowledge by sharing it with others and building upon these ideas and concepts. This construction can be achieved through the 'reactions and responses' of others.

Reviewing the literature has shown that the Web supports two different forms of student-student and student-tutor interaction; each form can be achieved using different methods: asynchronous interaction and synchronous interaction (Huang, 2000). Asynchronous interaction is time-independent and does not require real-time dialogue. It enables the tutor and learners to send and receive messages at any time, without the need for immediate response and gives them the chance to read, reflect and do more critical thinking (Liaw and Huang, 2000). E-mail, listservs, newsgroups and discussion groups, or forums, are the most common asynchronous methods used in the Internet. Bourne et al. (1997) indicated that the distinct advantage of listservs is that anyone with e-mail can participate.

However, the most popular and widely used method for transmitting asynchronous information messages on the Internet is e-mail. There are many purposes for which students can use e-mail in distance education to interact with the tutor and peers. Students can send questions, submit assignments and receive evaluation results, prepare for real-time discussion, share ideas, receive materials or ask the instructor for help and receive feedback (Simpson, 2000). In addition, since e-mail is relatively cheap and simple to use, it facilitates and encourages collaborative work and exchanging of ideas and information (Stevens, 1994). Today, Web-based mail services are available with user-friendly interfaces and the possibility of global access, by virtue of Web-based forms and server-side CGI scripts, flexible and simple e-mail interfaces that become available for young students.

Although e-mail is the most popular and widely used method for individual asynchronous interaction, discussion boards and bulletin boards are also common group-based approach used in online learning (Carr-Chellman and Duchastel, 2000). Asynchronous interaction via discussion boards refer to 'the posting of messages in a common area for participants to read and respond to' (Huang, 2000, p. 42). Often, discussion boards focus on the subject matter and aim to encourage student-student dialogue and learning from others' experiences. Berge (2000) believes that on-line discussions have the same purposes as face-to-face discussions. For example, asynchronous discussions could be used to focus attention on an issue, diagnose specific learning difficulties, encourage reflection and self-evaluation and teach via students' answers. In addition, students can learn 'by expressing their ideas, opinions, or solutions to others, by critiquing one another's proposed models, and by defending or modifying their initial models' (Oliver, 2000, p. 9).

On the other hand, synchronous interaction is similar to telephone communication or audio-video conferencing systems. Many protocols are available on the Web for conducting real-time conferencing. (e.g., CU See Me, Internet Relay Chat and Internet Phone). Internet Relay Chat (IRC), for example, enables students to discuss in a real-time status via an audio-visual window or using text. Aoki and Pogroszewski (1998) indicated that synchronous interaction has the ability to motivate learners to learn, provide feedback and support immediately and encourage student interaction. Text-based chat is a simple and popular technique for communication on the Web. It fosters immediacy and social presence, is useful for brainstorming and decision-making and helps in building a community of learners (Murphy, 1997). Developers can easily integrate chat rooms into their courses to hold conferences between students and experts, monitor students' participation and encourage them to work collaboratively (Liaw and Huang, 2000).

However, although Web-based synchronous interaction offers a chance for real-time communication on the Web, it often requires sophisticated software and hardware to be installed, which are usually more expensive than asynchronous delivery systems. In addition, one of the critical limitations of this type of interaction is that it is restricted by time zones and students' typing and communication skills.

Romiszowski (1993) proposed a comprehensive model for looking and using synchronous and asynchronous interaction according to two factors: type of learning supported by the technology (individual learning and group learning) and type of interaction (asynchronous and synchronous). E-mail, for example, is an asynchronous interaction method and appropriate for individual learning or student-student and student-tutor interaction. Romiszowski's model is represented as shown below (Table 4-7).

Table 4-7: Technology and learning

Technology and learning	Synchronous	Asynchronous
One on one	Telephone Videophone Multimedia workstation	Facsimile E-mail Voicemail Multimedia workstation
Group learning	Audio conference Audio-graphic system Videoconference Virtual classroom	Computer conference Computer-supported collaborative work environments Multimedia network

Romiszowski's framework indicates that Web-based learning could be designed in an interactive way to offer a rich social and collaborative learning environment, which could support and facilitate this kind of learning and interaction. These various types and levels of interaction put students in an active role rather than the passive role of recipients of information transmitted by other types of technology such as broadcast and static CAI programmes.

Stating another point of view, in a comparison between types of interaction available on the Web with those in the traditional classroom, Welsh (1997) distinguished between what is called 'full synchronous', 'limited synchronous' and asynchronous interaction (Table 4-8). He compared the involvement of the whole on-line class in a chat session to the conventional face-to-face interaction of students and the tutor in the classroom and called it 'full synchronous' interaction. However, he called the partial involvement of the on-line class (two or three students) 'limited synchronous interaction'. At the same time, Welsh compared flexible access and downloading of assignments from the Web site and sending and receiving assignments from the tutor via e-mail (asynchronous) to doing homework or personal tasks such as writing.

Table 4-8: Types of interaction (adapted from Welsh, 1997)

Interaction	Traditional classroom	Web-based instruction
Full synchronous	Typical class session attended by instructor and students.	Entire class meets via Web-based chat forum (text, audio or video).
Limited synchronous	Student group meeting outside of class time to complete assignments.	Two students or a student group meet in Web-based chat forum to complete group assignments posted to the Web.
	Instructor meets with individual students or student group during office hours.	Instructor holds regular Web office hours where chat forum is used with individual students and student groups to provide tutoring, feedback, etc.
Asynchronous	Student completes individual homework assignments involving primarily the tasks of reading and/or some from of personal expression such as writing.	Students download assignments and information resources from class Web site. Instructor receives written work and provides feedback via e-mail.
	Library is used to access information resources.	Students access relevant world wide information resources through annotated links suggested by the instructor and other students.

Lastly, since students react and participate differently based upon their personalities and attitudes, Kearsley (1998) noted that some students feel quite comfortable joining group asynchronous/synchronous interaction sessions via the Web while others prefer just to read others' messages, and do not participate actively (called lurking). Klemm (1998) suggested that to prevent lurking in discussion groups, students should be encouraged to post messages regularly, the teacher should grade on the quality of the postings and help students to think in a meaningful way.

4.6. Cost-benefit analysis of Web-based education

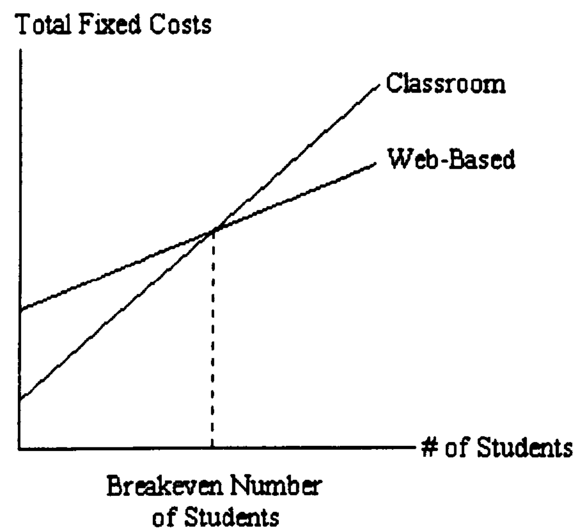
The review of the distance education literature (Chapter 2) shows that costs are one of the critical factors considered in producing, delivering and evaluating distance education programmes. These costs vary from one medium to another according to the number of learners and the degree of interaction and support provided by the technology. According to

Bates (1991), cost is made up of student equipment costs, production, distribution and telecommunication costs and the number of teachers needed.

Usually, the cost of Web-based distance education is compared to the cost of a conventional campus or other media (such as broadcasting). However, although the type of costs involved in Web-based learning are different from those involved in earlier technologies (e.g., print, broadcasting and computer-assisted learning) (Inglis, 1999), the costs of Web-based distance education also could be divided into fixed capital costs and variable operating costs (Bates, 1995; Zlomislic and Bates, 1999; Whalen and Wright, 1999). Fixed capital costs of Web-based learning are the costs of software and hardware needed to establish and develop learning (such as the costs of purchasing the Web server machine, Web server software and development and authoring tools) as well as the costs of developing course elements (e.g., text, graphics, audio, video, HTML pages and scripts). This type of costs depends on the type, quantity and quality of course materials (Inglis, 1999). However, variable operating costs are the costs of access, connection and time spent by the tutor and students.

Research has shown that although the fixed costs of Web-based distance education seem to be higher than the costs of a conventional classroom, 'these higher course development costs are offset by lower variable costs in course delivery' (Whalen and Wright, 1999, p. 42). The reason is that it is possible to mount and deliver Web-based courses to a larger number of students than in traditional education, without significant variable costs. However, to gain a saving, a sufficient number of students is required in order to 'recover' the fixed costs of the course (Whalen and Wright, 1999), as shown below (Figure 4-1).

Figure 4-1: Breakeven number of students (Whalen and Wright, 1999, p. 26)



However, although a relatively large number of studies have discussed the methodologies used to describe the costs of Web-based distance education, fewer studies have used or developed approaches to describe the cost-effectiveness of the Web. Lam and Paulet (1991) argued that cost analysis should go further to take into account what is called the 'internal efficiency' or cost-efficiency of the system, which seems to be the ultimate objective of cost analysis. By internal efficiency, they refer to:

> 'the beneficial impact on the learners, the learners' achievement, the number of learners who successfully complete the courses or programs and, perhaps, the degree of satisfaction with the learning experience' (Lam and Paulet, 1991, p. 54).

Brent (1999) described cost-benefit analysis as 'a set of alternatives with regard to both their costs and effects in producing an agreed upon outcome' (p. 234). The benefits could be 'cost-savings', 'value-added benefits', such as learning outcomes and social benefits, or 'return on investment', in which benefits are expressed by costs saved (Guilar, 1994; Cukier, 1997). The results of cost-benefit analysis would be a principal factor in determining the investment policy of institutes and public and private sector businesses (such as the World Bank) (Hawkridge, 1988). To conduct and implement cost-benefit analysis, Brent (1999) suggested a four-step approach, as follows:

1. Identifying the resources required to provide learning;

2. Identifying the cost or market price of each resource;
3. Determining the annual cost to operate the system; and
4. Examining the influence of the system on learning and comparing the annual costs with those of traditional methods (Brent, 1999).

The last step could be achieved by using and comparing many methodologies. Cukier (1997) suggested four approaches to examine the costs and benefits of network-based learning, as follows:

1. A values approach;
2. A mathematical modelling approach;
3. A comparative approach; and
4. A return-on-investment approach.

Cukier indicated that each of these approaches has its advantages and disadvantages. However, he argued that mathematical modelling is the most useful on a single cost-benefit study, since the variables of the model could be optimised according to the technology. The main advantages of mathematical models are that 'they can be relatively simple, easily quantifiable, and can be expressed in a variety of ways, for example, as total, average or marginal costs' (Cukier, 1997, p.147). Diacogiannis (1994) agrees with Cukier. He emphasised the importance of mathematical models for four reasons: they are clearer than other approaches (e.g., return on investment), can be numerical models providing quantitative results, help in decision making and help to evaluate different alternatives depending on a particular case.

In the light of Brent's and Cukier's approaches, Garson (1998) found that the Web provides many cost benefits to students when compared with other media and technologies. Examples are savings in costs of transportation, course packaging and delivery to individuals as well as flexibility in access at any time and any place. Others (Brent, 1999) have indicated the potential to deliver courses world-wide to reach a wider population, overcome teacher shortages and provide educational opportunities for isolated students with minimum costs as value-added benefits.

However, with the growing interest of distance educators in enhancing the quality of distance education, there is a need to maximise interactivity in on-line learning, including student-tutor interaction, student-student interaction and student-content interaction (Rumble, 2000). Jung (2000) argued that the amount of student-tutor interaction, amount of multimedia components in the course, choice of synchronous vs. asynchronous interaction and number of students in a course are factors that could affect the cost-effectiveness of Web-based distance education. For example, the interest in promoting student-tutor interaction led to increasing the cost per student to cover the fees of tutors and administrators (Trentin, 2000). However, Trentin believes that the problem is not only in shifting funding to cover interactivity fees but in 'evaluating to what extent the promotion in interactivity results in a higher quality course and what effect it has on overall costs' (p. 22).

In addition, promoting student-content interaction, by improving the quality of course materials using interactive elements (such as multimedia objects and interactive Web forms), has a significant effect on total costs (Inglis, 1999). Designing and using more advanced capabilities of the Web could increase development costs per hour (fixed costs) as well as the costs of access and delivery because of the limited bandwidth and costs of phone calls (variable costs). Therefore, the efficiency of a Web-based system could be enhanced in many ways, such as limiting and optimising interactive elements to enable learners to get real benefit with minimum expense, encouraging peer interaction and optimising group activities to reduce tutor participation and paying more attention to promote students' efficiency in learning and enhance their satisfaction with the learning experience (Inglis, 1999; Lam and Paulet, 1991).

4.7. Design elements of Web-based learning environments

Although the interactive, global, hypermedial and flexible nature of the Web offers many ways to enrich the learning experience, motivate learners and meet the diversity in backgrounds, 'many on-line courses lack basic design consideration with the Web simply being used as a medium for the delivery of instruction created within another framework' (Chellman and Duchastel, 2000, p. 229). Chellman and Duchastel indicated that it is not appropriate simply to upload traditional textbooks to the Web to create an on-line learning environment.

Powell (2001) also argued that although establishing on-line learning environments and delivering courses via the Web is growing rapidly, many Web developers and on-line tutors struggle with 'how to successfully use the available tools and technologies to organize instructional content into well crafted teaching systems that support learning' (p. 44). Powell pointed out that many instructional, structural, technical, navigational and content-related factors should be considered in designing and evaluating on-line learning to maintain and secure students' interest, motivation, satisfaction and success.

To design effective Web pages and content, Harbeck and Sherman (1999) argued that since students may be unable to navigate through a learning environment, deal with sophisticated software and hardware, make appropriate choices, participate in activities or control the programme, instructional designers and tutors should take close look at the design of the user-interface, guiding approaches, methods of encouraging interaction among learners and involving students in beneficial activities and individualised learning. They proposed seven principles to be considered in designing and developing on-line learning environments, particularly for young learners, as follows:

1. Web sites should be concrete; provide clear, simple navigation; have simple page design; and use large, obvious icons.
2. Children interacting with the Internet should be guided by an adult.
3. Web sites should be progressive and individualised in that the content and design of the site changes appropriately.
4. Web activities should have relevance to real world situations and provide integrated experiences.
5. Web activities should cover a variety of content areas, each independent of the others.
6. Web sites should provide active and enjoyable experiences to ensure a positive, affective experience.
7. Web sites should be exploratory, include multiple branching options, and provide predictable action (Harbeck and Sherman, 1999, p. 42).

Likewise, Ritchie and Hoffman (1997) pointed to many instructional design principles that could be adapted to design effective instruction for the Web. These principles are:

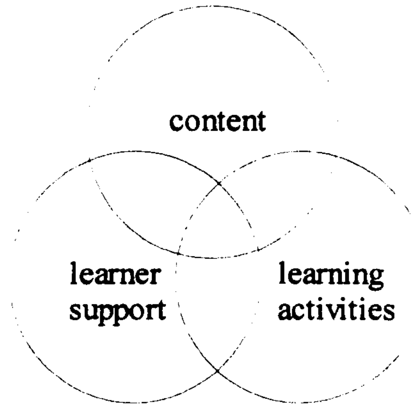
1. Motivating the learner;

2. Identifying what is to be learned;
3. Reminding learners of past knowledge;
4. Requiring active involvement;
5. Provide guidance and feedback; and
6. Testing (Ritchie and Hoffman, 1997).

Ritchie and Hoffman argued that the Web as a hypermedia environment uses graphics, colours, animated images, visual effects, sound and movies which have long been used as external stimuli to motivate learners. In addition, using the hypermedia capabilities of the Web, developers can offer different levels of instruction for learners who have diverse backgrounds or knowledge, to remind learners of their existing knowledge. Therefore, the learner can select among different links, take decisions and co-operate with other learners. Moreover, using synchronous and asynchronous methods, the on-line tutor can provide students with guidance and feedback during learning. Lastly, the recent interactive Web-based objects (e.g., CGI, Java, and ActiveX) could be exploited to construct online testing and engage students in online exams as self-tests to help the learners to evaluate themselves. In addition, CGI scripts can be used to provide learners with a remedy if they have problems, or to extend their knowledge.

However, stating another point of view, Oliver (1999) believes that although many studies have suggested design guidelines for designing on-line environments 'the advice is very broad and covers all aspects of instructional design. [...] The plethora of advice being offered is often difficult to digest and apply' (p. 241). Based on the notion of constructivism, as mentioned earlier in this chapter, Oliver described a framework to identify and distinguish between three main elements in the design of on-line learning environments. These elements that influence learning outcomes are course content, learning activities and learner support (Figure 4-2).

Figure 4-2: The critical design elements for effective on-line learning environments (Oliver, 1999, p. 243)



Oliver believes that, first, the learning environment should provide learners with the content and resources in a variety of ways and 'as a means to an end rather than an end in itself' with the freedom of the learner to choose his/her own path through the content. Second, the learning environment should provide the learner with such activities and opportunities for 'reflection and articulation'. Third, learner support is necessary to guide learners, provide assistance during learning and provide feedback.

However, while Oliver (1999) restricted on-line support to a narrower context, known as scaffolding, Simpson (2000) provided a more extensive and wider definition of on-line support. According to Simpson, student support indicates 'all activities beyond the production and delivery of course materials that assist in the progress of students in their studies' (p. 6), including academic support (e.g., exploring the course, providing feedback, chasing progress) and non-academic support (e.g., advising, assessment, administration, etc.). Simpson concluded that the Internet could enhance student support in two ways: 'supplying information of various kinds; and offering interactive and diagnostic programmes' using e-mail, synchronous and asynchronous conferences and information resources (p.80).

Moreover, Chellman and Duchastel (2000) argued that the design of on-line learning environments should consider 'the full spectrum of design, including both content and technology elements' (p. 229). Content elements are the basic instructional design elements (e.g., content, objectives and evaluation). Technology elements are the medium-related features that support learning (e.g., interaction mechanisms, management elements and interactive Web-based elements) (Chellman and Duchastel, 2000).

The review of the instructional design literature showed that various features and instructional and support elements should be available in on-line learning environments. These elements characterise Web-based education in particular and exploit the Web's capabilities to establish 'virtual' learning environments for distance students. The most common elements found in the writings of Saltzberg (1995), Sapp (1996), Khan (1997), Carr-Chellman and Duchastel (2000), Chellman and Duchastel (2000), Berge et al. (2000), Fisher (2000), Harrison and Bergen (2000), and Weston and Barker (2001) are addressed and described below. However, pointing out these elements does not mean that all of them must be available in any Web-based learning environment. Developers and instructors could choose the appropriate components they need or modify them according to the course objectives, learners' needs, costs and any other factors.

- **On-line modules**

Online modules use carefully designed and multiple forms of media such as hypertext, links, graphics, animation, real-time audio and video and other hypermedia objects (such as Java applets and Macromedia Flash presentations) to improve presentation and involve students in active learning activities (Weston and Barker, 2001). The purpose of on-line modules is to provide the student with a complete and up-to-date picture of the subject matter, including main concepts, links to Web resources, examples, exercises and reminders (Harrison and Bergen, 2000). Links to Web sites with authentic contexts or sites that afford access to primary source documents and immediate automated assessment and feedback are examples of useful active elements that should be included in on-line modules (Weston and Barker, 2001).

- **Study guide**

The study guide, or course outline, is the student's reference to the course content, tasks and activities associated with the on-line content. Usually, the study guide contains 'any prerequisites for the class, the objectives, a brief listing of topics to be covered, the required materials such as text, specific grading criteria for the course, participation requirements for the course and bibliography' (Harrison and Bergen, 2000, p. 59).

- **Course schedule**

The course schedule is needed to arrange the learner's time during studying and to keep students together as they work through the course material, but without striking the flexibility of the distance education programme.

- **Announcement board**

Using an announcement board, the instructor can post news or announcements to keep all learners up to date and involved (Huang, 2000). Students can access this board regularly to read the instructor's announcements. In addition, students can post their own announcements to the class.

- **Students' pages**

Students' and tutors' profiles could be presented through personal Web pages to foster the sense of community and that the class is not just a group of isolated learners. Personal Web pages that include student's e-mail address, photo, home town and other information encourage students to learn about each other and encourage individual interaction (McConnel and Sharples, 1997).

- **Interaction tools**

'Can we claim to be offering any kind of education if we do not offer our students the opportunity for dialogue at the same time?' (Simpson, 2000, p. 9). Of course not. Interaction can be done either in asynchronous or synchronous ways. The common tools of interaction are e-mail, discussion boards, listservs, chat room and conferences. Adding discussion forums and chat rooms to on-line courses may be a useful way to facilitate student-tutor and peer interaction and encourage co-operative learning. In addition, interaction elements can be 'a valuable teaching tool in countering the isolation felt by distance education students' (Dymock and Hobson, 1998, p. 157).

- **On-line assessment**

Web courses should offer an on-line assessment facility using different types of testing, including assignments and quizzes. Students can use these forms for self-assessment at the end of each module or at the end of the course for final evaluation. Students' responses may be marked automatically and synchronously using CGI or JavaScript programs or sent to the instructor to be marked (Khan, 1997; Goldberg, 1997). 'The provision of automatic assessment can offer enhanced possibilities both for self-study and for class administration' (Marshall, 1999, p. 40). Questions and assignments can be submitted via e-mail or discussion boards or off-line for more comprehensive evaluation and to avoid on-line cheating (Weston and Barker, 2001).

- **Class management**

Class management elements are all administrative tools necessary to ensure that the on-line class operates efficiently, including registration tools, assessment and distribution of grades and student tracking (McConnel and Sharples, 1997). A registration tool, for example, is needed to ease class enrolment and management. Students use this tool to provide personal information and join or withdraw from the class. In addition, server logs can be used to track students' participation and progress, assignment submissions, completion of quizzes and participation in discussions.

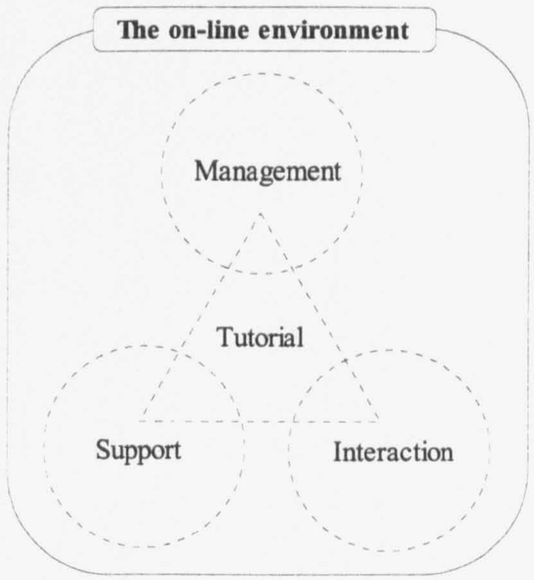
- **On-line library**

The online library may contain a series of well-categorised and searched links to relevant Web resources. Web designers need to exploit this new type of on-line resource in the course and avoid adding it as an additional part or second reference for students, alongside the course materials. The on-line library may contain Web search engines to search for course-related information, which are not available in the course library. However, it is important for the instructor to test search engines and directories, select those that are suitable for students' knowledge and provide them with help. Maddux (1997) argued that although search engines represent a step forward in improving the teaching and learning potential of the Web, they do not include all the sources on the Web and are not suitable for use by inexperienced learners.

The above review shows that the features and elements of on-line learning environments could be categorised into four main components:

1. a tutorial component (on-line modules, study guide and tests, etc.);
2. an interaction component (interaction tools such as e-mail, discussion boards, etc.);
3. a management component (class management, course schedule, announcement board, etc.); and
4. a support component (on-line library, personal pages and tracking, etc.)(Figure 4-3).

Figure 4-3: Elements of Web-based learning environments



The above figure shows that while the tutorial component seems to be the central and leading component in the learning environment, it is supported by other components and shares many of its features with the learning environment. In addition, many elements could belong to more than one component at the same time. For example, although e-mail and discussion boards are considered as interaction mechanisms, they are useful tutorial methods. Using e-mail, the learner can interact with peers in the class and with the tutor, ask questions, submit assignments and receive feedback. In addition, using discussion boards, students can post messages to the class, read classmates' posts, respond to teacher's questions or receive feedback about their posts. Similarly, on-line quizzes could be considered as a tutorial element, to assist in knowledge construction, or as an assessment tool to evaluate learning at the end of each module. The dashed lines indicate that the tools and elements of the components of the environment are not bounded within a single component but could be used flexibly in many ways within the learning environment.

However, Hobbs (1996) pointed out that, it is not easy for specialists with little training in computer to write scripts that create and manage forms and interact with other software in the server.

4.8. Instructional design for the Web

According to Gagne et al. (1988), the purpose of instructional design is to structure an environment to provide learners with conditions that support learning. Gustafson and Branch (1997) indicated that the main role of instructional design models is to provide conceptual and communication tools to visualise and direct processes for generating guided learning. With the growing development in Web-based education, the need to look for an appropriate design strategy (or model) is highlighted. The review of the instructional design literature shows that design, development and evaluation stages are the main elements included in instructional design models. Spector et al. (1992), for example, suggested a useful model of instructional systems design for analysing the relationship between learner characteristics, the learning environment and the resulting quality of computer-based instruction. They described the model as a 'cognitively oriented method for developing a useful and predictive process for designing CBI' (Spector et al., 1992, p. 45) (Table 4-9).

However, although this model is beneficial as a series of stages, Spector et al. did not indicate how to follow or implement this model. In addition, the design depends mainly on the results of behavioural and objectivist research, which has been challenged recently by the constructivist approach. More recently, Kemp et al. (1994) argued that the elements of instructional design process can be represented by answers to four questions:

1. For whom is the programme being developed?
2. What do you want the learners to learn?
3. How is the subject content or skill best learned?

4. How do you determine the extent to which the learning has been achieved? (Kemp et al., 1994, p. 8).

Table 4-9: Typical instructional design model (Spector et al., 1992, p. 45)

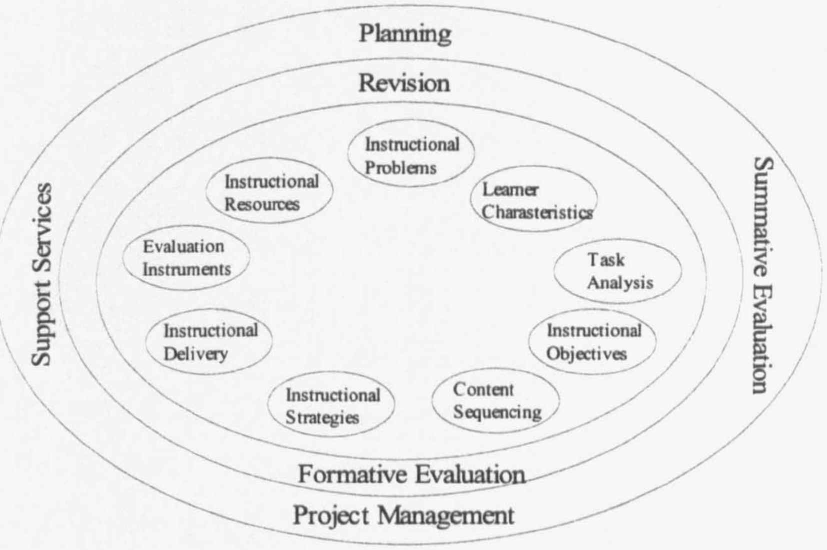
Instructional design phase	Typical Goals
Analysis	• Define training requirements. • Analyse target population. • Establish performance levels.
Design	• Specify instructional objectives. • Group and sequence objectives. • Design instructional treatments. • Specify evaluation system.
Production	• Develop learning activities. • Develop test items. • Perform formative evaluation.
Implementation	• Implement learning activities. • Administer test items. • Assess student results.
Maintenance	• Revise content materials. • Revise test items. • Assess course effectiveness.

Kemp et al. defined nine elements that need comprehensive attention in any instructional design plan. They identified these elements and their requirements, as follows.

1. Identify instructional problems and goals;
2. Examine learners' characteristics that should receive attention;
3. Identify subject content and analyse task components;
4. State instructional objectives;
5. Sequence content within instructional units;
6. Design instructional strategies to help the learner master the content;
7. Plan instructional delivery;
8. Develop evaluation instruments to assess learning; and
9. Support resources to support instruction and learning activities (Kemp et al., 1994).

They illustrated the above instructional design plan in an oval pattern diagram which presents the nine elements in a flexible and independent order, has no starting point and does not connect the elements of design with lines or arrows, as shown below (Figure 4-4). This framework indicates that applying all the elements is not necessary in every instructional design process. For example, in some programmes, identifying content sequence or learning objectives is not necessary at the earlier stage of design.

Figure 4-4: Elements of instructional design plan (Kemp et al., 1994, p. 9)



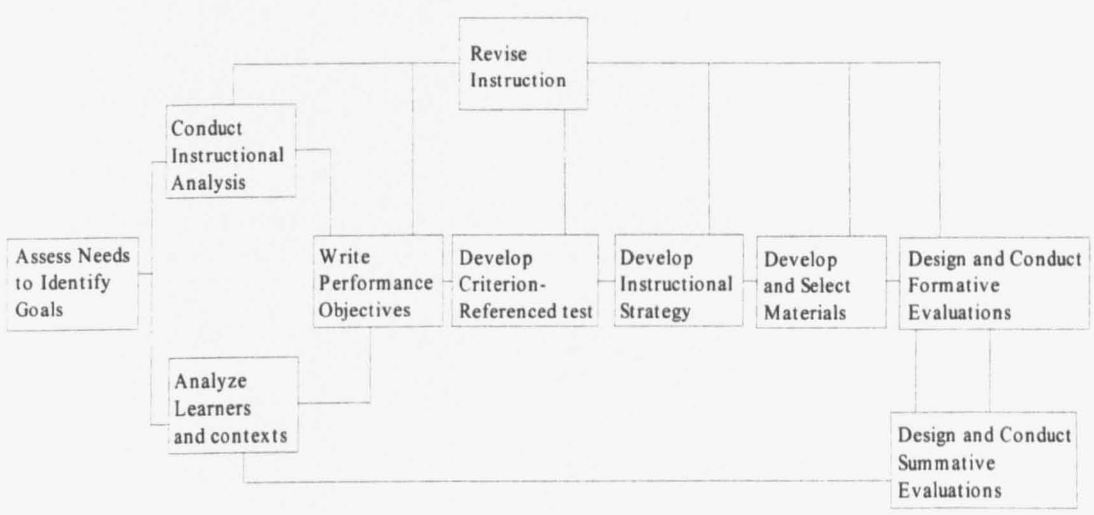
Gustafson and Branch (1997) agreed with Kemp et al. (1995) on the principles of instructional design when they argued that:

> 'Rectilinear portrayals of ID models do not acknowledge the actual complexities associated with the instructional development process. Curvilinear compositions of ovals connected by curved lines with two-way arrows better acknowledge the complex reality upon which the ID process is modeled' (Gustafson and Branch, 1997, p. 78).

However, they indicated that 'system analysis' and 'implementation' are additional core elements that should be considered in the instructional design process. They defined instructional development in terms of only four major activities: analysis of learner needs, design of a set of specifications for the relevant learner environment, development of all learner and management materials and evaluation of the results of the development, both formatively and summatively.

In a like manner, Dick (1995, 1996) and Dick and Carey (1996) provided a systems approach model as an objectivist-oriented model for designing instructional technology programmes. However, to take account of new trends in technology and learning theory, they modified their old version of the model to reflect the new trends in constructivist learning (Figure 4-5). Dick (1996) believes that this model incorporates concepts and procedures that are important to constructivists, including recognition of the importance of learner motivation and prior experience. He pointed out although 'the model remains basically a *systems* model, that is, the output of one step is the input for the next step' (p. 59), linearity is not a requirement of this model and designers may complete steps in any sequence. However, he commented that designers are encouraged to learn the process by beginning at the beginning and working through the model in an orderly fashion to 'facilitate the transfer of learning to the performance environment, and conducting formative evaluations' (p. 58).

Figure 4-5: Dick and Carey model for designing instruction (Dick and Carey, 1996 In Dick, 1996, p. 57)



However, criticism of Dick and Carey's model comes from Willis (1995, 2000) and Willis and Wright (2000), who criticised the earlier versions as well as the latest version of the model in terms of its linearity and support for the behaviourist approach. Willis (1995) argued that 'Dick's approach is not balanced; it proposes adding a bit of constructivist seasoning to the behavioural ID stew. Even when you add the seasoning you are still eating behavioural stew' (p. 9). Furthermore, he commented that 'while he will accept the idea of including some constructivist instructional strategies, his approach remains firmly anchored in the foundationalist, empirical-rational, behavioural tradition' (Willis, 1995, p. 9). More recently, Willis (2000) found that in Dick and Carey's model, non-linearity is the exception and linearity is the rule. 'If that is not done, chaos will be the result, the designers will be out of sorts, and learning will not occur' (p. 9). He explained his argument as follows:

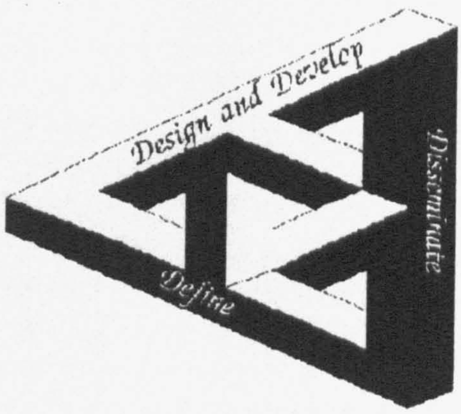
> 'Step 1 usually comes before step 2, unless you have a very good reason for doing it different. The basic structure of the Dick and Carey model encourages a linear approach. For example, *writing performance objectives* is one of the steps in the ISD model. Those objectives are necessary for the next step, developing *criterion-referenced test items*' (Willis, 2000, pp. 9-10)

Willis presented, for the first time, the first version of his most common instructional design model in a lengthy and argumentative article (Willis, 1995). He refers to this model as the R2D2 model (Recursive, Reflective Design and Development). Two of the main features of this model are that it is non-linear and internal interaction among its elements. It is non-linear since designers do not need to focus on the Define component first nor move linearly from stage to stage as tasks are completed. In addition, it is internally interactive since the design can be revised many times during the ID process and reflects on and analyses work to date.

Willis (1995) indicated that the reflective and recursive nature of the R2D2 instructional design model is suggested by the lack of 'focal point'. He argued that the recursive nature of the R2D2 model means that the same issues may be considered many times throughout the design and development process (Figure 4-6). Willis believes that the principles of focal points, tasks and sub-tasks are very useful and practical in developing similar constructivism-based projects. Some of these principles follow:

1. Objectives emerge during design and development stages and not the first stage.
2. The instructional design process is recursive and non-linear.
3. Designing and planning are reflective and collaborative.
4. Formative evaluation is critical in the design and development process (Willis, 1995).

Figure 4-6: Willis' R2D2 instructional design model (Willis, 1995, p. 15)



In his revised version of the R2D2 model and after five years experience in applying the original version, Willis (2000) re-investigated the question of whether specific rules and principles are the foundation for constructivist instruction design or whether guidance and general principles are desired. He concluded that 'trying to follow detailed, specific rules of design is discouraged because each context is unique' (p. 9). Fortunately, Willis provided three important and flexible guidelines for constructivist instructional design. These guidelines are Recursion, Reflection and Participation. In a nutshell, the first guideline (Recursion) emphasises that the instructional design process should not be carried out in one-way or two-way particular linear sequence, but should be flexible. The second guideline (Reflection) assumes that many important problems in practice cannot be anticipated and solved using pre-stated solutions. Therefore, further investigation may be required. The third guideline (Participation) emphasises the importance of involving both learners (as participants) and experts in the development and evaluation phases. This guideline is based on two assumptions highlighted by Merrill (1996):

1. Sometimes, learners have not the expertise to 'make good decisions'; and
2. There are principles based on the way students learn, and these are not subject to collaborative argument (Merrill, 1996, p. 58).

To show how his model looks in practice, Willis described a helpful example of developing a CD-ROM project to enhance literacy skills. The sequence of the three stages of the R2D2 model is summarised blow (Table 4-10). In the definition focus, for example, the

R2D2 model differs from the above models in that 'it is not important to write specific objectives at the beginning of a project. It may even be impossible to do that because the specific focus and direction of the ID project may not be well understood' (Willis, 1995, p. 17). Also, in the design and development focus, Wills emphasised the importance of interaction and multi-role of designers (media and format selection, selecting authoring tools, evaluation, etc.)

Table 4-10: Willis' instructional design focal points (adapted from Willis, 1995; Willis and Wright, 2000)

Stage	Tasks
The definition focus	1. Front-end analysis 2. Learner analysis 3. Task and concept analysis 4. Specifying instructional objectives
The design and development focus	5. Media and format selection 6. Selection of development environment 7. Product design and development 8. Formative evaluation
The dissemination focus	9. Summative evaluation 10. Final packaging 11. Diffusion 12. Adoption

Conclusion

The phenomenal growth of the Internet over the last few years, coupled with the development in the Web as a hypermedial, interactive, global and easy to use medium encouraged distance educators to expand the aim of distance education beyond that of adult education. The Web has several technical and instructional advantages. Web pages and components are platform independent (e.g., HTML pages, JavaScript, ActiveX, etc.), interactive and easy accessible world-wide. Students can access the Web using a computer with any operating system connected to the Internet.

The above review of the educational capabilities of the Web shows that the Web supports various types of active, collaborative and constructivist learning. Developers should exploit these different types of learning and the factors related in designing for learning. Furthermore, the Web has expanded access to resources from limited access (on the same computer) to universal navigation (on the whole Web), to provide one of the richest sources of information. The Web is an important advance for distance education. It has the ability to create educational opportunities that can go beyond the boundaries of the traditional class. In addition, learners can be involved in interactive and rich learning activities. Furthermore, the Web overcomes many obstacles available in earlier distance education (e.g., course enrolment, finding information, conducting interaction, etc).

However, Web-based distance instruction can be done well or poorly. It is the designer's and the instructor's role to ensure that a high level of interaction can occur in an online course. Much of the current educational use of the Web can be characterised as passive transmission of information rather than establishing active learning environments to support recent approaches in education such as interaction and learner collaboration.

Understanding the requirements of distance education and the capabilities of the Web is important for designing and developing relevant Web-based instruction. For example, designing for the Web requires transforming the Web from a passive publishing tool to an active learning environment to deliver instruction and support distance students. In addition, interaction between instructors and learners and among learners themselves, which is a serious limitation of many distance education environments, should be considered in designing a Web-based instruction environment. Making the learning experience interactive requires adapting and exploiting hypermedia features, involving the communicative approach and providing immediate feedback.

However, it should be mentioned that producing a learning environment for delivery via the Web is different from publishing an information system using traditional types of media. Web-based learning environments have their own nature, components, structure and evaluation strategies. Therefore, developing for the Web requires going through many additional tasks and sub-tasks in the instructional design process. Considering the principles of design for the Web and constructivist instructional strategies set out early in this chapter as well as Willis' R2D2 focal points (Define, Design and development and Dissemination) and the last three flexible guidelines above (Recursion, Reflection and Participation), a Web-based learning environment was designed, developed and evaluated, as shown in the next chapter.

PART TWO

THE DESIGN AND EVALUATION METHODOLOGY OF A WEB-BASED LEARNING ENVIRONMENT FOR DISTANCE EDUCATION

Chapter 5: A Web-Based Learning Environment for Distance Education: Design, Development and Implementation

Introduction

In this chapter, a Web-based learning environment was designed, developed and evaluated on the light of Wills' (1995, 2000) R2D2 instructional design model. Constructivist principles, tasks and sub-tasks were used to guide the design and development of the learning environment. However, since the Web is a medium that has its own nature and designing for interactive Web-based delivery is different from publishing an information system on a CD-ROM (Willis' example in his study) or other types of media, developing for the Web will require going through additional tasks and sub-tasks. These tasks and sub-tasks are shown below (Table 5-1).

In this environment, the principles and approaches of instructional design were implemented, as mentioned in the previous chapter. In addition, the elements of Web-based instruction, as mentioned in previous chapter, were adopted and implemented to construct the learning environment. Parson's (1997) stand-alone model for using the Web in education was chosen to construct the components of the learning environment. This model uses the Web as a learning environment to deliver the course content and learning resources, facilitate interaction between the tutor and peers, deliver tests, support students and manage groups of students.

Table 5-1: Instructional design tasks and sub-tasks of the Web-based learning environment

The definition focus	Sub-tasks
Learners analysis	- Learners' needs - Learners' background and educational level
Front-end analysis	Using, adopting or designing and developing an effective Web-based learning environment for teaching students at distance.
Defining the subject content and the learning objectives	- Defining the learning subject - The nature of the subject - Problems associated with teaching and learning the subject - Teaching/learning strategies of the subject - The subject and CAI - Task analysis - Aims and objectives
The teaching/learning approach	Defining a teaching/learning approach for designing instruction
Defining the requirements of the learning environment on the Web	Defining management component, tutorial component, interaction component and support component.
Defining technical requirements	Defining: - Software - Hardware - Web server machine - Internet connections
Defining user requirements	Software, hardware and Internet connection
The design and development focus	**Sub-tasks**
Media and format selection	Web-based hypermedia objects
Selection of development environment	Web page editor, photo editor, programming languages, etc.
Designing and developing the components of the learning environment	- Tutorials and assessment - Support utilities - Interaction tools - Management and monitoring tools - Help and on-line support - Organising the learning environment
Designing and organising the environment	- General design - Organising the components
Using the environment	Student's path through the learning environment
Uploading the site to the Web server	Uploading and trying the site in a Web server
Developmental testing (formative evaluation)	- Expert appraisal - Student tryout

5.1. The definition focus

According to R2D2 model, the purpose of the definition focus is to define the technical and instructional requirements of designing, developing and using the learning environment. These requirements are learners' characteristics, the subject matter, learning objectives, appropriate teaching and learning approach and software and hardware needed to develop and access the Web site. Although the definition of requirements begins at early stage of design, understanding these requirements 'will emerge across the design process and will be of much higher quality' (Willis and Wright, 2000).

5.1.1. Learner analysis

The first step in the design and development phase is to understand students' needs, have information about their educational and cultural background and determine why they need to study at a distance. In the R2D2 model, this stage is an on-going process rather than an introductory stage. Designers can collect information from learners about their feelings, what they prefer and what can be done to make the programme more interesting and helpful. In the present study, information about learners was needed to design the learning environment, choose types of learning, plan for learning activities and anticipate the degree to which students would need technical and educational support. Target learners were first year secondary school students (15-17 years) in Egypt, who had completed their studies at elementary (6-11 years) and preparatory (12-14 years) schools.

In Egypt, two types of public secondary schools are available: public secondary schools and public and private secondary 'language schools'. The first type of school is government-run and uses the Arabic language as a first language. Students at these schools study all subjects in Arabic. However, the English language is the second language. These schools account for more than 90 per cent of secondary schools in Egypt. The other type of schools, which may be government-run or private, uses the English language as a first language; therefore these schools are called 'language schools'. Students at these schools study in English and the Arabic language is only a learning subject. These schools are estimated to constitute less than 10 per cent of secondary schools in Egypt. Public schools were established by the government to be in line with private secondary language schools established by Egyptian or foreign organisations.

In the present study, participants were students of public secondary language schools. Those students are a small minority and have many educational problems. For example: there is an insufficient number of well qualified teachers to teach at these language schools, particularly for vital subjects, such as mathematics and science, there is a lack of support provided to those students, as the official language of the educational authority is Arabic and most resources and well-designed instructional materials (such as broadcasting, videotape programmes and CD-ROMs) are available in only Arabic.

Therefore, students wishing to develop their academic attainment and experience commonly use additional information sources, such as satellite television programmes and the Internet. Well-designed Web-based distance education programmes could be an efficient way to help those students to learn and interact with the world. Usually, language schools are well equipped with computers and the Internet to take advantage of the world-wide knowledge available in English and to interact with others around the world. Often, students at these schools have good skills and experience in using computers, WIMP-based programmes [*] and the Internet. This background is sufficient to allow them to use the Web and attend on-line classes in any subject, access remote resources and interact with others around the world using the English language.

5.1.2. Defining the course content and the learning objectives

According to the R2D2 model, defining the learning subject for the Web should involve more than listing its topics or the content area expressed by goals. Designing for learning should consider many issues, such as the nature of the content and the relevant methods of teaching it, problems that may face students in learning and the effect of modern technology on teaching the subject.

At this definition phase, the main topics in the learning subject should be defined. This procedure is very important to define 'what the learner needs to learn'. Defining the content is an essential step prior to defining the learning objectives, developing the content, selecting

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[*] WIMP means Windows, Icons, Menu and Pointer systems which is supported by both MS Windows and Mac systems.

suitable learning strategies for the topics, suggesting learning activities and building tests. However, although breaking the content down into sub-tasks or components is not recommended in the R2D2 model, in the present study, defining and organising learning topics and task seemed to be a critical starting point for detailed design and development of the components of the learning environment and support tools.

In the present learning environment (called Wired Class), the learning subject is mathematics. This subject was chosen for many reasons:

1. A part of the researcher's academic background is based on mathematics education at secondary schools.
2. Mathematics is probably the second most important subject in schools after language.
3. Mathematics is important as an international language of communication.
4. The nature of mathematics is such that it is not restricted by cultural, political or geographical boundaries like other subjects (such as languages and history).

For the above reasons, mathematics seemed to be a suitable subject to be delivered via the Web. Algebra, in particular, was chosen because it is an important step in the learning of mathematics. It involves new and important concepts for studying mathematics, such as the concepts of formula, equation, function and variable. Algebra helps students notice relationships and properties of numbers that they did not notice in arithmetic, and to develop their numerical awareness. Functions, equations, co-ordinate systems and graphs are important topics in algebra in the secondary school curriculum. Linear and quadratic equations and functions, in particular, are fundamental lessons in this curriculum.

In this stage, the curriculum focuses on the mathematical methods of dealing and representing relations and functions. These methods are:

1. Algebraic: using symbols and formulae;
2. Arithmetical: using tables and ordered pair; and
3. Visual (graphical): using graphs and diagrams.

Many algebraic problems can be solved by both symbolic and visual methods. Using algebraic methods, students use what is called the 'three slot schema' for equations of the form $y = mx + b$, usually looking for three pieces – the slope, the y-intercept and the x-intercept – to generate equations of this form (Moschkovich, 1999). There are two main classes of conceptual demands associated with solving equations in the algebraic form: simplifying expressions and dealing with equality-equivalence (Kieran, 1997). On the other hand, many problems can be solved using visual methods of solution. Equations can be represented graphically to find the common solutions or to explore a specific characteristic of a function. However, the visual method is subject to constraints and difficulties of graphing.

Shama and Dreyfus (1994) noticed that students prefer algebraic strategies over visual ones. However, Markovits et al. (1988) argued that it is easier for students to manage functions given in graphical form than in algebraic form. They believe that the graphical presentation is more visual and information can be obtained more easily. Moreover, they suggested that much more work should be done in the graphical form before the symbolic form. In general, research has shown that secondary school students have difficulties leading to a limited view of the concept of functions (Even, 1990), a tendency to memorise rules without understudying their genesis, failure to distinguish among different symbolic forms, moving among different families of functions and scaling issues (Borba and Confrey, 1996).

In addition, most students cannot understand the continuous nature of graphs of functions (such as $y = 2x + 3$) or obtain pairs of co-ordinates from the equation which defines a function (Orton and Frobisher, 1996). Students of lower ability, in particular, often find it easier to deal with tasks with a story than with abstract tasks (Markovits et al., 1988). Thus, it may be advisable to include some practical exercises in the materials.

In the last ten years, the belief that computers could enhance the learning of mathematics has been well investigated. Research has shown that graphical software has provided attractive and helpful tools to enrich teaching of concepts and developing more important skills in secondary school mathematics (David and Beverly, 1992; Davids, 1996). Today, students do not need to be very clever to construct a graph from a given formula. Plotting software allows students to control the graphing process by determining domain, range and scales, and to carry out many mathematical operations (such as changing parameters or zooming). Goldstein (1994) indicated that development in software is making many mathematical skills 'redundant' and one of most common examples of that is drawing graphs of functions. He suggested that teachers should encourage students to concentrate on thinking of a different order. Using this technology, teachers can help students by enhancing their understanding of concepts that are more important.

Functions and equations are important component on which many other topics and activities are centred. Therefore, the main topics which were chosen to be learned in Wired Class were functions and equations. These two topics and their content are shown below (Table 5-2). Alongside the students' book, many principal references (*) were used to review and update the content.

Table 5-2: The subject content

Functions and graphs	Equations
An introduction to functions	Equations in one variable
The co-ordinate graph	Equations in two variables
Direct variation	Linear equations
Linear function	The intercept of a line
Inverse variation	The gradient of a line

Most instructional design models suggest a scheme, which can guide designers to analyse the content of the instructional programme. For example, in their model, Kemp et al. (1994) indicated that the structure of a learning content can be broken down into six components: facts, concepts, principles and rules, procedures, interpersonal skills and attitudes. In mathematics, it has been agreed that the structure of mathematical learning can be classified into four types: recall, concepts, skills and problem solving (HMSO: Department of Education and Science, 1987; Orton, 1991; Kemp et al., 1994). Recall means remembering facts, formulae and definitions from memory (e.g., the formula of linear function). A mathematical concept is an abstract idea that describes the relationships between two or more facts (e.g., ordered-pairs, function). However, a skill is the ability of the learner to do something easily, fast and precisely (e.g., graph a function). Lastly, problem solving is a process by which the learner can provide a solution to a problematic situation using his/her

(*) These references are:
Abbott, P. (1996) Algebra, Teach your self books, London, Hodder Headline.
Jacobs, H. (1979) Elementary Algebra, San Francisco, W.H.Freeman and Company.

previous experience (e.g., find the solution of a linear equation). These four types of objectives are represented as shown below (Table 5-3).

Table 5-3: Content analysis

Content/Objectives	Recall	Conceptual	Skills	Problem Solving
1. Recall the definition of function	•			
2. Complete the table of a function given in a formula			•	
3. Construct a co-ordinate graph using x-axis and y-axis.			•	
4. Identify the co-ordinates of a point in a graph.		•		
5. Plot a group of ordered-pairs represented in a table			•	
6. Determine whether or not a given formula represents a function		•		•
7. Translate a formula to a graph.			•	
8. Recall the definition of direct variation.	•			
9. Write down the formula of a direct variation represented in a graph.		•	•	
10. Graph a direct variation represented in a formula.			•	
11. Describe the meaning of linear function.		•		
12. Distinguish between a direct variation and linear function.		•		
13. Write down the formula of the linear function.	•			
14. Graph a linear function.				•
15. Define the y-intercept and gradient of a linear function.			•	
16. Describe the meaning of inverse variation.		•		
17. Graph an inverse variation represented in a table.			•	
18. Describe the difference between direct variation and inverse variation.		•		
19. Describe the meaning of equation.		•		
20. Solve an equation in one variable				•
21. Solve an equation in two variables Give real life examples of equations in two variables				•
22. Describe the meaning of linear equation.		•		
23. Write down the formula of the linear equation.	•			
24. Graph a linear equation using its formula.			•	•
25. Describe the meaning of interception.		•		
26. Find the x-intercept and y-intercept of a linear equation using its formula.			•	
27. Graph a linear equation using points of interception.			•	
28. Find the solution of a linear equation using interception.				•
29. Describe the relation between the slope of a line and the value of a in the equation $y = ax + b$		•		
30. Find the slope of a line using table of values.				•
31. Calculate the slope of a line drawn through two points.			•	
32. Write down the formula of given linear equation in the slope-intercept form.		•		
33. Graph a linear equation given in a slope-intercept form.			•	

However, it is important to consider that these objectives are interchangeable and the same mathematical procedure could be described using more than one objective. Kemp (1985) and Kemp et al. (1994) emphasised the importance of considering the relationship between the subject content and learning objectives during planning the task analysis process. They argued that each one could help to refine the other. Furthermore, considering this relationship is very important for designing learning activities and developing test questions.

5.1.3. The teaching/learning approach

Having access to an interactive medium and hypermedia-based rich information source, like the Web, with the freedom for the learner to determine his/her own pathway, requires the use of an appropriate learning approach to facilitate effective learning. The possibility of interaction among learners via the Web requires instruction to be designed so that students can interact and co-operate to build their own experience successfully. Based on the constructivist epistemology, as mentioned in the previous chapter, constructivist theory seems to be the most suitable approach to design instruction for the Web.

One of the key features of constructivism is that learning is not a passive operation, but a process in which learners construct their own learning. Constructivists believe that learning becomes more effective through learners' active participation in the learning situation. In addition, social interactions between learners and the teacher and among learners themselves is a key issue in designing constructivist learning.

In the last few years, many frameworks and models have been developed and a variety of guidelines proposed for developing learning environments which support a constructivist approach. Honebein (1996), provided many principles which can be used as guidelines to designing constructivist learning environments. The main principles as reflected in his design of sample learning environments are summarised as follows:

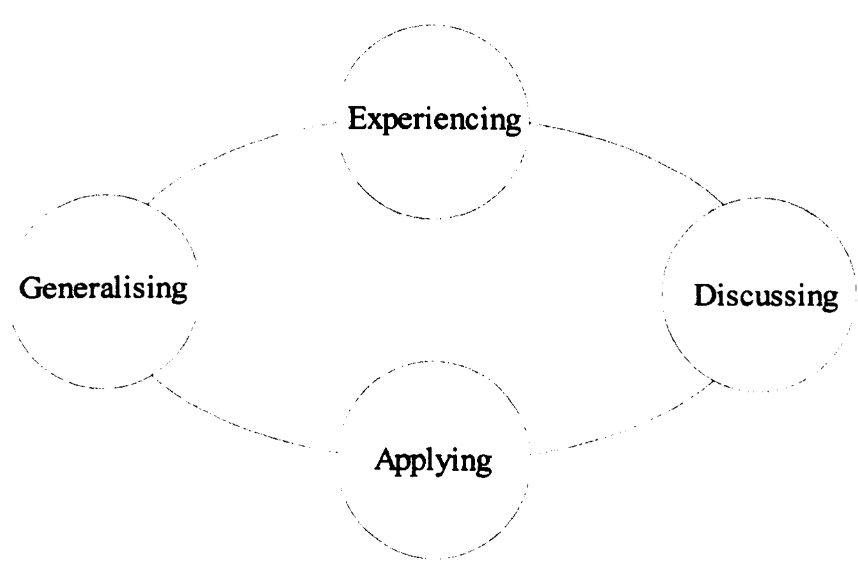
1. Provide students with experience in which they can construct their own knowledge.
2. Allow for student-centred learning.
3. Encourage social interaction and collaboration.
4. Use multiple modes of representation.
5. Encourage metacognitive and reflective activities (Honebein, 1996).

As shown in Honebein's principles, the constructivist-based learning environment is one in which the learner participates actively and on which he/she has a major impact. More recently, Nakahara (1997) has emphasised the designer's role of challenging the learners' thinking, active participation and social interaction to help learners to construct their own knowledge. The principles of this approach are summarised in two main points:

1. Learners acquire knowledge by constructions of their own and in the process of being reflective and making agreement. In this process, operational activity and reflective thinking play major roles.
2. Learners construct, criticise and refine knowledge through constructive interaction with peers or with their teacher (Nakahara, 1997).

Howe et al. (1995) suggested a constructivist-based approach for teaching and learning mathematics. This approach uses principles of co-operative and problem-centred learning. Howe et al. diagrammed the learning cycle in which learners can be involved to pass through this experience (Figure 5-1).

Figure 5-1: The constructivist learning cycle (adapted from Howe et al., 1995)



According to Howe et al. (1995), the learning process passes through four interrelated and continuous stages:

1. Experiencing: The learner must take an active role in his/her learning. The teacher engages the learner in activities which prompt his/her thinking to make learning effective;

2. Discussing: Viewpoints arising from the experiences need to be discussed with peers in order to be evaluated and validated;

3. Generalising: Hypotheses and results should be evaluated for viability through their application to other situations;

4. Applying: Planning how to use the revised learning and applying it to contextual situations validate it as viable knowledge and provide the learner with another experience which could be used again (Howe et al., 1995).

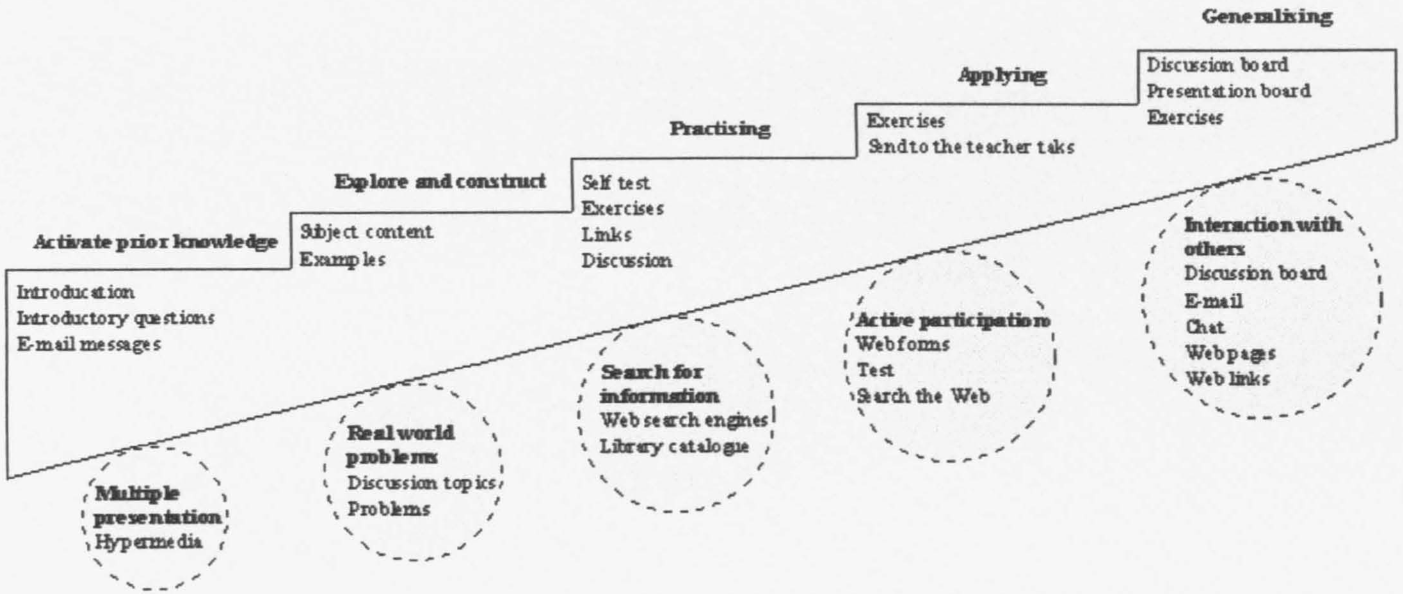
On the Web, well-designed hypertext and hypermedia could be used to help students to determine their own pace of learning, select the paths through the learning materials, solve problems, explore and construct their understanding. Gratto (1995) has indicated several practical aspects of constructivism that could be incorporated in the design of environments like the Web as follows:

1. Activating students' prior knowledge;
2. Having learners create knowledge structures as they move through the material;
3. Giving the learner a choice of example types and problems;
4. Providing real world problems for structured domains (Gratto, 1995).

In the present study, the objectives and principles of constructivism served as guidelines for developing problem-centred activities, establishing components of the environment, and encouraging and guiding students to participate actively. Therefore, the development was focused on placing the learner individually and in groups using a variety of contexts and providing them with a number of different views to help them to gain their experience using a variety of supporting tools (e.g., discussion boards, e-mail and feedback forms) and information resources (e.g., Web links and presentation boards). Learners were encouraged to explore and search through the environment and interact with its components and their peers. Problem-based learning as a strategy, in the mathematics curriculum in particular, will motivate learners during the learning process and produce high quality outcomes.

In the present study, the principles and objectives of designing constructivist-based learning environments, as mentioned above, are represented in the framework below (Figure 5-2). This framework shows that the learner needs to pass through five stages of cognitive

Figure 5-2: Constructivist-based approach for designing Web-based learning



activities gradually to construct his/her experience (but not necessarily in a linear manner). These stages (e.g., practising) are arranged from bottom to top; each step could be achieved by involving the learner in many jobs or tasks (e.g., self test questions, exercises, visiting Web links and discussion boards). At the same time, the process of getting this experience mainly relies on the principles and objectives of the constructivist approach (e.g., active participation and social interaction) as wheels. These principles and objectives can be achieved using the interactive nature of the Web (e.g., using synchronous and asynchronous interaction and hypermedia elements). This framework was considered as a guide in developing the components of the present learning environment, subject content, learning activities and learners' roles.

5.1.4. Front-end analysis

According to the R2D2 model, this is the second phase in designing an instructional programme. It is the designer's role to investigate the needs of the programme to see whether they are met by an already established learning environment or not and to evaluate the limitations of other alternatives (Willis, 1995). Therefore, an analytical review of many learning environments and development packages was carried out. The importance of this investigation is that it allowed the present study to assess the extent to which elements and features of on-line learning are available, assess the strengths and weakness of these features and learn how features and elements of on-line learning work.

The evaluation approach was mainly based on the above review of literature and conducted in the light of the following issues:

1. Limitations of previous distance education systems and the framework for describing the features of distance education technologies (type of interaction, type of learning, costs, ease of use, flexibility, etc.) (Chapter 2);
2. Bates' (1995) ACTIONS model for evaluating and comparing among distance education technologies;
3. Types and requirements of developing and receiving on-line learning and delivery of media via the Web (Chapter 3);

4. Models of using the Web in education , theories and types of on-line learning and the framework of features and elements of on-line learning (tutorial, interaction, management and support)(Chapter 4).

First, the initial review of Web-based learning products showed that they fall into two main categories:

1. Delivery and management environments; and
2. Developing and authoring tools.

Delivery and management environments, usually called 'platforms' (such as WebCT and Blackboard), are browser-based on-line programs designed to organise and manage course materials, support learners using interaction and support tools (e.g., e-mail, discussion boards, chat, whiteboard, class scheduling and registration), monitor student's progress and administrate students' enrolment and records. In addition, these environments provide some instructional tools (e.g., quizzes creators, course templates, course calendar, etc.).

Developing and authoring tools are easy-to-use authoring packages or editors (such as ToolBook Instructor II and Authorware) designed to create advanced on-line learning materials without the need to learn HTML and sophisticated programming languages. Often, these packages are collections of other programs, such as photo and multimedia editors, HTML editor, scripting language and FTP (File Transfer Protocol) programs.

In the present study, delivery and management environments as well as developing and authoring tools were reviewed and evaluated by reading developers' and users' manuals, installing and examining them on a test Web server or trying them in their vendor's server, examining Web-based courses using these products and reviewing the literature that pointed out the advantages and limitations of these products.

WebCT, Blackboard and TopClass were found to be the best-known delivery and management environments. These products were reviewed and compared in the light of the above criteria. The overall review of these learning platforms showed that they comprise most of the components and elements that should be available in a Web-based learning environment, as defined above in Chapter 4. They allow the tutor to use traditional assignments and upload them quickly to the Web server, track and monitor students' progress, generate assessment questions and quizzes, distribute files and grades, provide feedback and manage students enrolment. At the same time, these products allow the learner to access Web-course material, communicate with the tutor and other students (via e-mail messages, class announcements, discussion groups and chats) and take self-assessment quizzes and exercises and review the results immediately.

WebCT, for example, uses the Web browser as the interface for the course-building environment and provides a wide variety of functions that can be used in on-line learning. The features of WebCT can be categorised into three types:

1. Tutor utilities
2. Course tools
3. Interaction tools

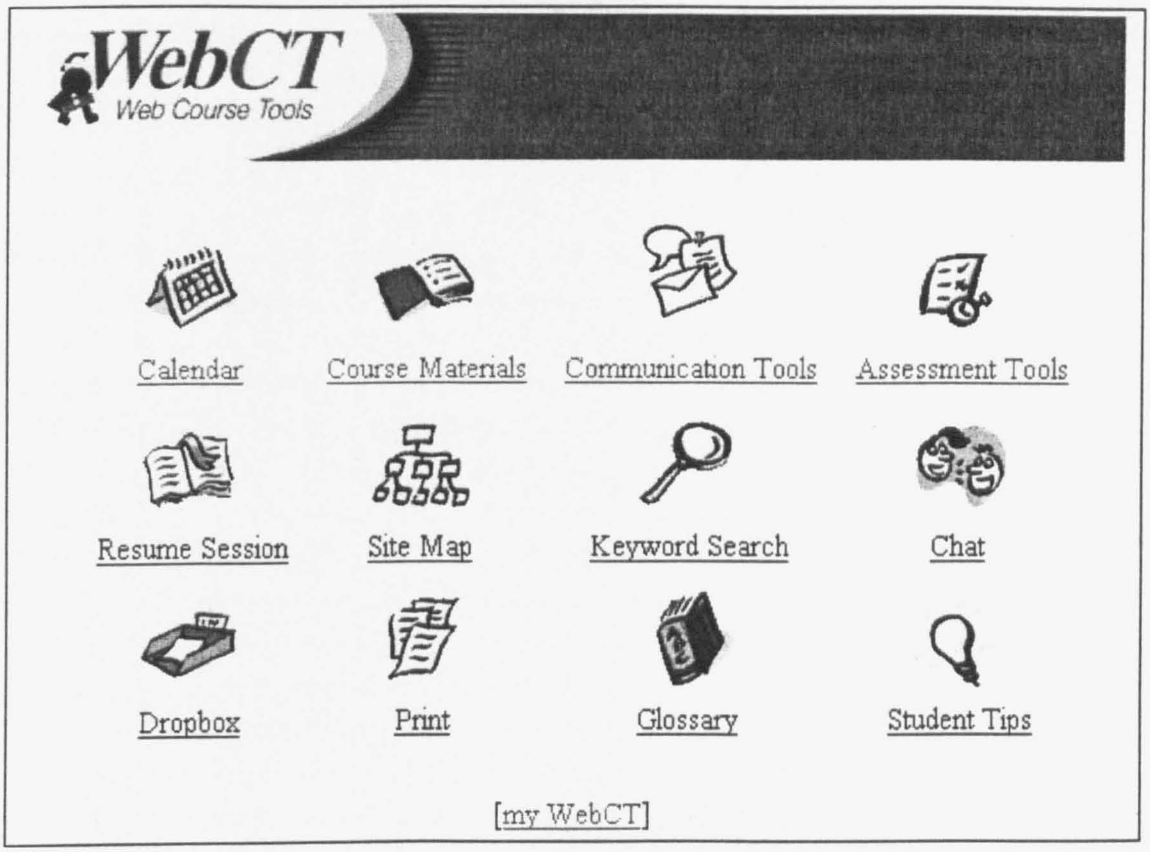
Tutor utilities allow the tutor to upload course files to the WebCT server, manage student information and control the appearance of the course, while course tools help the tutor to present course information, organise the structure the course and evaluate students. Interaction tools allow the tutor to communicate and help and support students.

WebCT (Figure 5-3) provides an easy-to-use interface to facilitate the presentation of the course content (such as colour schemes, page layout, etc.) and a set of instructional and administrative tools to facilitate learning, communication and collaboration. Examples of these tools include a conferencing system, on-line chat, whiteboard, student progress tracking, group project organisation, student self-evaluation, grade maintenance and distribution, access control, navigation tools, auto-marked quizzes, electronic mail, automatic index generation, course calendar, student homepages and course content searches.

Similarly, Blackboard offers a number of interesting features to the tutor and students which are easy to set up, manage and use. As defined by its vendor, it is a multi-function instructional platform that integrates content building, communication tools, assessments and student tracking. Tutors can add various types of materials to the course, whether they are MSWord, WordPerfect, PowerPoint, HTML, or multimedia files.

In addition, Blackboard provides a set of management and administrative tools to facilitate learning and manage students and resources. For example, it provides a course calendar and announcement tool, asynchronous and synchronous communication mechanisms (threaded discussions, e-mail, real-time chat and whiteboard), a content distribution tool, on-line file exchange and automatic sequencing of links. However, although it provides an editor for creation of assessment questions (such as multiple choice, true/false, ordering, etc.), it does not provide any tool to create highly customised course materials or to add more presentation and assessment features.

Figure 5-3: WebCT user-interface



In a like manner, TopClass is an integrated learning environment that has its own Web server to facilitates managing content materials and learners, supports interaction using powerful synchronous and asynchronous tools (e.g., whiteboard), supports multimedia objects (including audio and video), enables off-line delivery of course content for users without a network connection and supports different file formats (MS Word, PowerPoint, Macromedia Flash, etc.). In addition, it uses Learning Objects technique to combine objects (e.g., streaming audio and video, audio, Web links, etc.) within course materials. TopClass supports a wide range of testing options, including the ability to support multiple choice, true/false, essay and fill in the blank question types.

The 'Go to Coursework' link, for example, lists all the courses for which the student is enrolled. Clicking on the course displays the course modules or chapters, on-line handouts, tests and assignments. Also, Class Announcements allow the learner to read the announcements sent by the tutor. However, students cannot post or reply to Class Announcements; only instructors may do so.

The above three learning environments were reviewed and compared and the advantages and limitations of each product were highlighted to see whether any of them was suitable for use in the present study. Based on the above instructional and technical evaluation issues, each learning environment was evaluated in the light of following criteria:

1. Accessibility: How accessible are learning resources? How compatible is the learning environment with students' hardware and software? Does the learning environment support different types of media formats and programming scripts (e.g., audio, video, Java Scripts, CGI scripts, etc.)?
2. System requirements: What are the system requirements to deliver and receive instruction?
3. Design and delivery of course materials: Does the product support designing and developing course content? And how?
4. Social and content interaction: Does the learning environment support student-tutor, student-student and student-content interaction? What tools are used to support these types of interaction?
5. Navigation, indexing and search features: Is the site easily navigable? What are the strengths and limitations of the navigation design? Does the site offer a search tool?
6. Monitoring and management features: Does the site control student log-in and log-out? Does it track course access and student performance? Does it have a grading tool for both the tutor and students?
7. Assessment: Does the learning environment support various types and tools of assessment?
8. Support utilities: What tools are provided to support distance students (e.g., resources, on-line library, etc.)?

9. Technical help and support: Does the site provide students with on-line help and support (e.g., frequently asked questions, help topics, on-line support, etc.)?
10. Costs: What are the costs of the learning environment (fixed, capital, current, etc.)?

The comparative analysis shows that although these platforms offer considerable and easy-to-use tools for facilitating student-tutor and student-tutor interaction, supporting and managing students, tracking students' performance and managing students and course files, and despite their high capital and variable costs (including the costs of annual licence, maintaining software and revising and updating courses), they do not provide efficient on-line course editors to facilitate design and implementation of features of rich and interactive on-line learning, such as:

1. adding and designing text, hyperlinks, images, image maps, tables, form fields and other elements for and adjusting them for Web appearance;
2. defining or controlling the reading sequence through the content;
3. allowing the user to explore more related Web materials;
4. deploying interactive hypertext features in the content;
5. enhancing student-content interaction;
6. storing diverse formats of information and adding links to other kinds of materials;
7. integrating formatted texts and multimedia objects; and
8. developing his/her own interactive applications, scripts or programs (e.g., calculators and animations) to support students.

In Blackboard and WebCT, for example, the tutor must use an appropriate external HTML editor to generate the HTML code or files then place them in the platform or upload them using the transferring tools. Therefore, to design and develop this kind of instruction, developing and authoring tools are required. Two of the most common authoring tools are ToolBook Instructor II and Authorware. These two applications were designed to simplify the design and programming of instructional materials using a simple interface.

ToolBook Instructor II, for example, provides tens of pre-defined designs and provides support for visual programming and scripting (using OpenScript language) to create interactive course materials. In addition, it provides pre-defined templates and wizards to allow developers to create instructional presentations quickly and easily. In addition, it contains many useful editors for audio, icons, cursors, bitmaps, menus and colour palettes as well as a full set of object creation tools for creating buttons, media players, text fields, hyperlinks, animations and ActiveX controls.

However, unfortunately, trying ToolBook Instructor II, which is similar to Authorware, showed that:

1. It creates the course as a series of frames and pages which present course information and request a student response. Based on the response the design could branch the learner to another frame, page or set of questions.
2. Since it is designed for CD-ROM as the natural distribution medium, not the Web, only specific features and functions are available when developing for Web-based learning. Moreover, using these features and functions requires a large plug-in file for downloading and use in the Web browser.
3. A course for Web distribution could be produced only by exporting the last version of course to HTML with Java applets and/or ActiveX support. The exportation results showed that the Web version was different from the original design of the course. Texts, images and form fields were converted to difficult-to-read/download Java applets and Java Scripts with many coding errors. In addition, creating layouts took a long time and it was difficult to predict the results on the browser.
4. Although it is claimed that ToolBook Instructor reduces programming time, to get the most out of the program and develop interactive instructional materials it is necessary to learn the Open Script programming language supported by the system, which is still far from finding a solution to on-line programming problems already solved using server-side CGI scripts, as mentioned in Chapter 3.
5. Most of its functions are based on the 'Librarian' course management system, provided by the same vendor, which is still very far from exemplar management systems, such as WebCT and Blackboard, as shown above.

However, the most important limitation was related to the design of delivery and management environments above. It was found that [*] ToolBook Instructor cannot 'communicate' or send and receive data (such as students' performance in quizzes, path

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[*] This conclusion is based on a lab experiment conducted for the purposes of the present study.

through course content, restrictions of access, etc.) from management systems (such as WebCT and Blackboard) and therefore the tutor may not able to place courses developed using these tools in management systems to take advantage of their management and interaction capabilities. Therefore, in Blackboard or WebCT, the course developer needs to design the course materials from scratch to be harmonious with the design of the platform (user-interface, navigation, themes, etc.) and operate and communicate in an efficient way with other tools and features (e.g., discussion boards, tracking scripts, tests and grades). However, in this case the high costs paid to purchase and run one of these platforms will be the costs of interaction tools (e-mail, discussion boards, chat, etc.) and course management tools (enrolment, tracking, grading, etc.) rather than the costs of the core element of on-line learning (course content, materials and tests). Therefore, in the present study, it was found that it might be cost-effective and useful to design and develop an integrated learning environment that combines and facilitates links between tutorial, interaction, management and support components.

Developing Web pages or sites has become simple with the development of Web editors. These editors are tools that work as word processors to create Web pages without writing the HTML code behind the page. There are many Web editors available, which vary in their features and capabilities. The earlier generation of HTML editors worked as converters to change documents from some formats to HTML pages. These editors were limited in their capabilities.

The recent generation of editors, which are truly HTML editors, known as WYSIWYG (What You See Is What You Get) editors, are used to create Web sites without the need for a HTML background. However, developing sophisticated sites requires developers who are experienced enough in HTML. The actual benefit of WYSIWYG editors for developers is that they save time that would otherwise be spent in writing HTML code and direct the attention of developers toward more important tasks.

One of the powerful WYSIWYG editors released in the last few years is Microsoft Front Page for designing and editing HTML pages. Developers can add text, images, tables, form fields and other elements easily to Web pages, letting the Front Page editor generate

HTML tags, including extensions such as cascading style sheets, frames and ActiveX Controls and display them as they would appear in a Web browser.

FrontPage has many useful features, as specified in Chapter 3, which can be used in developing instructional materials. However, although Front Page is considered as the cutting-edge technology in HTML editing, it is not adequate to develop sophisticated and integrated Web-based learning environments using only a HTML editor. Developing instruction for the Web requires additional programs and high-level programming languages to add interaction, support and management features. These programming languages are used to develop CGI scripts to be used in combination with HTML forms, Java scripts and Java applets.

Lastly, although designing and developing a learning environment from scratch is very time consuming and requires a wide range of skills it is flexible enough to give the designer complete control over the design and development of instruction and allows him/her to implement and modify a variety of elements of on-line instruction for specific population of learners. To design, develop and evaluate this learning environment, the same approach used in describing and evaluating learning environments above (accessibility, system requirements, design of course materials, interaction, navigation, monitoring and management, assessment, support, help and costs) was implemented again to guide and describe the design and development of the proposed learning environment.

5.1.5. Defining the technical requirements

Designing and developing for Wired Class was based on three types of technical requirements: Software, hardware and Internet connection. Software requirements include:

1. A HTML authoring package to generate the HTML Web pages;
2. A Web client (browser) to preview and test the generated Web pages;
3. A multimedia editing package to produce multimedia objects (e.g., images, animated images, audio, video clips, etc.);
4. A programming language package to build interactive Web pages and write programs for communication and learner support;

5. Internet programs, such as File Transfer Protocol (FTP) and Telnet, to establish connection between the development machine and the Web server to upload and update files and documents; and
6. A Web server (e.g., MS PWS, Apache, Netscape Server Enterprise, etc.) to host and deliver the learning environment.

Making the learning environment accessible via the Web required a Web server machine connected to the Internet. Therefore, a 200 MHz, 32 Mb, MS Windows 95 PC machine was installed (in the computer room at Institute for Learning, University of Hull) and connected to the campus LAN using 'hardwired connection' with permission to run the machine for 24 hours a day. The PC model was chosen for many reasons:

1. The high cost of assigning and maintaining another operating system, like UNIX, in comparison with assigning and maintaining a PC machine.
2. The availability, ease of use, flexibility and efficiency of IBM CGI scripts.
3. The compatibility with the developing machine (PC) in which the learning environment was developed.
4. The researcher' previous experience in programming and managing MS Windows operating systems and Web servers.

To make the PC machine run as a Web server, MS Personal Web Server (MS PWS) software was installed. MS PWS effectively transmits information in HTML pages from the Web server machine to users' Web clients by using the Hypertext Transport Protocol (HTTP). In addition, to make the machine accessible via the Web, the server was connected to the Internet (or to another computer connected to the Internet) for 24 hours a day. Internet connection could be established using 'dial-up connection' or 'hardwired connection'. The first type is based on telephone lines, slow, expensive and not suitable for working for a long time or with a big number of users. However, the second type makes the host a full-fledged Web host and offers high speed and performance for users. Usually, this type of connection is common in big organisations and universities, and provided free of charge to users.

Therefore, in the present study, it was possible to manage a PC as a server using the first type of connection (hardwired) exploiting networking facilities in the University of Hull. This type could offer the speed and availability needed for an instructional Web server. In addition, an IP address was assigned to the machine by the Computer Centre. The assigned Host Name was 'w134.loten.hull.ac.uk' and the IP address was '150.237.136.134'. Either the Host Name or the IP address could be used to access the machine via the Web. However, the host name was easy to remember and was delivered to the users.

Since the choice of the appropriate software and programming language is based on the Web server, Visual Basic 5 and VB5-CGI Objects (*) were used to develop server-side CGI scripts to run on the Web server under MS Windows 95. Java scripts and Java languages were used to develop hypermedia objects (e.g., Calculator and Grapher).

Lastly, in designing Wired Class, identifying students' hardware and software was a pre-requisite to the design and development processes. In the present study, the target users used IBM compatible computers. The speed of the majority of these PCs varied between 60 MHz to 300 MHz (Intel and Pentium). However, many schools still used PCs with 800486 processors, which are considered as slow machines at this time. These PCs were connected to the Internet Service Provider (**) using telephone lines and modems (usually 56 KB). At the time of the study, Microsoft Internet Explorer 4.0 and Netscape navigator (4.0 & 4.5) were the common browsers used at schools. The speed of students' computers, type of Internet connection and clients they use to access the Web were essential factors considered in the design and development phase.

5.2. Designing and developing the learning environment

Considering the above constructivist-based approach for designing Web-based learning and the front-end analysis approach used in describing and evaluation Web-based learning platforms (WebCT, Blackboard and TopClass), constructing the present learning environment required the design and development of the following elements:

1. Tutorials and assessment
2. Instructional support utilities

(*) VB5-CGI Objects is a collection of powerful and easy-to-use Visual Basic 5 objects (by Eazyware: http://www.eazyware.com/vb5-cgi/) to develop CGI scripts on any CGI capable Web server under Windows 9x/NT4.0. The objects are designed as native compiled ActiveX DLL's (they produce and submit the HTML code to the Web server) and therefore run in the same address space as the compiled Visual Basic 5 CGI application.

(**) The ISP in this case is the Technological Development Centre (TDC) at Ministry of Education in Cairo, which is responsible for providing schools with the Internet service

3. Interaction tools
4. Management and monitoring tools
5. Help topics and support
6. Navigation system.

Tutorials contain course content and learning materials arranged in a hierarchy of new concepts, examples, exercises, links to related Web sites and discussion areas. Assessment also is an integral part of the tutorial elements and contains self-tests and quizzes. Management and administration tools are designed to help students to register with the on-line class, access their grades, edit their work, etc. This component also helps the on-line teacher to ensure how the on-line class is in operation and to provide information about students and their progress. Security and access related problems were important issues that were considered in this component.

The purpose of the interaction component is to facilitate interaction between the learner and elements of the learning environment, including learning materials, peers and the teacher. To facilitate interaction with the content, it was necessary to design interactive learning aids (e.g., graphics plotters) to respond to and deal with the learners' inputs, using HTML forms to submit the questions and feedback and asynchronous and synchronous communication tools, such as discussion boards, e-mail and chat). The next sections discuss the design and development of these elements in the light of instructional design models, learners' roles, learning activities and the teacher's roles.

5.2.1. Tutorials and assessment

Tutorials, also known as content delivery, refer to the course materials that are to be delivered to the students. The course content may be in the form of text, graphs, multimedia presentations or interactive Java simulations. Tutorials (modules and lessons) are the pivotal component in the learning environment and all other components and elements are designed to serve the subject as represented in the modules. Since the subject content, as represented in the student textbook, is not suitable to be delivered directly via the Web, converting the textbook materials to Web pages would make them nothing more than electronic pages for reading via the computer screen.

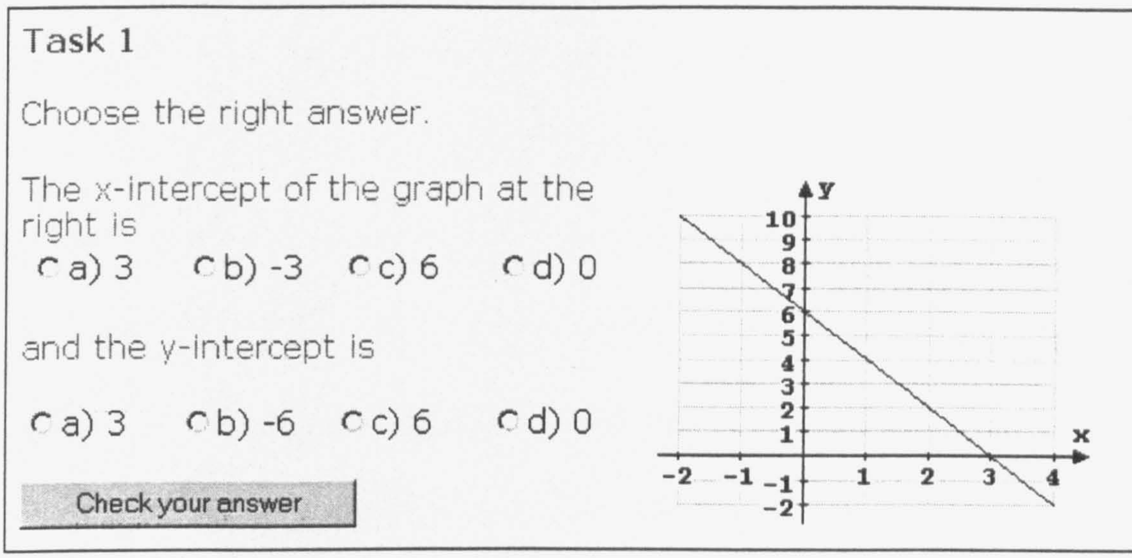
The need to conduct interactive learning required the traditional content to be re-edited and interaction objects to be added (e.g., interactive graphs, hyperlinks, quizzes, etc.). To achieve this purpose, first, the subject content was logically divided into two modules, each module containing six lessons followed by a revision and exam lesson. Second, each lesson was segmented into seven chunks using the principles and objectives of the teaching approaches discussed above. These parts were entitled the lesson, further examples, self-test, exercises, links, discussion and send to the teacher.

Basic elements of the course content (e.g., facts, concepts, skills, examples, etc.) were presented under the 'lesson' section. However, they were re-written in the light of constructivist principles. Meanwhile, essential concepts and problems were left to be represented in other parts of the lesson (e.g., discussion), as shown below. Formatted text (using colours, different fonts and styles, etc.), still images and animated graphs were used to represent the lesson content. At the same time, each lesson was segmented logically into many small chunks, each representing one concept, skill or problem.

However, although the lesson section contains one example or more to illustrate a new concept or problem, additional and different levels of examples were provided separately under the 'further examples' chunk, allowing the learner to find more examples and illustrations, if needed.

Self-test (Figure 5-4) is an interactive component in each lesson provided to stimulate learners' thought and action, encourage them to ask questions, motivate them to learn and help them to know whether they understand the main concepts and ideas in the lesson or not. In this task, the learner answers two questions or more using 'multiple-choice', 'matches', 'true-false' and 'filling the blanks' formats. Self-assessment questions allow learners to access areas of the course (within the course or externally on the Web) that have been restricted, or revise specific parts of the lesson again; they are asked to contact the teacher if they repeat a mistake.

Figure 5-4: Self-test question



Self-test tasks are provided using HTML forms and CGI scripts which run in the Web server. These scripts catch the learner's answer, check it, generate a HTML page including the appropriate feedback then forward it to the learner's browser to let him/her know the right answer at the same time. Using Java Scripts in this case was not appropriate because it requires the answer to be included in the HTML code which can be viewed by the learner if he/she is experienced enough. Even using 'encoded' or 'encrypted' code, it is not possible to generate appropriate feedback pages.

Exercises are similar to traditional textbook exercises, which are very common tasks in maths education. In Wired Class, the student needs to print out the exercises page and use paper and pencil to answer exercises (e.g., solving equation, graphing a function, etc.). The objective of the exercises is to give the learner the chance to practise more mathematics traditionally (using paper and pencil). The teacher's role then is to ask learners about their answers and progress in this task by requesting results using e-mail. These exercises allow more interaction between the learner and the content and between the learner and the teacher.

Unlike CAI courseware, which is restricted by the courseware database, 'links' work as a portal to Web resources. In this part, many useful and well-selected Web sites are suggested for learners. These links vary between tutorial Web sites, illustrating the main concepts and facts included in the lesson using other methods, to problem-based solving sites that encourage learners to construct their knowledge using different and high-level techniques of thinking. To select the topic and type of a link, the objectives of each lesson and the needs of other tasks (e.g., exercises and discussion) were considered. For example, visiting these links is necessary for solving problems in the 'send to the teacher' task. Many questions were considered when selecting any site to be linked to Wired Class:

1. What is the goal of the site?
2. Is the material designed for students similar to those of Wired Class?
3. Is the information useful and appropriate for the course objectives?
4. Is the author of the site qualified?
5. Does the site provide links to more detailed information or other sites?

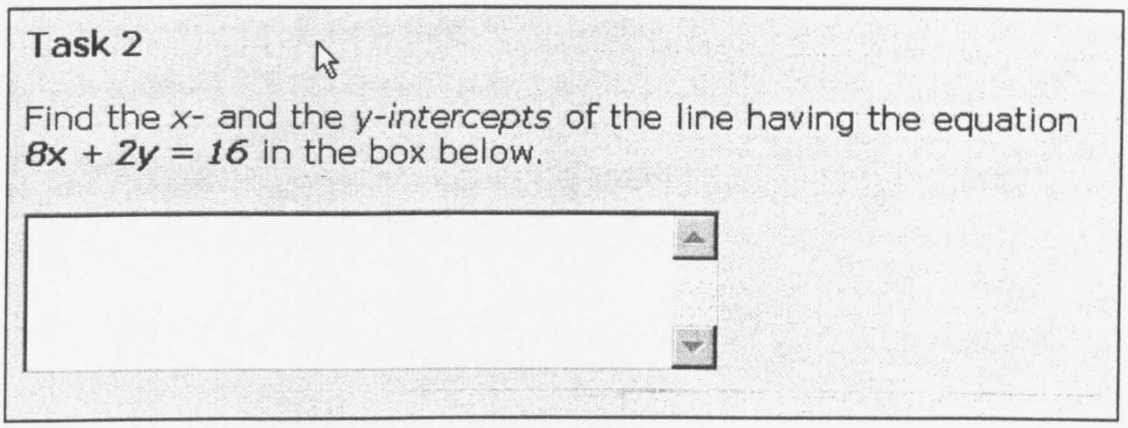
For example, if the site provides links to other external sites, these external sites should be reviewed first. In addition, Wired Class students' attention should be drawn to whether they can continue visiting these external links or not. In addition, since many Web pages are deleted or moved quite often and new Web site uploaded every day, links can get out of date, therefore links should be reviewed and maintained regularly.

Peer discussion, also, is one of the essential elements in collaborative and constructivist learning. According to constructivist epistemology, peer discussion offers the chance for students to interact asynchronously, negotiate meaning and reflect on their learning and viewpoints through collaborative problem solving. In this part, students are encouraged to construct a part of their knowledge via interaction with each other. A problem is suggested, either by the tutor or students, and learners are required to participate by filling-in and submitting a simple HTML/CGI-based form. Then, the learner's participation is added to the discussion board of each lesson. Therefore, the learner can read others' participation in the board, compare different points of view, ask a participant for more explanation or comment on others' responses. Access to discussion boards could be done via each lesson or from the starting page. The teacher's role is to monitor the discussion board, motivate students to participate more positively, evaluate learners' participation and send his/her comments to learners, publicly or individually, if needed.

Lastly, the 'send to the teacher' (Figure 5-5) section is the last part in the lesson hierarchy. In this part, the student needs to answer and submit various types of questions using HTML forms. Types of questions are not limited to multiple-choice or filling in blanks.

Students can answer essay type, compilation or open-ended questions, which require manual grading by the tutor.

Figure 5-5: 'Send to the teacher' tasks



Therefore, this task minimises the problem of 'textual entries' that faces CAI programs, whereby textual entries by the learner can be misspelled and the program has to be written in a way that can deal with many probabilities. Using HTML forms and CGI scripts, learners' responses are collected in a database in the Web server to be assessed and analysed by the human teacher who then sends results and feedback to the learner. This task, in particular, is an extremely important part of each lesson since mathematics requires a human teacher, not an auto-marking program to analyse students' responses and send the appropriate feedback. In addition it could be used to:

1. evaluate students' achievement to know whether the learner understand the lesson or not;
2. help the tutor to keep students notified of their progress and mastery of the lesson content.
3. encourage students to ask the tutor and motivate them to learn.

5.2.2. Support utilities

Instructional support utilities include course schedule, on-line library, student's page builder, Web publisher, Web search tool and on-line notebook

- **Course schedule**

The purpose of the on-line schedule is to guide students through the course and help them to manage their time and group-based activities, without destroying the flexibility of distance education. The importance of the schedule is it keeps students studying together, as far as possible, to offer the chance of interaction and co-operation among them. Therefore, a timed study plan is added to guide learners week by week and lesson by lesson (Table 5-4).

The on-line schedule was developed based on the assumption that traditional class students are able to study the course modules in seven to eight weeks (two times a week). At the end of each module, a revision and test were provided to allow learners to recall, summarise and practise the main concepts and skills included in the module. In addition, the course schedule provides week by week tasks that should be achieved. These tasks (such as discussions and group presentation) are not pre-defined; instead, they are left to the teacher and students to suggest.

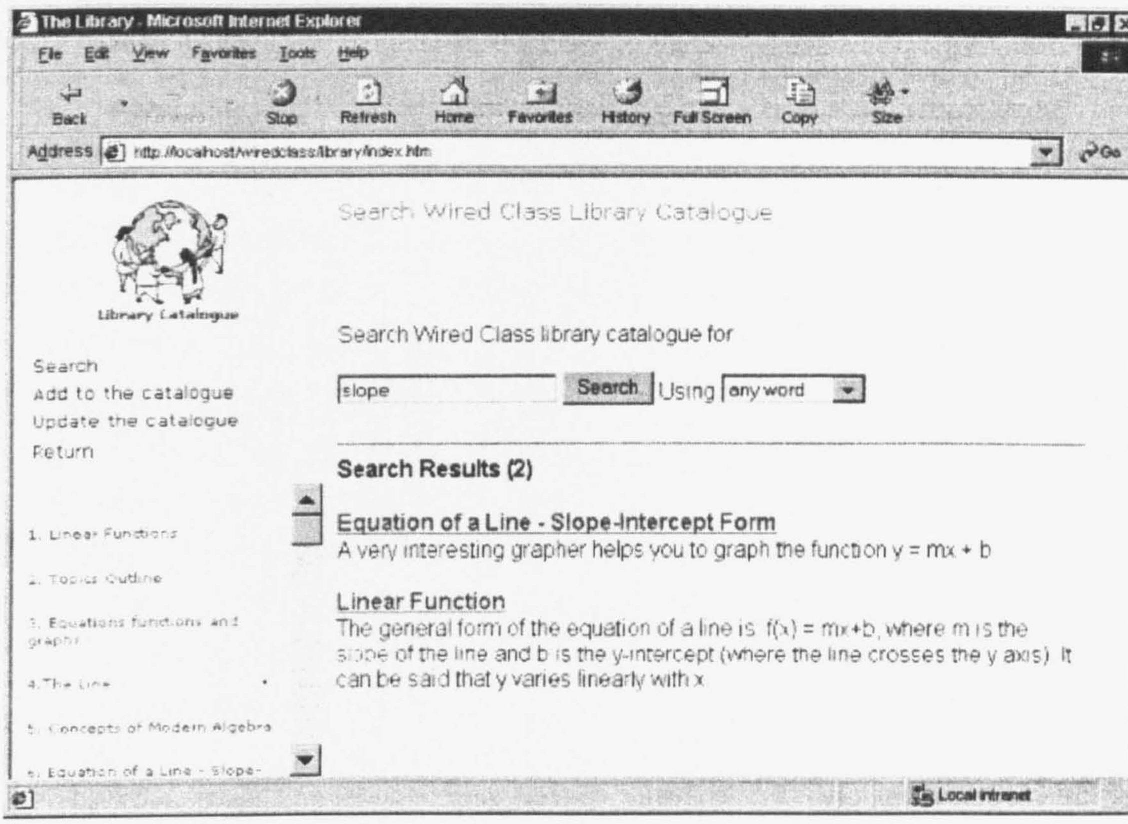
Table 5-4: Studying schedule

Modules	Week	Lessons	Tasks
Module 1 Functions and Graphs	Week 1	Lesson 1: Solving Equations in one Variable Lesson 2: The Co-ordinate Graph	Task(s)
	Week 2	Lesson 3: More on Functions Lesson 4: Direct Variation	Task(s)
	Week 3	Lesson 5: Linear Functions Lesson 6: Inverse Variation	Task(s)
	Week 4	Lesson 7: Summary and Exam	Task(s)
Module 2 Equations	Week 5	Lesson 1: Solving Equations in one Variable Lesson 2: Solving Equations in two Variables	Task(s)
	Week 6	Lesson 3: Linear Equations Lesson 4: The Intercepts of a Line	Task(s)
	Week 7	Lesson 5: The gradient of a Line Lesson 6: The Slope-Intercept Form	Task(s)
	Week 8	Lesson 7: Summary and Exam	Task(s)

- **The on-line library**

The purpose of the on-line library is to employ one of the unique features of the Web as a global and easy accessible source of information. The on-line library introduces learners to the Web as a supplemental source of course-related information in different formats. This information could be on-line tutorials, provided by other courses and tutors, quizzes, discussion topics, subject-oriented forums and instructional aids (e.g., graphical calculators) to support students in their learning (Figure 5-6).

Figure 5-6: Wired Class on-line library



The on-line library catalogue is designed to be searchable using a Java Script-based search engine. Search results are yielded as links and short descriptions of relevant Web resources. In addition, public search engines are made available to search the Web, if the library fails to meet the student's needs. Students are encouraged to add Web resources to the library catalogue using the 'add to the library catalogue' facility

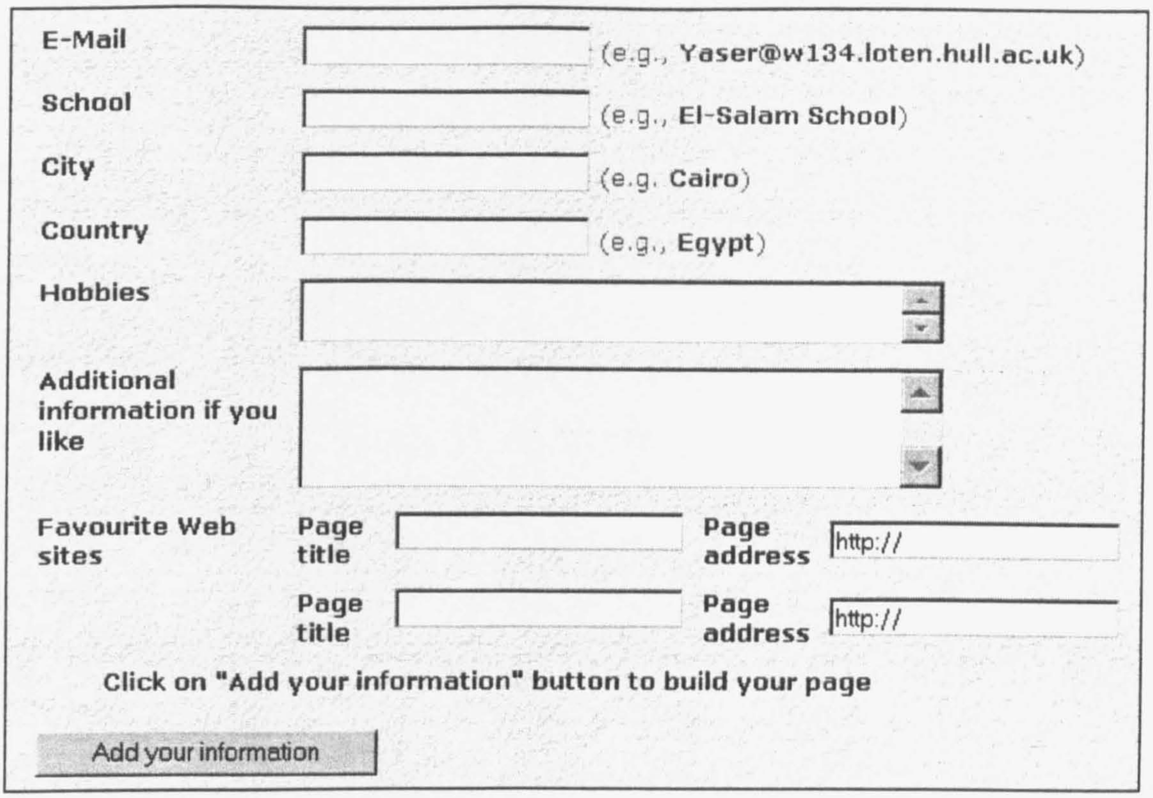
- **Page Builder**

Just as traditional classroom students see and contact with each other, on-line students need to see and know each other. Therefore, students' personal Web pages could be used to foster the sense of community and minimise the sense that students are isolated from each other. Usually, personal Web pages present the student's profile (e.g., interests, country, education level, personal photograph, e-mail address and links to favoured Web sites)(Figure 5-7). This information is essential to encourage interaction among students.

However, although there are students who may able to build their own personal Web pages using WYSIWYG HTML editors, designing, building and uploading Web pages for the majority of learners is not an easy task. Therefore, the need was recognised to design a Web-based tool to help students to build their own Web pages. This tool is called 'Page Builder'. Page Builder is a pre-defined 'template' script. This script allows the student to enter his/her personal information (e.g., name, e-mail address, interests, etc.) and personal image then upload it to Wired Class server using a simple HTML form. The script uses this information to generate an HTML page, specifies an HTTP address and links the page to the student's Web page.

One of the most important features of Page Builder is that it uploads the learner's image easily from his/her local disk to the Web server. Therefore, the learner does not need any additional programs, except the Web browser, to build a good-looking page. In addition, the learner could modify his/her page later using his/her username and password. This feature encourages learners to update their pages regularly and allows them to correct any mistake they discover in the future.

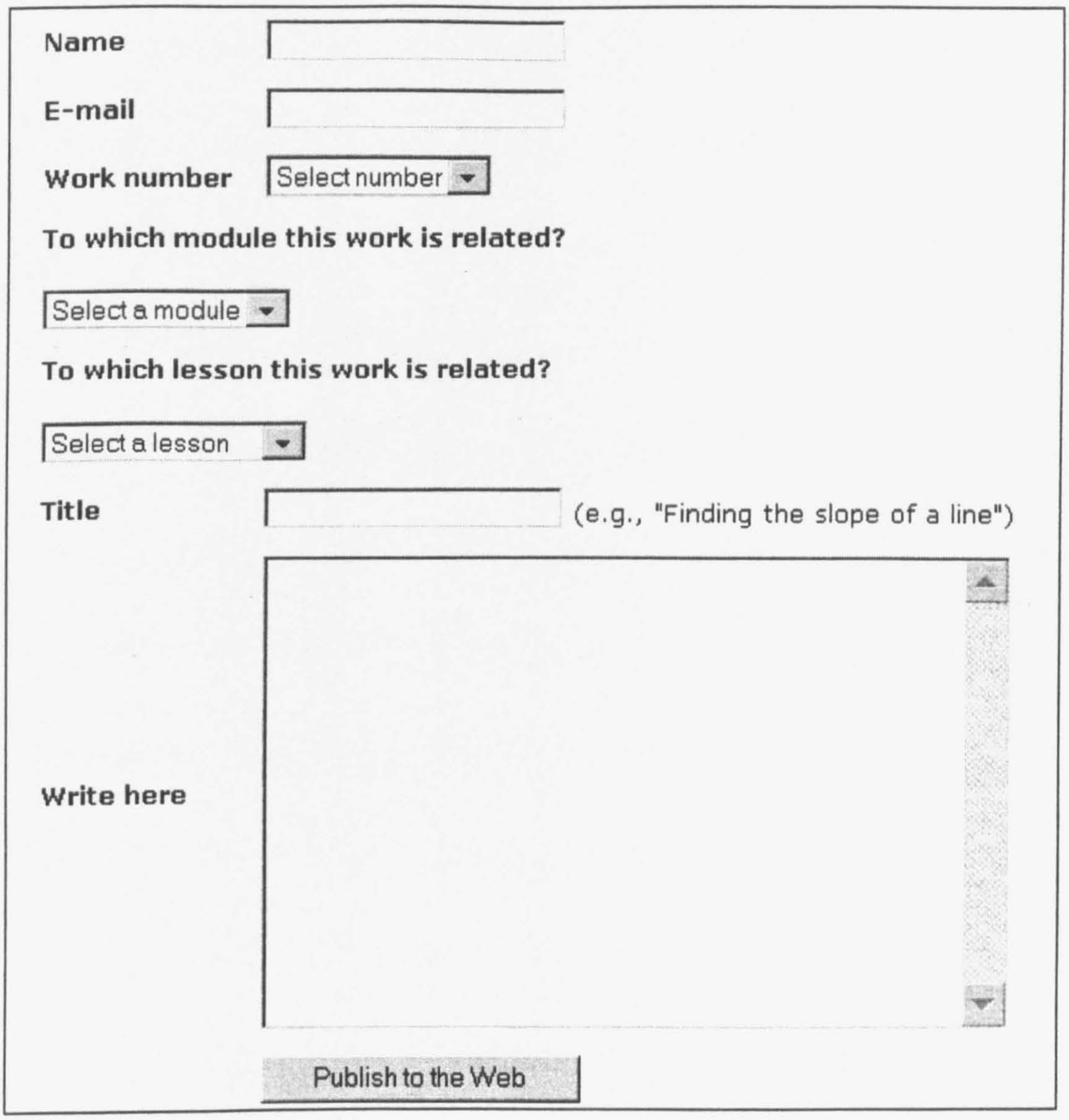
Figure 5-7: Page Builder form



- **Web Publisher and presentation board**

As the on-line learner's role is changed from recipient to participant, strategies and tools are needed to add an additional interaction dimension to Wired Class. One of these interactive strategies is asking learners to provide course-related presentations. In the traditional classroom, learners can use different types of media to present their work to the class (e.g., whiteboard, graphs, maps, etc.). A similar tool can be provided in Wired Class called the Web Publisher. Using HTML forms, the learner can submit his/her work to be added to the presentation board where students publish their work. In the presentation board, students' presentations are listed, ordered and linked to the presenter's name (Figure 5-8). In addition, the presenter is able to re-edit his work using his/her username and password.

Figure 5-8: Web Publisher and the Presentation Board



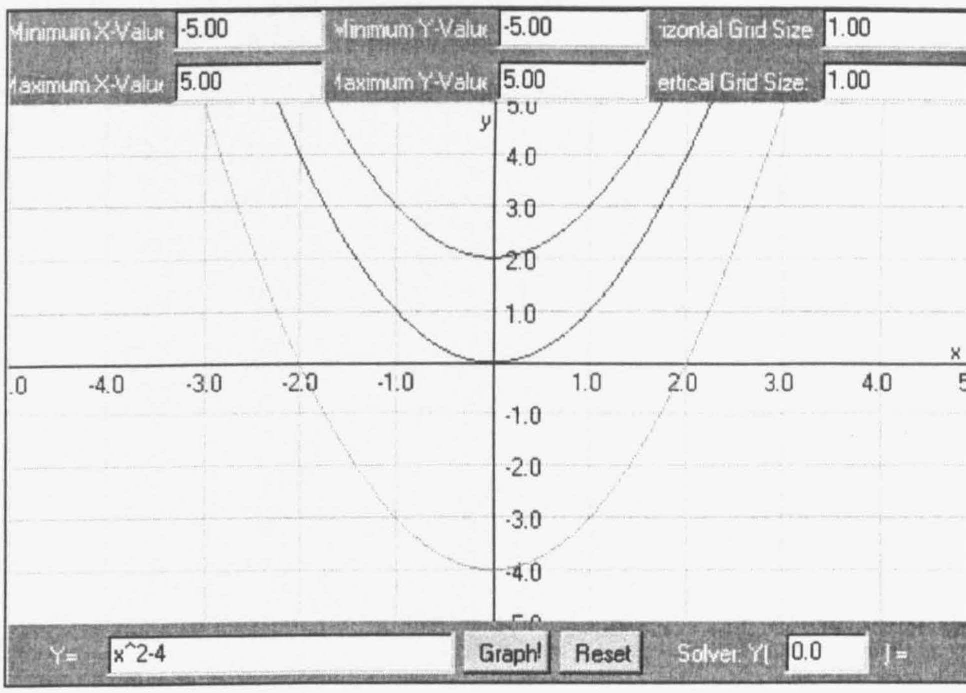
- **Search the Web**

To search the Web, relevant search engines were selected to be used by the learners in Wired Class. However, to avoid having to access each search engine's Web site separately to seek for course information, these search engines are gathered in a simple HTML form using Java Script. All the learner needs to do is to type a search keyword, or keywords, and select an appropriate search engine, from an opposite drop-down menu, to show the search results in an internal frame within Wired Class.

- **Learning aids**

The purpose of learning aids is to provide students with interactive and support tools that can be used in mathematics learning. Examples of these tools are calculators (numerical and graphical) and equation solvers. Using only Java enabled browser, graphical calculators (Figure 5-9) can help students to examine and visualise graphs of functions, define their domains, investigate relationships, compare functions and zoom in and out. Many mathematical tools were designed, adopted or employed to help students in their learning, particularly with the lack of face-to-face tutor support.

Figure 5-9: Graphical calculator (Grapher (*))



- **Notebook**

Students' notebook is an on-line notebook that allows the learner to save any course related information (e.g., comments, exercises, teacher's feedback, etc.) in a personal and secure file in the Wired Class server, using his username and password. Developing a 'notebook' is a relatively difficult task and not found in any learning environment reviewed above. However, using CGI scripts it is possible to allow the students to transfer and keep

(*) Grapher is a Java applet designed and developed for Wired Class students in conjunction with Russell Schwagre, programming specialist, UK.

their information in the Web server and retrieve it again using their Web browsers only. Functions such as 'copy', 'cut' and 'paste' are used to facilitate information editing. The most important advantage of 'notebook' is that learners do not need paper and pencil or additional software to manage their tasks.

5.2.3. Interaction tools

Interaction tools varied between asynchronous (e-mail and discussion boards) tools and synchronous (chat) tools.

- **E-mail**

E-mail is one of the most popular and widely used asynchronous interaction tools in the Internet and the Web. The potential of e-mail is that it is a very fast text-based mechanism for conducting interaction between the tutor and students. Web-based e-mail in particular has shaped a new revolution in popularising e-mail using an easy access, simple user interface. For these reasons, a Web-based e-mail service was selected to serve in Wired Class.

There were two possible ways of offering an e-mail service via Wired Class. The first was to install e-mail software onto the Wired Class server to work as an independent Web-based e-mail service, using the domain name of the Wired Class Web server. Although this option allows a full control over the e-mail service, it is very costly and only suitable for big organisations. The second option was to subscribe to a free e-mail service on the Web. Currently, the number of free e-mail service providers is estimated at more than hundred. These services varied in their capabilities and suitability for Wired Class students.

The search for the most suitable free Web-based e-mail service for Wired Class students revealed that that Egypt Network offers an appropriate service. This service was selected for many reasons:

1. It offers a non-restricted e-mail address: Most e-mail service providers control the way in which the user can choose his/her e-mail address. For example, Microsoft Hotmail does not allow users to use special characters, such as the point (.) and hyphen (-). However these characters are allowed in Egypt Network e-mail.

2. Egypt Network offers a suitable and easy to remember domain for target users using the domain <username@egypt.net>.
3. Most e-mail servers have a high traffic rate. However, Egypt Network is favoured only by Egyptian users, allowing it to get a relatively low traffic rate.
4. The e-mail server is located in Egypt, which makes access to the server faster than other world servers (such as Hotmail and Yahoo).

For these reasons, Egypt Network was chosen as the Wired Class e-mail service provider. This enables every student in the class to get an e-mail address as soon as he/she registers. To use the e-mail service, learners are asked to enter their username and password within a form located in the Wired Class site. Students can use e-mail to prepare for real-time chat, share ideas, send questions to the teacher and receive feedback. In addition, unlike other learning environments (e.g., WebCT and TopClass), students are able to contact each other within Wired Class or other people who are not members in the learning environment.

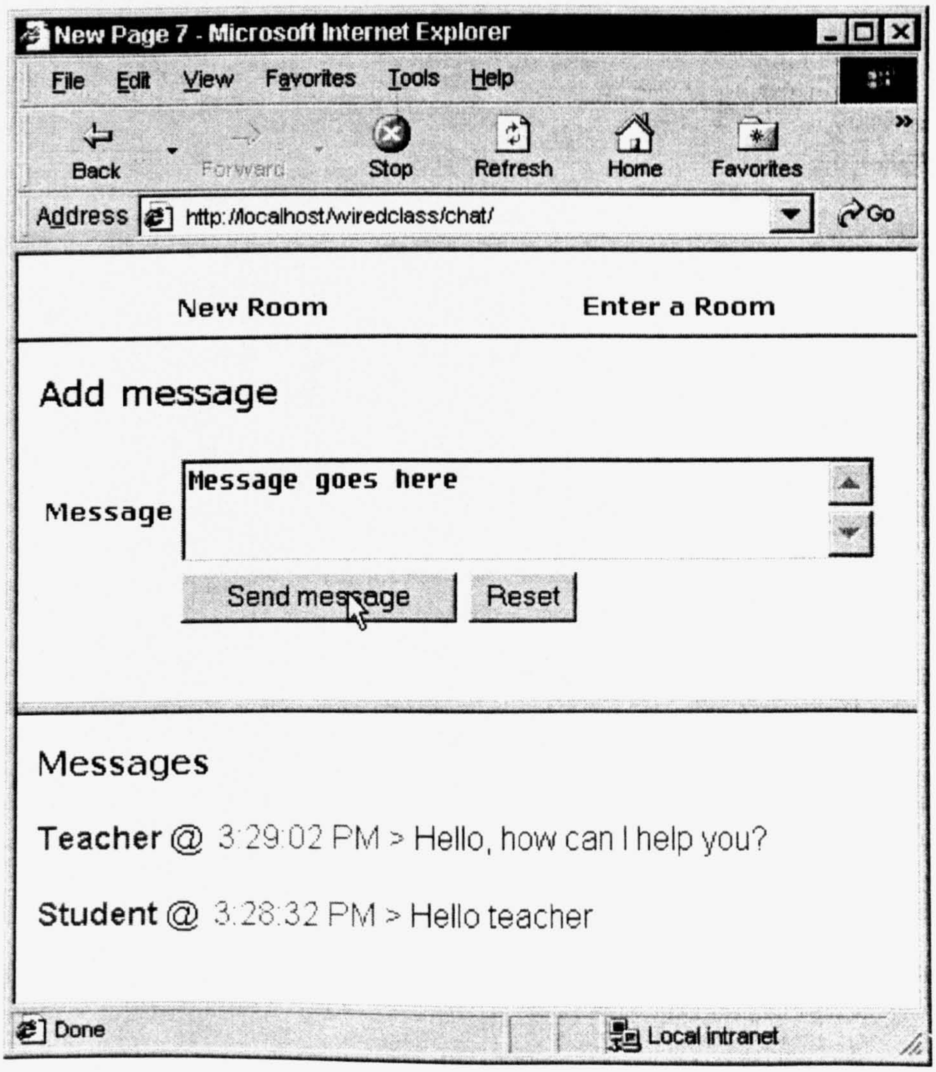
- **Chat rooms**

Using these chat rooms, learners can interact synchronously with each other to share ideas, solve problems and work collaboratively on a project. Designing a chat system means designing a real-time and multi-user channel for communication via the Web. Although there are numerous chatting systems available which vary in their capabilities (using text, audio and video), most of them are not suitable, either technically or educationally, to the students' level or to be hosted in Wired Class Web server. However, suitable chatting systems were found to be too expensive to be used in small-scale educational applications or at schools. For these reasons, it was necessary to design and develop a simple, and efficient, chat system for Wired Class students. A text-based chat system was found to be the most popular type for easy and fast interaction via the Web. This kind does not require a high specification machine or any additional software in the user's machine except the Web browser.

Technically, conducting a chat room requires running a script in the Web server to be used by two users, or more, at the same time. The main functions of this script are receiving one participant's inputs, using HTML form, then forwarding them to the other participants' browsers who are running the same chat script. The chat system was designed as two windows in the student's Web browser. The upper window allows the student to input his/her information and a short message. At the same time, the lower one shows students' names and their participation (Figure 5-10).

The essential idea behind this simple design is that a CGI script handles each participant's inputs from the upper form, saves them in a temporary text file, then forwards them (after 5 seconds for example) to the other participant's lower window. The last task is achieved by involving the HTML command 'refresh' in the HTML code in the lower window. The complete CGI scripts in conjunction with HTML forms were designed and developed with students' needs and level in mind. Additional features were added to the chat system make it easy to use and interesting. For example, the learner can establish any number of new rooms and invite others for conversation. Alternatively, others can access a room already established by the teacher or someone else using the option 'enter a room'.

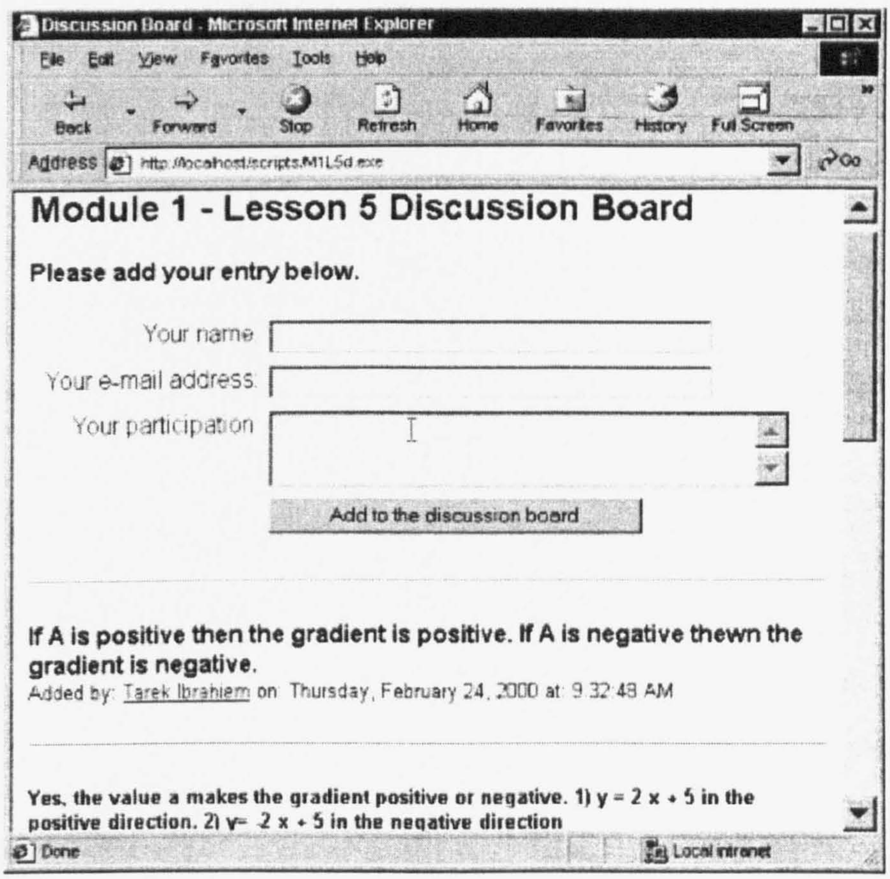
Figure 5-10: Wired Class chat rooms



- **Discussion boards**

The discussion board is a virtual area where learners exchange their personal ideas and examine them against others' points of view. Using discussion boards, students can post and read messages addressing course-related information and problems. An investigation of discussion board programs available on the Web showed that using one of them in Wired Class would not be suitable to the students' level and discussion objectives. It was found that the majority of discussion boards are 'threaded' discussions, which are suitable for debating more than one idea or topic in the same board. In addition, the thread style discussion may not allow students to take advantage of messages presented under sub-titles. For these reasons, a simple discussion board was designed and developed, as shown below (Figure 5-11).

Figure 5-11: Discussion boards

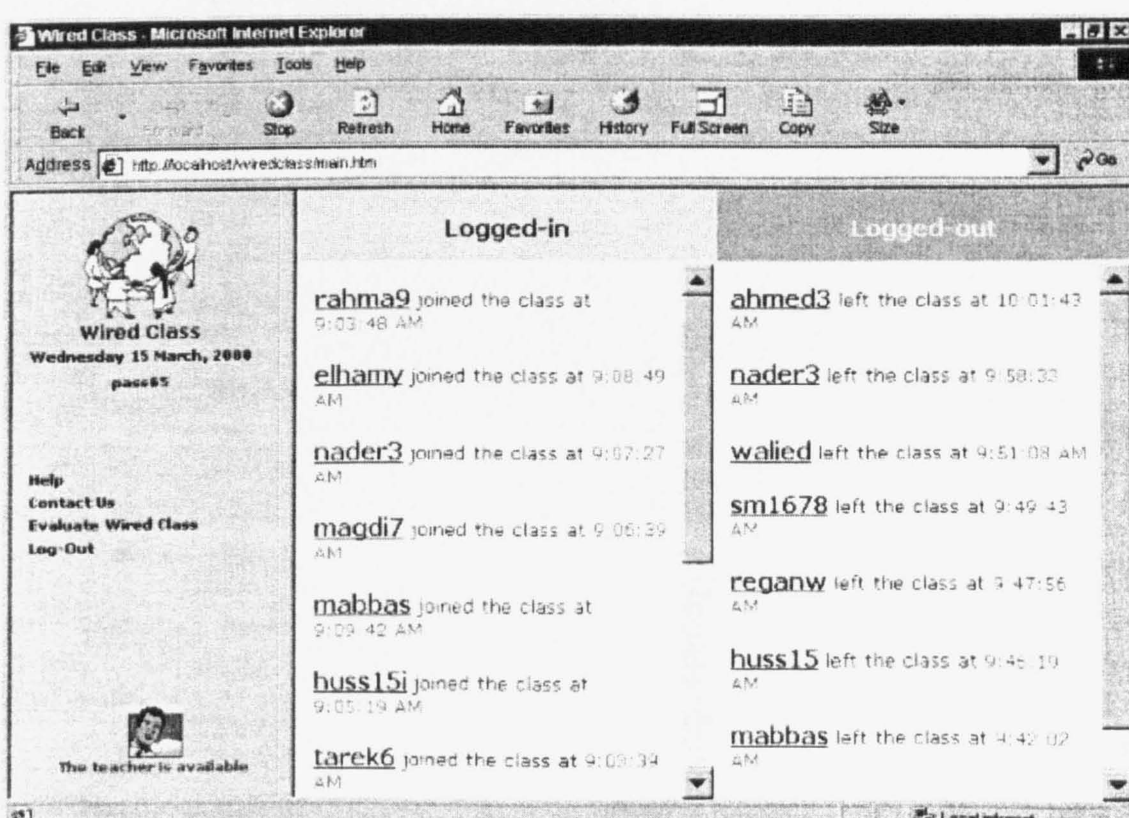


The design of the discussion board interface, as shown above, consists of two parts: The 'send' form and list of participants' messages to the board. This design allows the learner to submit his/her message to be added below at the top of the list. So, the learner can read others' messages to the board and compare his/her point of view against theirs. Technically, all posted messages are organised and saved in a HTML file in the Web server called a 'discussion file'. Every 'discussion file' in the server has a unique name. Every time the learner executes a discussion board script in the server side, the script generates an HTML page combining the HTML form (for inputs) and the specified 'discussion file' to appear on the same page in the user's browser.

- **On-line students' page (who is on-line?)**

Since students access Wired Class at different times during the day, the on-line students' page presents a list of students who have logged-in to the class, with the time of logging-in/logging-out and links to those students' personal pages. The importance of this tool is that it allows the learner to know who is on-line while he/she studying, encourages students to contact each other and minimises the sense that everyone is studying alone (Figure 5-12).

Figure 5-12: On-line students' page



5.2.4. Management and monitoring tools

Course administration refers to the different options available to the on-line tutor to manage his/her learning environment, enable/disable access rights of students, monitor students' progress and contact students. In Wired Class, management tools include control panel, student enrolment, students' grades and notice board.

- **Tutor's control panel**

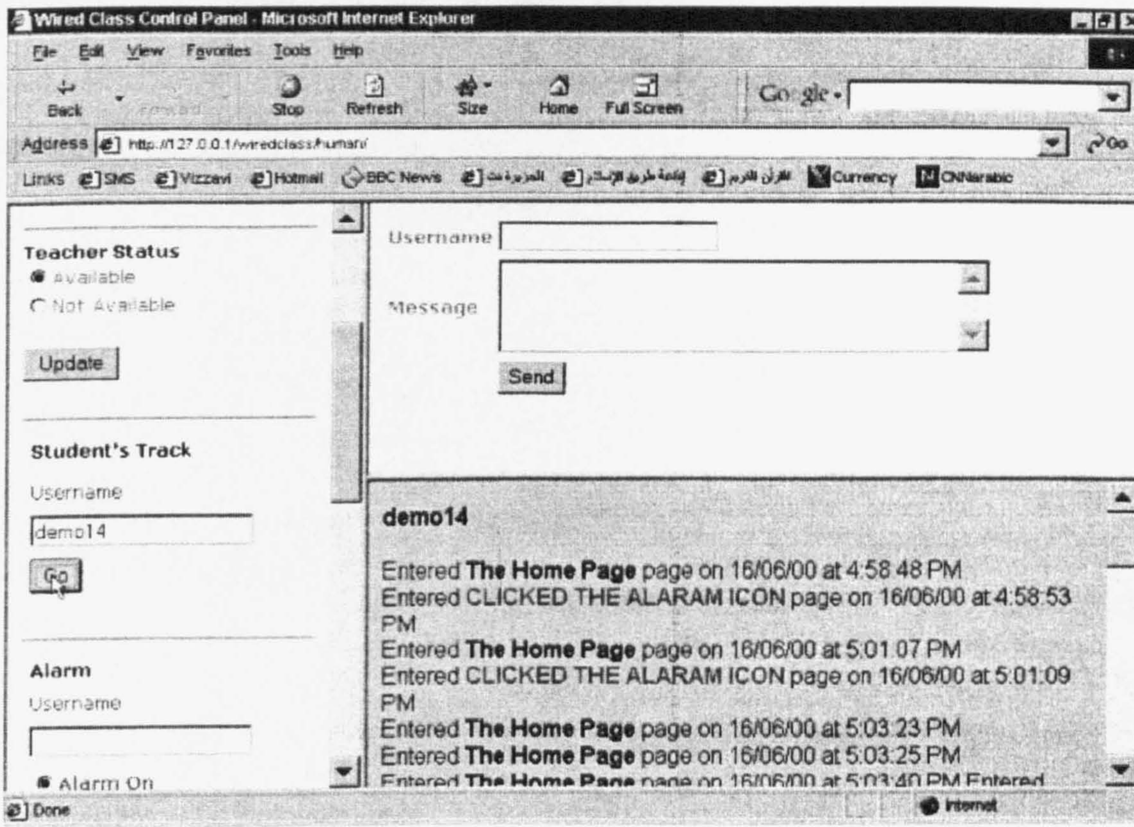
The control panel is a group of easy-to-use tools, which allows the tutor to manage, contact, support and monitor students' performance using the Web browser. Using the control panel the tutor is able to:

1. send an instant message to any student using his/her username only;
2. ask one student or a group of students to contact him/her while they are studying;
3. receive and organise students' messages in one window;
4. send public messages to the entire class via the notice board;
5. search and update the on-line library catalogue;
6. monitor students' participation and participate in discussion boards;
7. track a students' pathway through Wired Class components and modules;
8. turn on/off the feature of 'on-line tutor', allowing students to know whether the tutor is on-line or off-line;
9. update student's grades in each lesson; and
10. access the Wired Class MS Access database to get information about a student's performance and progress.

The control panel (Figure 5-13) is used by the on-line tutor as long as he/she is available. At the start of any learning session, the tutor selects the 'Available' radio button then clicks the 'Update' button to inform students that he/she is on-line and able to receive and answer their questions. Messages sent by students appear at the bottom of the control panel and the tutor can reply to students instantly without leaving control panel or while doing other tasks.

In addition, since the tutor is not in direct contact with students and does not have traditional type records to monitor their performance and track their activities, the control panel allows the tutor to trace all site pages visited by the student, the number of tasks completed, tests taken and the time spent in learning the course material. Using this information, the tutor can encourage and support struggling students, diagnose their difficulties and provide the appropriate feedback to them.

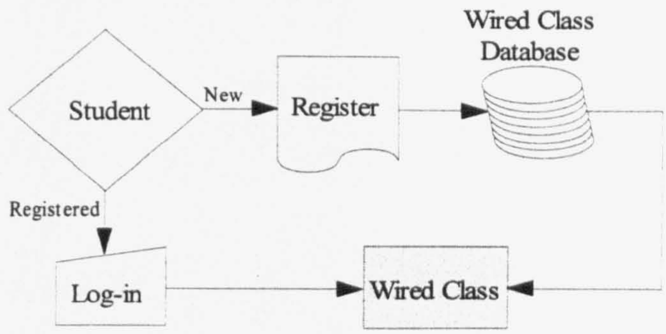
Figure 5-13: Tutor's control panel



- **Student enrolment**

On-line student enrolment is one of the unique features that characterise Web-based learning environments. Unlike other media (such as television) the Web offers the possibility of enrolling students directly. Paper-based forms, post and telephone are replaced by HTML/CGI forms. In Wired Class, students are enrolled using a registration form, which requires the student to enter his/her personal information (e.g., name, gender, school, date of birth, etc.) and choose a username and password. In addition, the student is able to register him/herself in other services, such as e-mail. After registration, the student can use his/her username and password every time he/she accesses Wired Class. The enrolment procedure is diagrammed below (Figure 5-14).

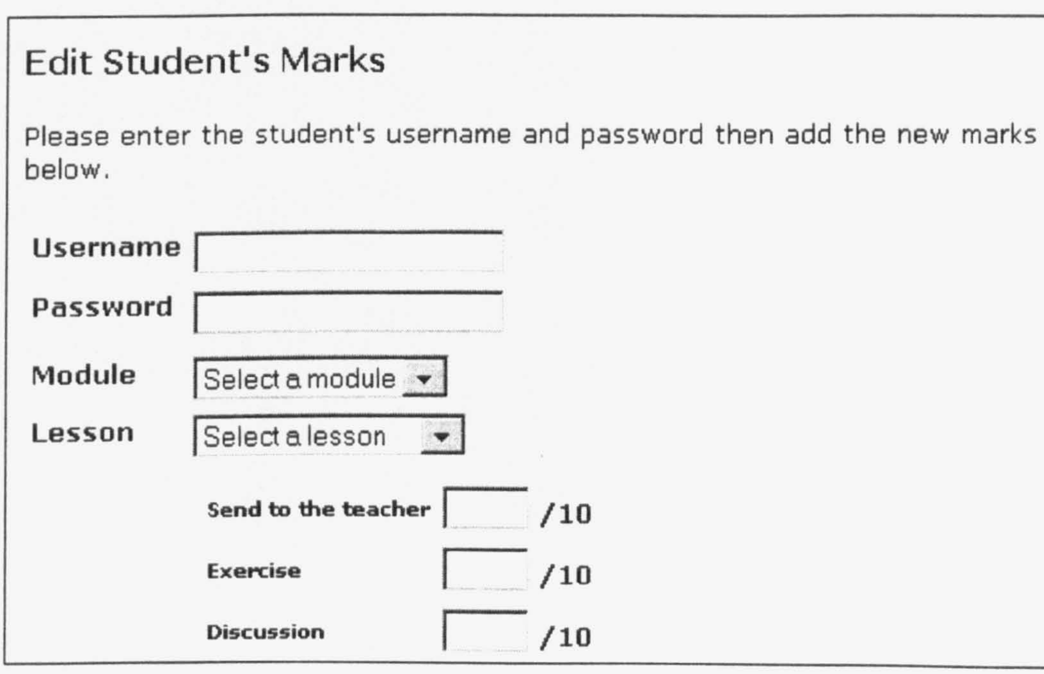
Figure 5-14: The design of enrolment tool



- **Student's grades**

The student's marks page is a grade tool, which allows the learner to access his/her own grades in each lesson, as entered by the tutor. The grades page consists of two parts: the editor and the viewer. The editor allows the tutor to update the learner's grades page regularly using only the student's username. However, the viewer allows the learner to view his/her marks in previous lessons (Figure 5-15).

Figure 5-15: Grades editor



- **Notice board**

Notice board is similar to the traditional class wallboard on which notices are fixed. In Wired Class, a need was perceived for a similar board on which the teacher and students could show their notices. However, although it was easy to specify an area in Wired Class to show the teacher's notices, it would not be practical for the teacher to receive and publish daily and weekly notices using the HTML editor. For this reason and to encourage learners to show their notices in Wired Class, a tool was designed to help the teacher and students to post their notes.

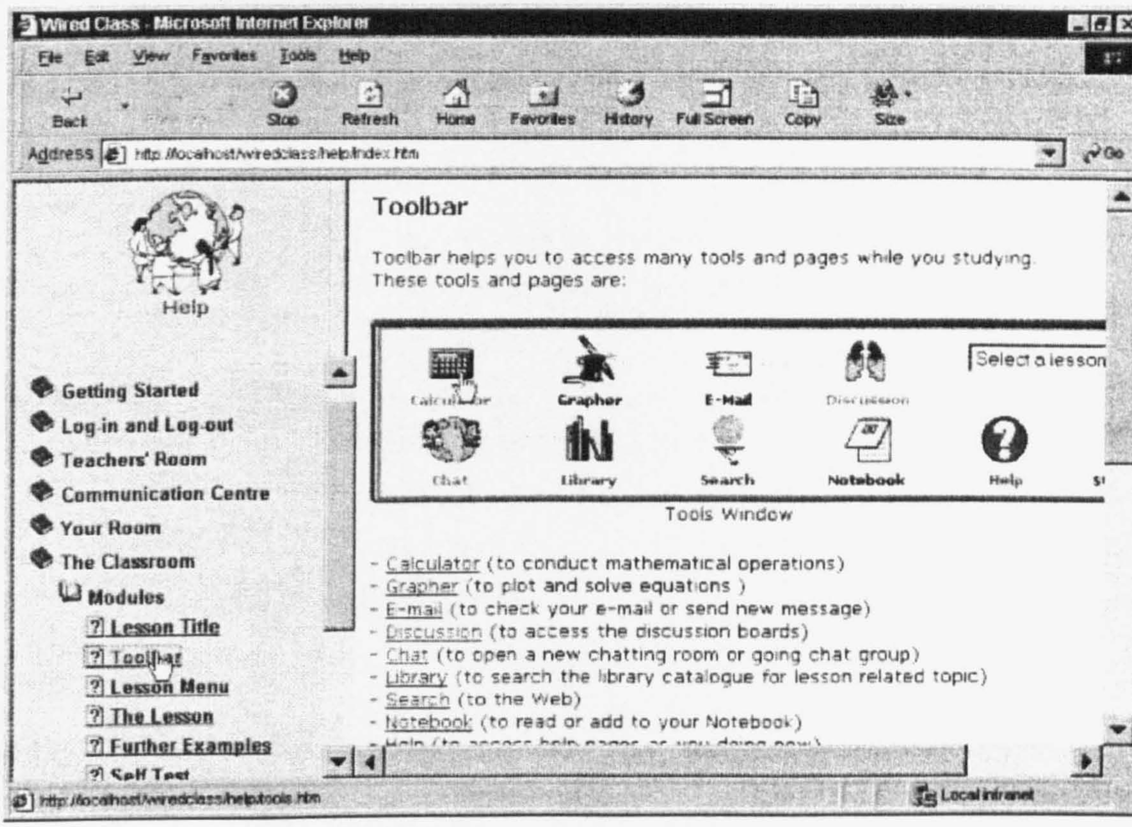
Using 'notice board editor', the teacher and students are able to post their notes only by filling-in a simple form. The notice board can be used for many purposes. The teacher could use it to arrange for on-line discussion or announce about new arrangements or changes in the class system. At the same time, students themselves could use the board to announce an event or to indicate a public event.

5.2.5. Help and on-line support

Help topics are an essential feature in courseware development and student support. Therefore, a simple and easy access help system was designed to provide students with the information they need to use the various features and elements of Wired Class, including the function of each element and information about the Internet, the Web, search engines, etc.

Help pages are accessed from the 'help' icon or from within any component in Wired Class. In designing help topics and index, the standard MS Windows help style was considered as an easy to use and familiar style of design. In addition, learners are able to get any information they need by clicking on the help node to show a pop-up sub-window. Moreover, a short preview and graphical presentation were provided allowing the learner to learn how to use Wired Class and its components (Figure 5-16).

Figure 5-16: On-line help

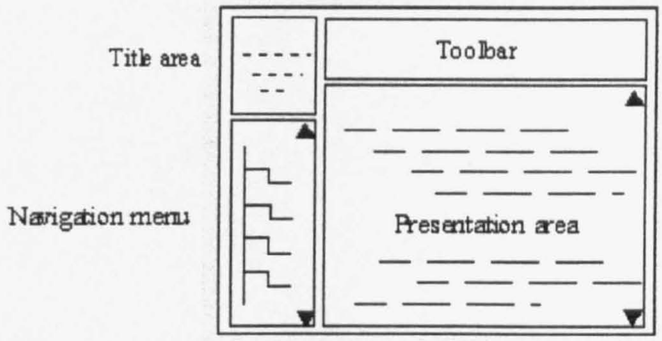


5.2.6. Organising the learning environment

Since modules are the main tutorial component on which learners spend their time studying, presenting modules and lessons was given more attention than other components. The design and organisation of modules began with the identification of four areas in the page: Title area, navigation menu, toolbar and presentation area (Figure 5-17). The title area shows the number of the module, the title of the current lesson, the current date and time, an area in the upper left corner has been allocated for this purpose. The current date and time involved using date/time JavaScript.

The navigation menu lists the course content. Each menu contains the seven parts of the lesson (e.g., further examples, self test and exercises). This menu is a graphical expanded/contracted menu developed using JavaScript to allow the learner to focus on the current part he/she is studying and to know where he/she is in the lesson. Three types of icons are used: 'closed book', 'opened book' and 'page' icons. The 'closed book' icon means that this node can be expanded to yield two nodes or more. At the same time, each node is linked to one Web page. Clicking on the 'opened book' icon closes the book and contracts the menu, allowing the learner to move to the next part. Nodes that contains one link are presented using the 'page' icon.

Figure 5-17: The design of lesson interface

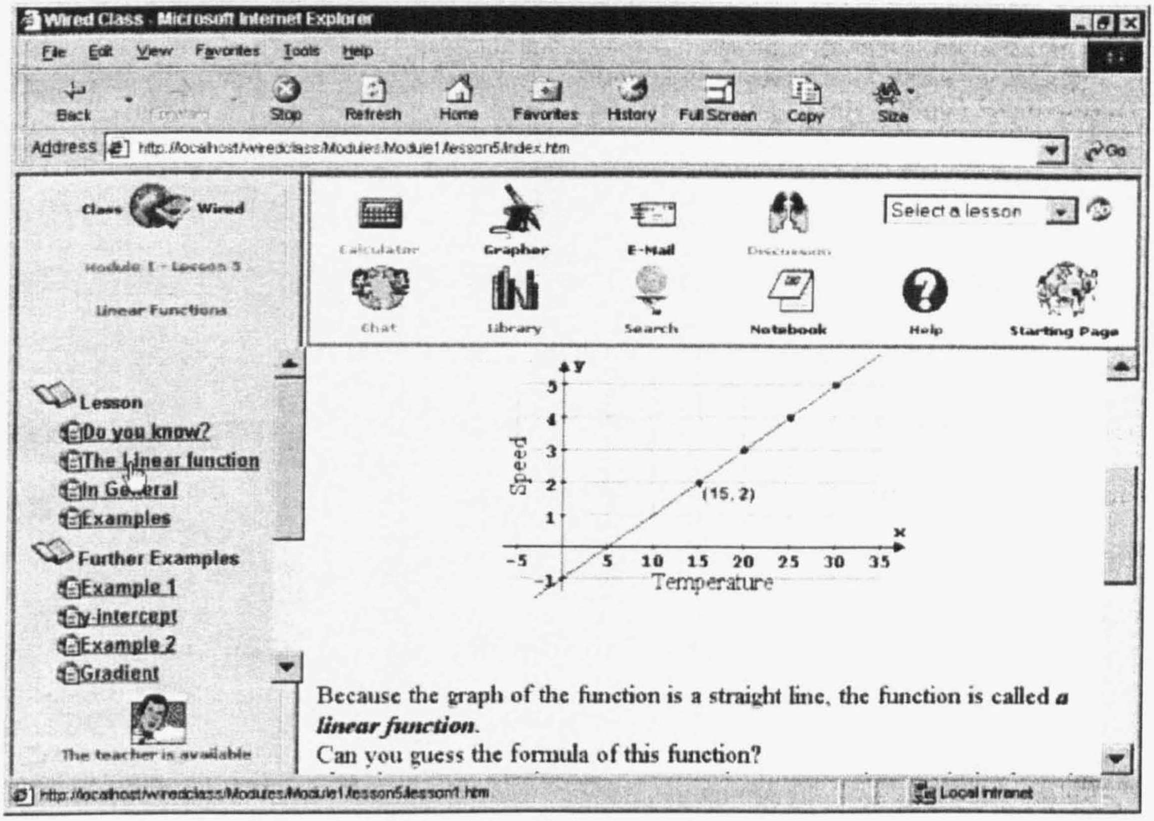


The toolbar window contains all the tools needed to support the learner while studying (e.g., calculators, notebook and course search). In addition, links to other important pages (e.g., e-mail, chat and the starting pages) are also added to the toolbar. At the same time, a dropped-down menu is provided, allowing the learner to access any module or lesson from the current lesson (Figure 5-18).

Lastly, the presentation area is the main window on which the content of the lesson is viewed. Any other course information or external links are viewed within this window, allowing the learner to stay within the main lesson window as well as he/she studies. For example, in the fifth lesson (module one), the presentation area presents the objectives of the lesson. However, the expanded menu, in the left-hand frame, presents the lesson content.

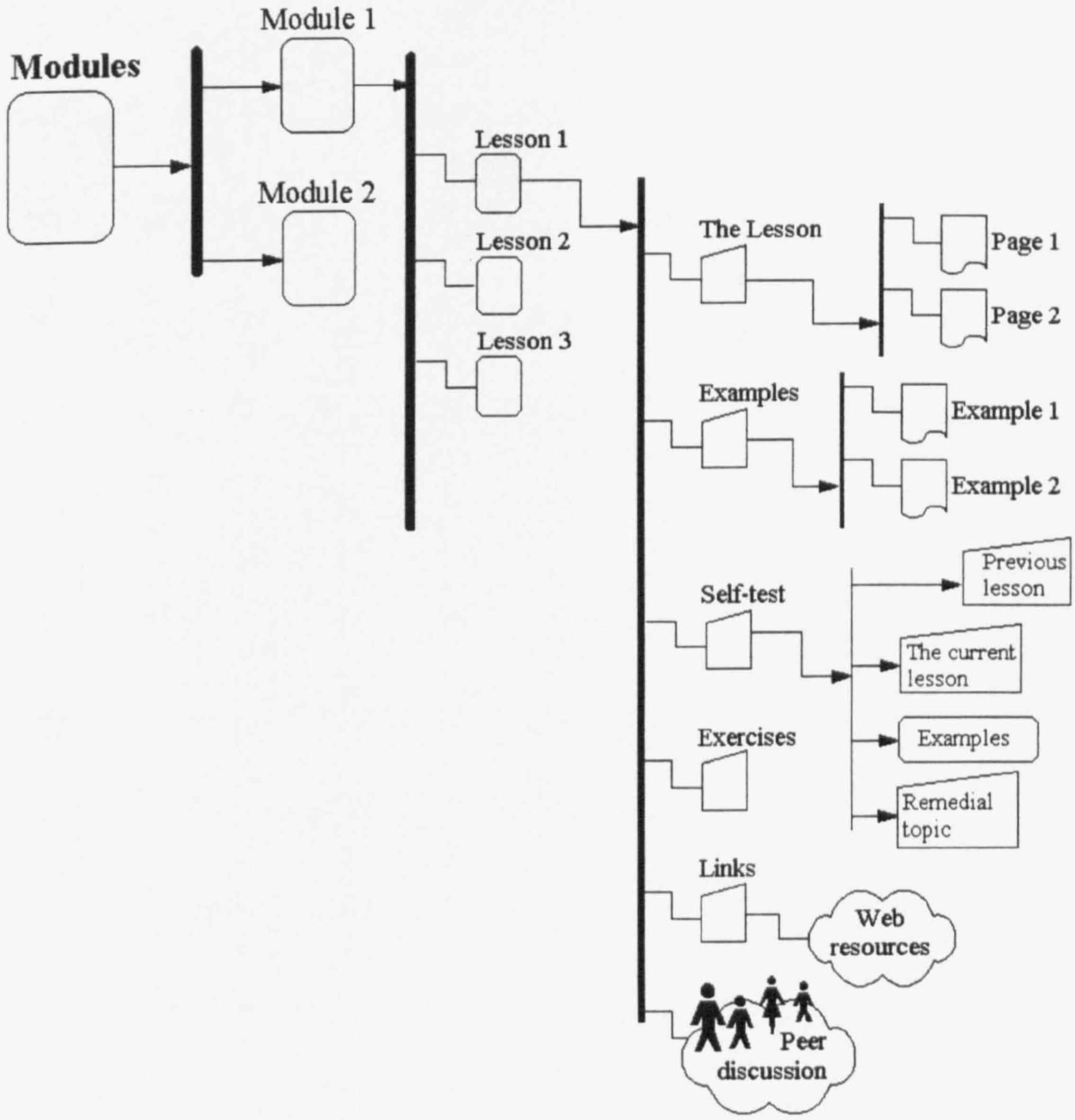
As shown under 'the lesson' node, there are four sub-nodes ('do you know?', 'the linear function', 'in general' and 'examples'). Each node is linked to one Web page that presents one idea or concept. The first link begins by introducing the concept of linear variation and the linear function (do you know?), then moves toward the mathematical meaning and definition of 'linear function', generalises the concept and illustrates it in an example. More examples are provided under the 'further examples' link and new concepts (y-intercept and gradient) are introduced as well. Under the 'self test' link, three questions are provided, allowing the learner to know whether he/she understands the meaning of 'linear function' and the concepts of 'y-intercept' and 'gradient'.

Figure 5-18: Lesson user-interface



Exercises are provided under the 'exercises' link to give the learner the chance to practise maths problems using paper and pencil. New examples and ideas about graphing linear functions and finding the slope and gradient are provided via the 'links' node. The objectives of each link, accompanied by an explanation of its content, are provided with each link. Under the 'discussion' link, students are encouraged to make deductions from some facts that would be available to them by graphing two functions that differ in the values of gradient. In 'send to the teacher' task, different types of questions (multiple-choice, filling-in the blank and completion) are provided, allowing the learner to choose the graph that represents a linear function, type the slope of some linear functions and tell the teacher why he/she has chosen the graph. In general, the design of the navigation system is used throughout the modules and lessons can be diagrammed as shown below (Figure 5-19).

Figure 5-19: The hierarchical design of modules and lessons



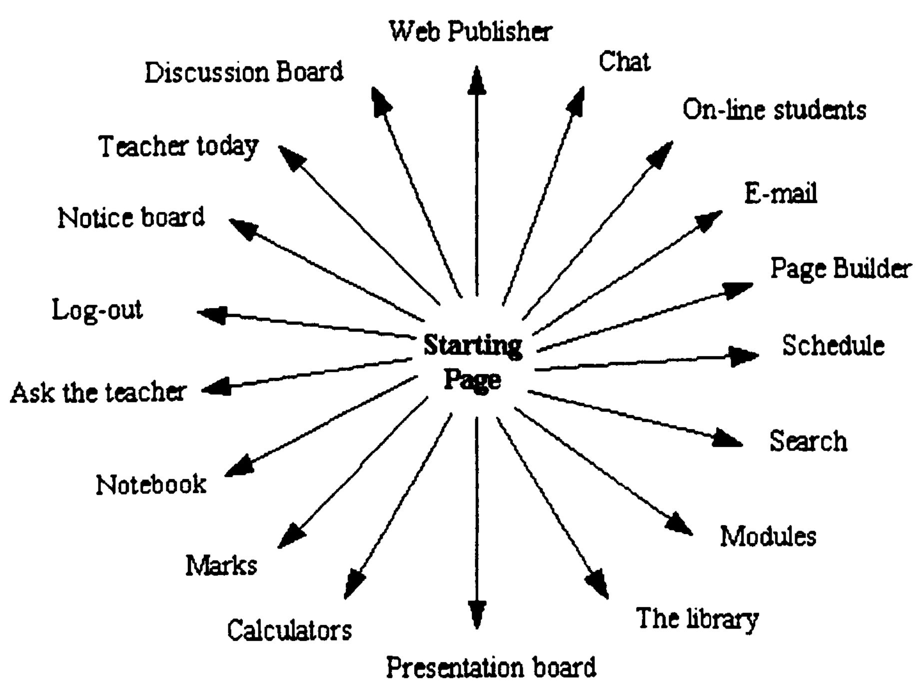
This diagram shows that there are four levels in this hierarchical design of the modules and their contents:

1. The first level consists of the two modules of the course, allowing the learner to choose between them.
2. The second level contains the lessons of each module.
3. The third level contains the components of the lesson (the lesson, examples, self test, etc.).
4. The fourth level is the lowest level, which contains the target content. This content could be a single Web page, image, or external Web page in other Web server.

This hierarchy is based on the 'indexed' design of hypertext documents, as mentioned in Chapter 3. This hierarchy allows the learner to track his/her movement throughout the site and avoid him/her to get lost in the site. Furthermore, this exploration design enables the learner to access any module, lesson or skip a page or task while studying.

Other components of the learning environment are organised to allow the learner to access any of them from one starting page, based on an indexed hierarchy. The learner can access any page without the need to pass through other pages or routes. In addition, the learner can return in one click on the 'starting page' icon to the starting page from within any page. The initial design of the starting page of Wired Class is diagrammed below (Figure 5-20).

Figure 5-20: The initial navigation design of Wired Class



In addition, since learners may get lost if navigation aids (e.g., captions, icons, banners, colours and nodes) are not well designed, many features were considered in the navigation design, as follows:

1. Pages are designed to help learners to keep track of where they are, where they can go from the current page and how they can reach a specific page.

2. Clear and consistent navigational aids are used throughout the site to minimise the attention and mental effort needed to deal with the user interface.
3. Classical and restricted navigational aids (e.g., next, previous, first, last, home, etc.) are replaced by well-described choices and links arranged logically in clear hierarchies to improve the understanding of the environment.
4. Navigation tools are well described to help the learner to choose the relevant path to get the information.
5. Along the site, a link is offered to help learners to return to the starting page (*) from which the learner can access to any page on the site.
6. Instead of listing the contents of pages using traditional tables, JavaScript was used to design graphical expanded menus similar to the familiar MS Windows menus.
7. Frames are used along the site to eliminate the need to load main menus many times, to guide learners to the different sections and to show external links inside Wired Class.

5.3. Developmental testing of Wired Class (formative evaluation)

A major drawback of linear instructional design models is that the evaluation process is delayed until the end of design and development phase. This delay may eliminate the opportunity to obtain important feedback from students, which could improve the programme and prevent the designer making more mistakes (Willis, 1995). In the R2D2 model, which was used as a framework for developing Wired Class, formative evaluation throughout the design and development focus is emphasised. Consequently, even before trying out the first version of Wired Class, evaluation procedures were carried out at various times and stages, to improve the design of instruction.

To carry out formative evaluation, it is recommended that experts in different areas related to the aspects of design and development and members of the target population (students) should be involved to test and try out the programme, then provide their feedback (**). Therefore, formative evaluation was carried out at two levels, 'expert appraisal' and 'student tryout'. Expert appraisal could be carried out before the student tryout. However, in

(*) Usually, the first page in a Web site is called the 'home page'. In Wired Class, this page is called the 'starting page' to indicate to the 'top level' page in the Web site.
(**) This issue is discussed in detail in Chapter 6: Research design

the present study, it was considered that carrying out both experts' appraisal and students' tryout simultaneously would be more beneficial and cost effective. Two important examples emphasised this point of view.

First, while reviewing the first version of the 'modules' component, an expert suggested that 'external links should not be provided in conjunction with each lesson'. He thought that 'external links would disturb learners during studying or make it difficult to concentrate on the objectives of the lesson'. However, during student tryout of Module 1, Lesson 1, as shown below, it was noticed that external links helped students to participate in on-line discussion and answer exercises. Therefore, external links were not removed completely but, with the expert's viewpoint in mind, the number of links in many lessons was reduced to two or three.

Second, a Web developer argued that there was a need to integrate more multimedia and hypermedia objects with the textual content (e.g., audio, video, plug-ins-based objects such as Real Audio and Macromedia Flash, etc.). But in the students' tryout it was noticed that students' software and hardware specifications as well as Internet connection did not allow them to use more sophisticated multimedia objects. Even students' experience in installing and using plug-ins and multimedia objects did not allow the use of more advanced hypermedia objects.

To prepare Wired Class for formative evaluation by experts, a sub-directory was added under the Web server (called WiredClass). Therefore, the HTTP address of the Wired Class Web site takes the form 'http://w134.loten.hull.ac.uk/WiredClass'. To test whether Wired Class is successfully accessible via the Web, the above HTTP address is accessed using other computers connected to the Internet from inside and outside the university campus. This test showed that Wired Class is fully accessible and the machine works at an appropriate speed.

Following the installation and the initial test of the Web server, many tests were carried out to see whether or not Wired Class server works as expected without coding or programming problems. This initial test is known as 'de-bugging'. De-bugging tests were carried out to:

1. find broken internal and external links;

2. check the compatibility of Wired Class with some standard Web browsers (e.g., Internet Explorer and Netscape);
3. discover any troubleshooting and scripting errors; and
4. collect information about the speed of logging-in to the server when used by many users at different locations (UK, USA and Egypt).

Many colleagues, with different experience in using the Web and Web developers, were invited to visit Wired Class Web site from their own machines. Visitors were asked to give their first impressions and opinions about the general design of the site, navigate throughout the site and try some scripts, such as chat rooms, discussion boards and Page Builder and report any problem or error they found to the designer. In addition, Wired Class Web site was registered with Developers' Web site [*]. This site contains hundreds of classified Web-based applications and scripts in different areas and is accessed by thousands of Web developers and experts every day.

5.3.1. Expert appraisal

Since the developmental testing of any educational programme seeks to enhance the design and make improvements, quantitative and qualitative information collected at the design and development phase dose not require deep statistical treatment in order to be interpreted (Romiszowski, 1986; Savenye and Robinson, 1996). Therefore, only an intellectual and simple statistical analysis of the coded responses and comments was carried out to investigate the strengths and the weaknesses of the system.

Romiszowski (1986) argued that if the majority of experts (80% or more) provide the same negative comment or respond negatively to the same item (disagree or strongly disagree), the designer should modify or re-design and develop the weak aspect or component. However, at the same time, if one expert provides a comment or suggestion that could guide the design and development process toward making an important change, this matter would be treated seriously. Open-ended items as well as closed ended items using a Likert-style five-point response scale (strongly agree, agree, neutral, disagree and strongly disagree) were used and the items were scored by the following key:

[*] This site (Developer Com, http://www.developer.com) is the most famous library, forum and portal for Web designers and developers.

Strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2 and Strongly disagree = 1

The questionnaire consisted of many sections, as described in the next chapter. In addition to the evaluation questionnaire, informal e-mail-based interviews were carried out with three experts for in-depth analysis of comments and faultfinding. Evaluation criteria were categorised into six evaluation dimensions, namely technical design, site structure, navigation style, instructional design and quality of content and Web resources. Each dimension contained closed-ended as well as open-ended questions to allow experts to reflect on their experience. Criteria and conditions of design (Table 5-5) are based on the design of the experts' questionnaire and the literature of Web design, as shown in the next chapter

Experts who had good experience and were familiar with target learners were asked to participate in the developmental testing, as follows:

1. Three secondary school maths teachers in Egypt.
2. Two computer technicians at Egyptian secondary schools.
3. Five assistant lecturers in educational technology (University of South Valley, Egypt).
4. One lecturer in educational technology (Ain-Shams Faculty of Education for Girls, Egypt).

In addition, many university lecturers in educational technology and Web developers were asked personally by e-mail to participate as experts in the formative evaluation of the learning environment. However, experts accepted to participate in the study only after an invitation message (Appendix 3) was posted to three listservs [*] in Web-based instruction and distance education with total number of more than 8,000 members world-wide. The message asked for people who had good knowledge and experience in:

1. designing and developing Web-based learning;
2. teaching in on-line classes; or
3. managing or facilitating Web-based learning environments.

[*] These listservs are:
WWWDEV (World Wide Web Courseware Developers' Listserv, http://www.unb.ca/wwwdev)
WWWEDU (The World Wide Web in Education List, http://www.ibiblio.org/edweb/wwwedu.html)
DEOS-L (The World Wide Web in Education List, http://www.ibiblio.org/edweb/wwwedu.html).

Table 5-5: Criteria and conditions of evaluation

Criteria	Conditions
The design of starting and subsequent pages	1. Attractive 2. Well laid out. 3. Appropriate for screen appearance. 4. Consistent throughout the site. 5. Displays the relevant tasks and functions. 6. Suitable for the downloading time. 7. Uncluttered with headings and subheadings. 8. Provides high quality hard copy of page content for off-line studying
Font sizes, style and colours, white spaces and margins	9. Used appropriately. 10. Help students to focus on the content.
Text, graphics icons	11. Well aligned. 12. Clearly reflect the content they represent.
Captions	13. Concise and accurately describe the images and graphs.
Multimedia objects	14. Suitable for students' level. 15. Support course objectives. 16. Used effectively throughout the duration of the course to support the learning process.
User interface	17. Attractive and easy to use. 18. Options and objects of user-interface are arranged in a clear structure.
Site design	19. Uses standard and compatible with standard browsers. 20. No troubleshooting or coding errors are available. 21. Has secure access. 22. Based on a consistent procedures to submit, process and assess students' work.
Structure	23. Contains the essential components of an on-line learning environment • Tutorials (modules, resources, support materials, etc.). • Assessment (self-assessment, tutor assessment, etc.). • Interaction (asynchronous and synchronous) • Management (registration, tracking, grading, etc.) • Support (on-line library, help, etc.) 24. Provides appropriate tool to students who need to share and display their work. 25. Suitable synchronous and asynchronous interaction tools are provided to facilitate interaction. 26. Allow the teacher to mange students.
Navigation	27. The hierarchy of the site is simple and well organised. 28. Helps students keep track of where they are. 29. Uses clear navigational aids. 30. Indexing provides quick access to information. 31. Students can easily locate the information in the different lessons. 32. Links are well labelled. 33. The student can return easily to the home page from any

Criteria	Conditions
	location on the site 34. Navigation icons are consistent throughout the site. 35. Links are minimal and simply act to connect nodes in a specified sequence.
Course content	36. Objectives are clearly stated in each lesson . 37. Accurate and relevant to the objectives. 38. Lessons are logically organised in segments (e.g., examples, exercises, discussion, etc.). 39. Developed in accordance with the needs and knowledge of the target learners. 40. Provides real life situations and contexts to facilitate the study of abstract content. 41. Graphs, figures and formulae are clear and accurate. 42. Examples are relevant to the objectives and the content of lessons. 43. Discussion topics are relevant to the objectives of the course.
Web resources	44. Objectives and content are well described. 45. Suitable for the learners' level. 46. Appropriate for the course activities. 47. Easily located. 48. Logically categorised. 49. Meet learners' needs.
Design of instruction	50. Course schedule is flexible. 51. The responsibilities of the student and the obligations of the on-line teacher are stated clearly. 52. Encourages interaction between the teacher and students. 53. Motivates students to participate in learning activities. 54. Encourages students to provide individual work. 55. Provides student-centred activities. 56. Student's performance is monitored. throughout the learning process. 57. Collaborative learning is encouraged. 58. Formative assessment is founded throughout the course.

Members were provided with a description of the objectives of the programme, information about target users of the learning environment, features and components of Wired Class and criteria of evaluation above. As a result of this message, a member of WWWDEV Listserv posted the following message asking other members to review Wired Class:

> 'I saved a WWWDEV listserv message from doctoral candidate Alaa Sadik a few days ago and just went back to it to check out his "Wired Class" Web-based learning environment. It's based on his well documented research in appropriate technology and pedagogy as well

as end-user analysis. Great use of Java, Javascript and HTML. Definitely worth a look if you haven't seen it yet'.

In addition, a member of WWWEDU posted the following message that reflects his interest in participation in the formative evaluation process.

> 'I saw your post on wwwedu and checked out Wired Class. I myself have been working on Venture Capital funding for a project which uses the same technologies and teaching strategies. I thought your work was very interesting, both on the technical side and reading through your teachers' manual'.

Consequently, many of those who visited the Wired Class Web site found another invitation message asking them to review Wired Class and provide their feedback and comments via e-mail or by filling-in the evaluation questionnaire provided within the site.

The overall findings of the panel of experts (30) who completed the on-line questionnaire and were interviewed (3) via e-mail were very positive (3.9 to 4.7 for more than 80% of the elements of the learning environment) and supported the assumption that Wired Class meets the criteria and conditions of instructional and technical design of Web-based learning environments. The expert panel rated the technical design of the site (4.3), site structure (4.6), design of navigation hierarchy (4.7), instructional design (3.9) and quality of content and resources (4.1) with low standard deviations indicating a high level of agreement among the panel members. However, elements of design that received negative comments or ratings less than 2.5 (multimedia objects, learning materials) were modified according to the experts' comments.

The experts were also asked to rank what features were the most beneficial and what features of the system were least beneficial. The most beneficial features were the tutor's control panel, consistency of interface design, design of navigation, compatibility with standard Web browsers, self-assessment, synchronous interaction tool (chat) and page builder. The least beneficial features were using multimedia objects through the site, student management and monitoring students' performance.

In addition, the appraisal provided useful comments and suggestions and led to many changes in the technical and instructional design and structure of the learning environment in many aspects. Feedback varied from general comments in favour of the design of the learning environment, and specific technical comments, with the aim of improving the design of user-interface elements (fonts, colours, etc) and the navigation system (e.g., menus, frames and links labelling) to structural and instructional views concerning the design and structure of course content, learning theory, tutor's and students' roles and support tools (e.g., Page Builder, chat rooms, etc.).

Examples of overall comments are found in the following feedback:

> 'Looks really great. Impressive. You have developed many useful tools. How long did that take? You develop them by yourself or as part of a grant team?'.

More specifically, in terms of structure of the learning environment, an expert found that Wired Class contains the essential components of an on-line learning environment:

> 'I have tried Wired Class and found that it offers key structural features that we require. It includes a variety of novel features including navigation features, progress tracking, a bulletin board and chat facility, on-line student evaluation mechanisms, and much more'.

However, in terms of navigation and breaking the content down into many chunks, an expert commented that:

> 'You don't want the content to be broken down into too many pieces, so that the student is faced with too much navigational complexity'.

In addition, in terms of using frames, experts thought that the frame-based style did not allow the teacher to guide students throughout the content and, at the same time, many students may not be able to bookmark or print frames properly. An expert commented that:

> 'Be careful how you use frames. What if you want to send your students to a specific page? You can't give them an URL. I recommend using tables and image maps instead'.

Therefore, many pages through the site were redesigned in tables to eliminate frames. However, many elements (e.g., lesson page and the on-line library) were found too complex to navigate through without using frames. To enhance on-line discussions among students, an expert emphasised the importance of finding a way to ensure that students mastered the course materials before going on any further and participating in discussion:

> 'How do you know that everyone has read the material before they start the discussion?'

Similarly, many changes were made in the design of the learning environment, as follows:

1. The number of icons on the starting page was reduced to a reasonable number and were specified only for groups of links, called rooms. Experts argued that the large number of icons may disturb students and make them overwhelmed.
2. 'Times New Roman' font was replaced by 'Verdana' font. An expert pointed out that this font is more suitable for Web publishing and available in all computers and operating systems.
3. The layouts of some pages were redesigned for old versions of Web browsers .
4. Many CGI scripts were rewritten as a result of programming errors. For example, in the old chat script, if a student entered the name of a chat room already opened by someone else, an error message appeared telling the user this path is not found. However, using the new script, the learner gets the message: 'Sorry, this room is not available. Please return and check the name again or click on make a new room'.
5. Cookies [*] were used throughout Wired Class allowing students to enter their usernames and passwords once a session. In the initial design, students were asked to enter their usernames and passwords in access and every time they submitted work or used a tool (e.g., notebook).
6. Links to external Web sites in many lessons, particularly the earlier lessons, were replaced by new links or removed. In addition, the total number was reduced, since many experts argued that some links had a similar content and objectives or were not suitable for the learners' level and lesson objectives.

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[*] Cookies is a Web-based technique allowing the Web designer to store information in a small text file, called a 'cookie' on the user's hard disk. However, only the information that the user provides, or the choices he/she makes while studying can be stored in a cookie. For example, Wired Class cannot determine the learner's name unless he/she types it. In addition, a cookie does not give that or any other site access to the rest of the computer and no other site can read it. Cookies for Wired Class were developed using VB5-CGI scripts.

7. Feedback in 'self test' tasks was modified to encourage learners to search and construct their answers based on constructivist principles.

In summary, the survey results were very favourable and indicated a high degree of acceptance by the experts.

5.3.2. Student try-out

The purpose of the student try-out was to improve the design of learning by revealing students' reactions and feedback to the course content and other components. Kemp et al. (1994) and Whitelock (1998) argued that student tryout could be carried out at different levels, such as 'individual try-out, 'small group try-out' and 'one-to-one trials'. However, at the same time, the level and cycle of try-out depend on factors such as time, cost and the availability of try-out students. As the purpose of formative evaluation is to enhance the learning environment, rather than prove or generalise evaluation results, it could be argued that formative evaluation can be carried out using only a small group of students.

To conduct developmental testing, Romiszowski (1986) argued that:

> 'There is no need for large numbers at this stage of testing. Our orientation is to go deeply into any problems encountered, by means of close observation of the students while they are studying, or by personal discussion of any learning difficulty encountered or error made. Large groups hinder, rather than help such a clinical approach to evaluation. We could say that the minimum number of students for each test session of a chapter is one and the maximum in most cases is three' (p. 409).

A student try-out of Wired Class was carried out for four weeks with a randomly selected small group of eight students from the target population. Students' background showed that:

1. all of them knew how to use a computer and the MS Windows operating system;
2. seven of them knew what the Internet is;
3. only three were very familiar with the Web and had used it before; and
4. no one had studied any formal or informal courses via the Internet before.

Moreover, all students were new students and the researcher checked that none of them had studied the course before by asking them to answer a maths pre-test. It was obvious that no student had studied the topic before. Framework, formative evaluation data was collected using informal discussion group, checklists, observation and students' logs.

The review of the literature showed that assessment of students' achievement of course objectives, soliciting reactions and observing behaviour in the learning environment are the most appropriate ways to collect information about the efficiency and usability during the formative evaluation phase (Clark, 1994; Jones, 1998; Lockee et al., 1999). Learning materials can be evaluated by asking students to go through the learning materials, study the content and do real tasks (such as answer exercises and respond to discussions) then evaluating their learning. In addition, students should be encouraged to report any problem they may find to the designer. Meanwhile, the structure and design of the learning environment can be evaluated by observing students while they are using the learning environment and recording any problem or unexpected event that arises (Jones, 1998).

In addition, the analysis of the students' feedback and comments in developmental testing of Wired Class was diagnostic (formative) rather than to approve or disapprove (summative) of the materials (Tuckman, 1994). The treatment of the qualitative information obtained from students does not require any statistical treatment in order to be interpreted; 'the instructional designer performs an intellectual analysis of the events which occurred during the session and comments made by students' (Romiszowski, 1986, p. 416).

Lastly, it has been argued that if the results of the evaluation will be used to modify and enhance the programme during the design and development phase and will not go beyond the development stage, the reliability of the evaluation instruments (e.g., observation and test) should not be a criterion for a satisfactory result; the developer and the clarity of the objectives of evaluation are the only important factors in obtaining reliable observation results (Sax, 1979; Croll, 1986; Simpson and Tuson, 1995).

In Wired Class, many functions and components were developed to monitor and track students' activities and progress and these are recorded in files, called logs. Analysis of students' logs provided useful information (such as the time spent in a specific lesson or discussion topic and students' grades in 'send to the teacher') to understand the problem behind student failure to answer exercise questions and enhance the design of the programme.

'Send to the teacher' tasks, for example, indicated that many students were not able to understand new concepts in a specific lessons and might need more examples and exercises to practise. In addition, since completing any lesson requires responding to its discussion topic, every student responded to the discussion topic by adding his/her viewpoint to the board. However, many students reported that they could not understand some discussion topics or post one possible answer. These topics were modified and rewritten to make them easier. At the same time, new Web links were suggested to help students to participate more successfully in the discussion.

In observing students' behaviours with Wired Class, two aspects of design were considered: technical design and user-interface and navigation design, as shown in the checklists (Appendix 4). The items on these checklists are based on the literature (Corry et al., 1997; Wilson, 1999) and the principles of design for the Web, as mentioned above in discussion of designing the components of Wired Class. The observer attempted to observe students to see how they understood and dealt with the different elements of design and to record any unexpected problems. The initial observation of students showed that students, even those who had no prior Internet experience, used the learning environment and understood the purpose of its components without reporting significant problems. Clear instructions, consistency of design, appropriate screen appearance and help topics were reported by students as the most helpful features.

Observation led to many changes in design and construction of the components of the learning environment. For example, one of the significant changes in the design was a modification to the starting page to categorise the components into five groups rather than separate links. Each group is called a 'room' and each room contains components which serve the same objective or are similar in features (such as interaction tools). For example, e-mail, chat rooms and discussion boards are categorised into one room called 'Communication Centre'.

Additionally, other links were added to some rooms, such as 'ask the teacher' in the 'Teachers' Room', to improve their functions. Moreover, the starting page was divided into two frames; the right-hand frame contains the five rooms with links to their elements (e.g., modules, discussions, on-line library, etc.). The left-hand frame shows the Wired Class logo, welcome message, student's username and links to the help and log-out pages (Figure 5-21). The frame style design was chosen to reduce downloading time and help students to return to the components page.

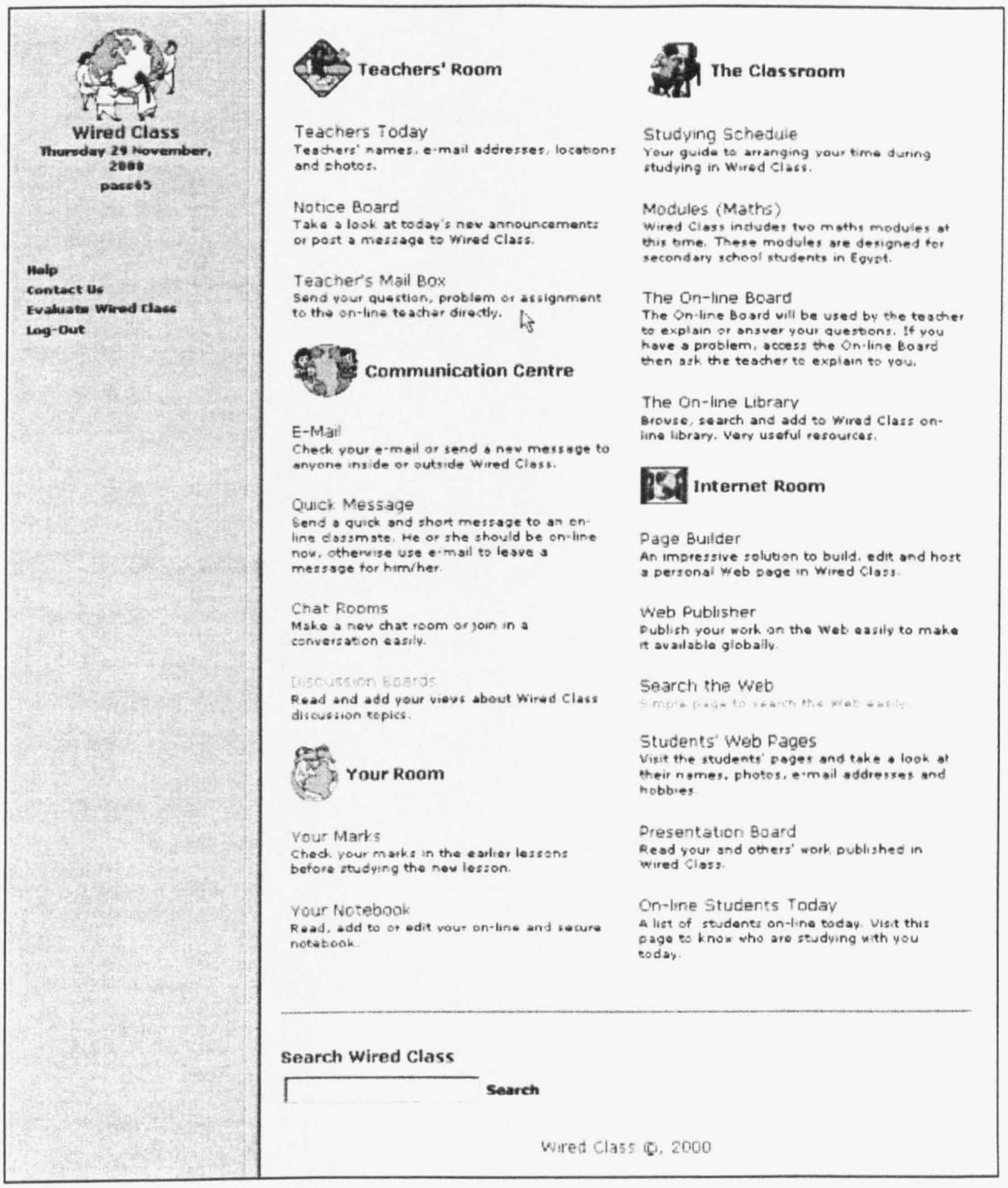
To log-in to Wired Class, the student needs to enter his/her username and password, or register as a new student if he/she has not registered yet, then submit the form to access the starting page above, which contains the main components. New students are encouraged to click on the 'Help' link to have a tour around Wired Class, showing the components of Wired Class, their functions and how to use each of them.

In addition, it is essential for each student to build a page using Page Builder. Having a page for each student is very necessary to introduce students to each other and facilitate interaction among them. Then, the learner needs to access the 'Teacher's Room' to find who is the on-line teacher or to read the class notice board. After that, the learner may need to know whether other students are on-line at the same time or not. This step is necessary for the learning process, to encourage the learner to communicate and co-operate with others while studying. Lastly, the learner can check his/her grades in the previous lesson, if applicable. This feature may encourage and motivate students to maintain and enhance their performance in future lessons.

The above procedures are pre-requirements for accessing the 'Studying Room', in which the modules and other instructional tools are available. At this point, it is recommended for learners to access lessons via the course schedule for two reasons:

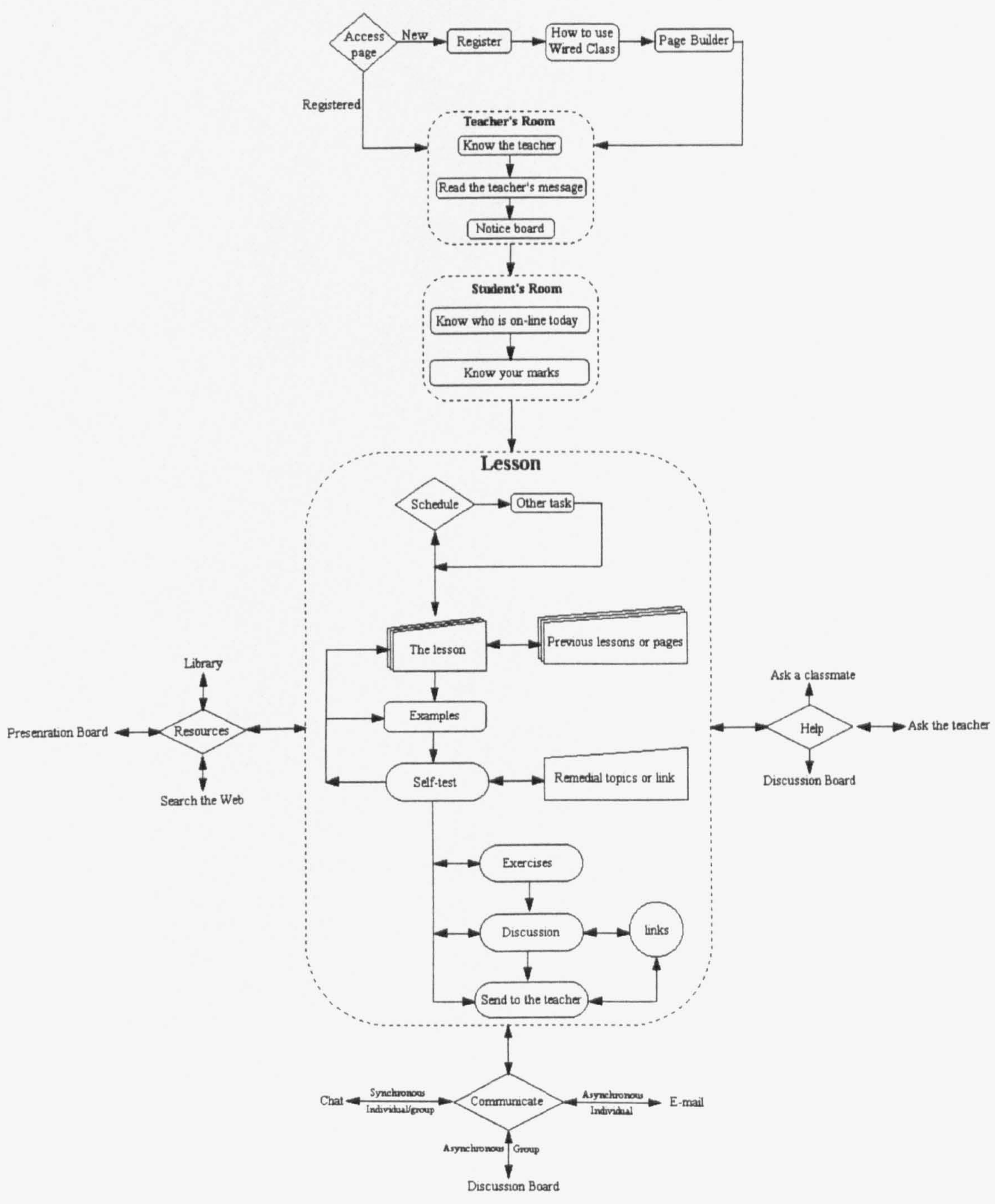
1. To help the learner to manage his/her learning time.
2. To inform the learner of the weekly instructor-generated activities.

Figure 5-21: Organising components of Wired Class



The lesson page is the ultimate destination for the learner each time he/she accesses Wired Class. The first three sections (the lesson, further examples and self-test) may be studied in sequence. However, the other four sections (exercises, links, discussion and send to the teacher) can be accessed and studied in any order. For example, the learner can jump to the discussion board to read and post his/her point of view regarding the discussion topic then complete the 'Send to the teacher' task and lastly answer the 'Exercise' task, or he/she can practise some exercises first, then respond to the discussion board and complete the 'Send to the teacher' task. The learner is supported by many tools that enable him/her to interact and co-operate with classmates, ask for help or to get lesson-related information. For example, to enable students to interact with other peers, Wired Class provides various types of individual/group or asynchronous/synchronous interaction tools such as e-mail discussion boards and chat (Figure 5-22).

Figure 5-22: Using Wired Class



5.4. Implementation of Wired Class

At the end of the design and development phase, there is a need to implement the designed programme under real, or simulated, conditions. The purpose of this implementation is to supply information on how the programme functions in the reality for which it has been designed and to gather information about students' performance and satisfaction with the programme. The implementation at this stage is known as field-testing (Romiszowski, 1986). Although the purpose of the field-testing is to test the effectiveness of the programme rather than diagnose its deficiency, information about the students' behaviour, reactions and performance was collected during learning sessions as a part of the evaluation methodology, as mentioned in the previous chapter.

This section discusses the practical procedures taken to implement wired Class and collect summative data. The strategy of data collection focused on the students' academic achievement during and at the end of the learning sessions, their perceptions and their on-line behaviour in the learning environment. Web technology allowed the present study to investigate students' behaviour and the learning process in different ways, using quantitative and qualitative methods:

1. Students' responses to formative evaluation tasks at the end of each lesson;
2. The extent to which students participated in the learning activities;
3. The study time spent by students;
4. The extent and the nature of dealing with the various components of Wired Class;
5. Students' scores in the final achievement test; and
6. Students' perception of Wired Class as measured by the perception questionnaire.

5.4.1. Preparing and scheduling for implementation

To implement Wired Class, many practical procedures were undertaken. First, the researcher obtained a formal list, from the Egyptian Education and Culture Bureau in London, of language secondary schools in Cairo which have Internet access, the districts in which they are located and their postal and e-mail addresses. The list showed that all the fifteen districts in Cairo have schools that have Internet access. However, only twenty-seven schools distributed among the fifteen districts fulfilled the requirements of the research experiment (e.g., sufficient number of computers and computer labs). Only eight schools, distributed among seven districts, were selected randomly to be the sample of the study.

Second, the Egyptian Education and Culture Bureau in London sent a letter to the Ministry of Education in Cairo asking for a permission for the researcher to carry out his study for teaching first-year secondary school students at a distance via the Internet. A list of schools, the purpose and period of study, the research instruments, the facilities needed and the number of students who would participate in the study and other related information was sent in advance to obtain permission.

The researcher received a letter from the local education authority in Cairo giving formal authorisation to carry out the study and another letter from the Security Office at the Ministry of Education in Cairo, presenting his image and other personal information, to enable him to access to the intended schools (6 days a week from the first of February to the end of March 2000). However, the letter of authorisation did not make it mandatory to participate in the study; it allowed the headmasters and teachers to agree or refuse to participate in the study.

Third, after the researcher met the headmasters of the eight schools and explained the purpose and the requirements of the study, only five schools agreed to participate in the study. The headmasters who refused to take up the study argued that the Internet labs at their schools would be busy during the period of study, there was no guarantee that the study would lead to an acceptable level of achievement for the treatment group or the experiment might disturb the school system. Moreover, two of the schools that initially agreed to participate were eliminated from the study after the researcher faced regular access problems at the beginning and during the study. These access problem were due to the lack of co-operation between headmasters and teachers at those schools.

Since only three schools participated in the study, the drawback at this stage was the reduction in the number of the treatment group and the limited geographical distribution of students (Table 5-6). However, the researcher found that these three schools were scattered around Cairo City and represented different economic, social and educational backgrounds. The principal advantage gained at the end of this stage was that the researcher was certain that these three schools were very enthusiastic to provide all the facilities and co-operation needed to carry out the study.

Following the selection of the schools, meetings were held with technicians and maths teachers at these school. The researcher provided a presentation about Wired Class, the purpose for which it was designed, the technical requirements, accessing Wired Class, including registration procedures and dealing with its components and how the classes could be organised to use it. The researcher emphasised the importance of co-operation between the technicians and maths teachers for the success of the study. At the same time, intensive discussions were conducted between the researcher and technicians and maths teachers about the current level and experience of students in dealing with Internet and the WWW. The technicians showed that the students at these schools were quite capable of using the Web and learning with Wired Class.

Table 5-6: The distribution of the treatment group subject

School	Boys	Girls	Total
1. El-Maadi Experimental Language School	7	3	10
2. El-Hadayek Experimental Language School	17	1	18
3. Hafez Ibrahiem Experimental Language School	7	3	10
Total	31	7	38

Following the meetings with technicians and teachers, meetings were held with students who were randomly assigned to work as a treatment group, as shown in the next chapter. Students had shown high interest and good experience in using the Web. Surveying the students (38) revealed that a significant number of students (65.6%) had good Internet experience and many of them had Web-based e-mail accounts and used the Web to search for course-related information. However, a few students indicated that they did not have sufficient practical background or they had never used the Internet before (34.4%). These students were taken into account during the implementation of Wired Class and special orientation sessions were held by Internet technicians and the researcher to help them access and use the Web.

Using OHP and LCD panels, which were found in the three schools, group tutorials about Wired Class were presented to explain basic ideas and information about:

1. How to access the Web;
2. Using Web browsers;
3. The Web as a global library and tool of interaction;
4. Prerequisites for access to Wired Class, including signing-up for a username and password, signing-up for an e-mail account and building a page using Page Builder.

Furthermore, brief handouts containing the main graphical user interfaces of Wired Class with explanations of their contents and links were given out to students to be revised at home before using Wired Class. At the end of the presentation, the researcher encouraged students to try to register with Wired Class and explore its components themselves. Arrangements were made at the computer and Internet labs at these schools to avoid technical or discipline problems in the future. For example, recent copies of Web browsers (MS Internet Explorer 5 and Netscape Communicator 4.5) were installed, the resolutions of screens were optimised and computers were re-arranged in a suitable way in the labs.

In addition, a notice board was fixed outside each lab, displaying the times at which the Internet would be used by Wired Class students, hardcopy of Wired Class user interfaces, current Egyptian and World news from the Internet and Web addresses related to maths and other subjects (e.g., science and geography) to encourage students and inform them about the advantages of the Internet. The researcher and a maths teacher (*) at El-Hadayek Experimental Language School exchanged roles as on-line tutors. The researcher found that the co-operating teacher was very enthusiastic to participate in the study, had good experience in using the Internet and developed some maths materials to be used via the Web by his students. In addition, in 1995 he had been seconded by the Ministry of Education to study training courses in instructional technology at the University of East Anglia in the UK for six months.

Moreover, the Web and on-site facilitators' roles were entrusted to two enthusiastic technicians at Hafez Ibrahiem Experimental Language School (**) as well as the computer technician at each school. The researcher found that the technicians had a good technical and

(*) Mr. Ragab Gaber, a maths teacher, B.Sc. in maths education.
(**) Mr. Sayed El-Saeed and Mr. Afifi El-Sherief

instructional background and facilities to manage students via the Internet and at schools as well. The two facilitators were asked to answer students' technical questions and ensure that students attended Wired Class according to the timetable. However, they were told that they would not be responsible for leading or driving the learning process.

As shown above, the number of students used as a treatment group varied from one school to another. For example, while eighteen students were used in the second school, El-Hadayek Experimental Language School, only ten students were used in the first and third schools. The researcher found that the second school had a large number of students with good Internet facilities including four Internet labs (three from the government and one given by the Coca-Cola Company). Two of them contained PCs with high specification software, hardware and Internet connection. Therefore, a decision was made to exploit the capabilities of this school, particularly with the high interest shown by the headmaster and teachers at this school. However, each of the other two schools contained only two Internet labs.

Studying with Wired Class was organised in co-ordination between mathematics teachers and Internet technicians. Headmasters and teachers were informed from the beginning that no changes would be made in the studying schedule; the treatment group would be studying in the Internet lab at the same time as the normal mathematics classes. Furthermore, they were assured that students would be under the supervision of the researcher who was originally a mathematics teacher and assistant lecturer at the University of South Valley. A list of the names of students in the treatment group was prepared at each school and copies were given to both the mathematics teacher and the technician, to ensure that all, and only, treatment group students would attend Wired Class.

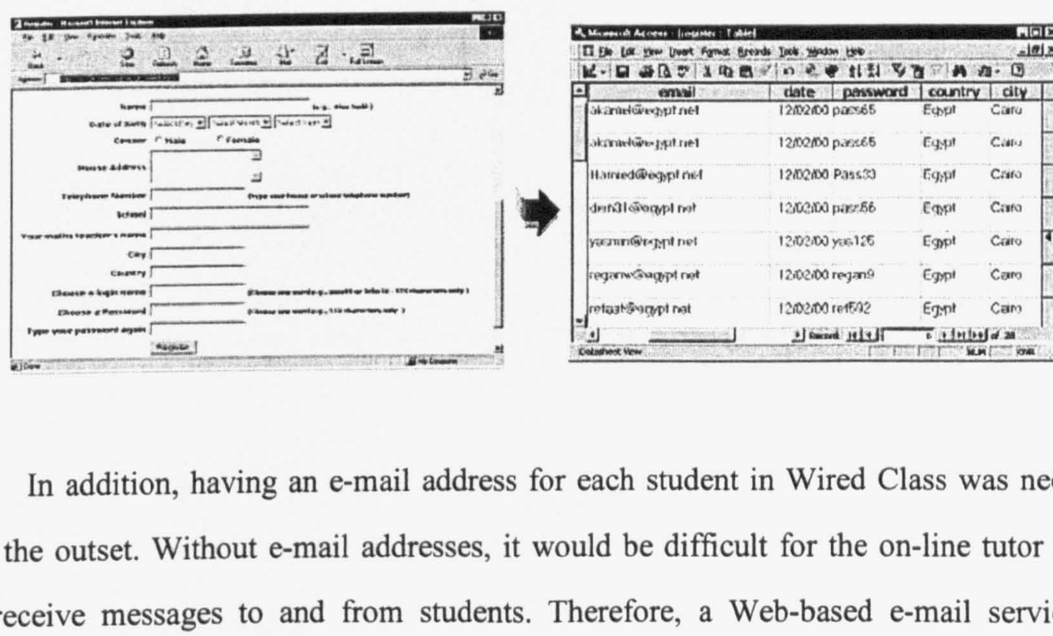
5.4.2. Class management

Paying attention to management tasks was essential to run Wired Class successfully, particularly with the lack of face-to-face interaction and isolation of students from the on-line teacher. Tasks included in Wired Class management are student enrolment, signing-up for e-mail accounts, building Web pages, time-tabling and scheduling and introducing students to one another.

Enrolment was a pre-requisite for students to begin studying with Wired Class. According to its design, every student had to fill-in and submit an on-line form including information about his/her name, date of birth, school, mathematics teacher's name, etc. Using the registration form, every student had to choose a log-in username and password to be used every time the student accessed Wired Class. A link to the registration form was made available in the starting page, allowing students to access the form easily.

All students' enrolment information were handled and recorded using server-side CGI scripts and a MS Access 97 database allowed the on-line tutor to monitor the registration records easily and help students who had access problems or forgot their passwords, as shown below (Figure 5-23). At the end of the registration procedures, students were asked to access the help pages and explore the different parts and elements of the learning environment and how to use it.

Figure 5-23: Capturing and recording students' information in a server-side database



In addition, having an e-mail address for each student in Wired Class was necessary from the outset. Without e-mail addresses, it would be difficult for the on-line tutor to post and receive messages to and from students. Therefore, a Web-based e-mail service was provided to students from within Wired Class, to enable them to sign-up for e-mail accounts. Every student was asked to access the e-mail page and sign-up for an e-mail account. Students were asked to use the same username and password as they used to access Wired Class. It was pointed out that students should ask for help from the local technician at the school if they faced any problem while signing-up.

The researcher ensured that every student in Wired Class had an e-mail address and every student was encouraged to send a confirmation message to the on-line tutor telling him he/she had accessed and used e-mail successfully. The e-mail address of Wired Class student took the form username@egypt.net.

In addition, building a Web page for every student, containing personal and contact information as well as a personal photo, was an essential task in the management process. Page Builder, as mentioned in the section on designing the components of the learning environment, offered an easy solution to students to establish good-looking Web pages without the need to learn HTML and uploading skills. These pages would help students to know each other and the tutor to remember students' faces and names, which is critical in distance education.

In addition, links offered in students' Web pages might provide a good opportunity to begin conversation and exchange ideas amongst themselves. Moreover, since every student who accessed Wired Class had his/her name added to the 'on-line students' page with a link to his/her personal page, if students had not built their pages yet, their names were provided to the class with broken links, so others could not access their pages and recognise them. Therefore, the on-line tutor, using e-mail, as well as on-site facilitators, encouraged and helped students to scan their personal images and build a page using Page Builder as early as possible.

In the early days of implementation, students were asked to visit each other's Wired Class pages and provide their feedback and comments to their peers. The objective of this activity was to introduce students to one another, encourage them to interact informally and reduce the distance among them. Furthermore, they were encouraged to communicate with each other via e-mail, particularly with peers at other schools and exchange ideas and views about studying in Wired Class.

Lastly, although the Web offers a flexible medium for students to access learning anytime/anyplace, time-tabling and scheduling were necessary tasks to ensure that all students knew when and how the course would start and finish. The need for a timetable was highlighted since the implementation was restricted by the school setting and for every maths lesson the treatment group had to move to the Internet lab to join Wired Class. Therefore, a schedule was prepared and presented within Wired Class to help students to monitor and assess their progress. The schedule assumed that students would be able to study two lessons a week and that they would complete studying the two modules in eight weeks.

5.4.3. Learning activities

Learning activities were suggested by the on-line teacher, and students in many settings, on a topic basis. These activities were designed to focus on the course objectives that were being covered during every week according to the studying schedule, based on a constructivist approach, as mentioned above. In these activities, students explored, created and applied knowledge in a social setting. Many considerations were taken into account in designing and using these activities. For example:

1. The activities should take advantage of the unique capabilities of the Web in general, and the attributes of Wired Class, in particular.
2. Activities were suggested during learning and according to students' needs and skills.
3. The sense of exploration and discovery was built into activities.
4. Activities were developed to go beyond using the Internet only as a source of information. Web-based asynchronous and synchronous communication methods and tools were taken into account as well.

These activities included accessing related topics on the Web, sharing, using e-mail to post information, introducing problems to multi-user chat rooms, linking resources to personal pages and updating the library catalogue, searching on the Web for solutions of course-related problems and participation in discussion groups. During each week of the eight weeks, a new topic was introduced and examined using different methods. By carrying out these activities, students not only gained experience in using the Web, but also they created a body of knowledge and resources that could be used in other tasks.

First, in the second week, for example, students were encouraged to examine the topic of 'direct variation' and asked to join the discussion board to discuss whether a problem presented a case of direct variation or not. Students responded and provided similar answers and most of them were correct. For example,

1. 'The graph does not represent a direct variation because it is not a line'

2. 'Because the function is not in the form $y = a\,x$'.

3. 'If we plot the table we will not get a line'

However, many students did not participate in this discussion and only read others' messages. Those students were encouraged by the tutor to visit two instructional Web sites related to the discussion topic. The tutor encouraged them by commenting: 'Good question and excellent answer about direct variation are available in this Web site' and 'If you visit this Web site you will find how to determine if a function is a direct variation by working with the table of values!'.

A very few of students discovered additional useful Web sites starting from the two suggested sites and forwarded them to their classmates and the teacher. However, others jumped to the 'Search the Web' page to make a Web search themselves. The on-line tutor participated in the discussion, made his own contributions, sent feedback to students individually, monitored the board and encouraged lurkers (students who do not like to participate in group discussions).

Second, throughout Wired Class, students were encouraged to visit specific Web sites related to the lesson topic in which they were involved. This type of activity was accomplished by establishing what is known as a 'topic hot list'. The topic hot list was used as a collection of sites that were found to be most relevant, useful, interesting and essential to understanding the given topics. The topic hot list was found to be an easy strategy to exploit Web resources for an activity or lesson tasks.

In Wired Class, topic hot lists were simply called 'links'. These links were selected carefully, taking into account technical and pedagogical standards, to target specific learning objectives, rather than merely sending students to Web sites hoping they would find something useful there. Links were made available to a variety of media formats (e.g., full-text syllabus, searchable databases, hypermedia resources and Java-based tools). Learners used links to investigate new or difficult aspects of the current topic, answer 'Send to the Teacher' tasks, copy and paste to their notebooks, discussion boards or e-mail.

A small number of links was gathered for each lesson according to its objectives. For example, in module 1, lesson 3 (definition and graphing functions), students were asked to visit Marco Janssen's (*) Web page and take a look at the tables that represented his records then graph one of them. Students were asked to obtain his recent records then update the table provided for them in this lesson. At the end, students were exposed to a discussion about whether or not a new pairing of numbers resulting from interchanging the two columns of 'Marco Janssen's' table of records represented a function.

Third, Web publishing was another interesting activity, which could be a strong motivator for students. Wired Class offered students the opportunity to share their work with their classmates. Using 'Web Publisher', the 'Presentation Board' and 'search engines', students were encouraged to publish a short presentation about the current topic. Small groups of students were asked during the eight weeks to investigate a specific problem or find the solution to a problem, then publish it to the presentation board.

5.4.4. Tutors' and site facilitators' roles

Once implementation of Wired Class was begun, the on-line teacher and facilitators played important roles to support students over a distance. The principal role of the teacher was facilitating two types of interaction: learner-learner interaction and learner-content interaction, as mentioned in Chapter 2. However, the principal role of the site facilitator was to undertake other non-educational tasks needed to make Wired Class run smoothly (e.g., registration, students' technical and scheduling problems, etc.). The roles of both the on-line teacher and facilitator were exchangeable and could be categorised into two main functions: monitoring and support. Monitoring could be done depending on many techniques. Support varied between instructional support and organisational and technical support.

Since attendance at on-line classes was essential to complete the course, the initial role of the teacher and facilitators was to track student attendance. Unlike the traditional method, paper-based rolls, in Wired Class, tracking a student's attendance rate was a very easy job. As shown above, as soon as any student accessed Wired Class, his/her name was added to the 'logged-in' page, allowing the tutor, and students as well, to know who was on-line that day.

However, monitoring students' attendance was not enough, particularly with young learners. Attending Wired Class according to the schedule and spending minutes or hours

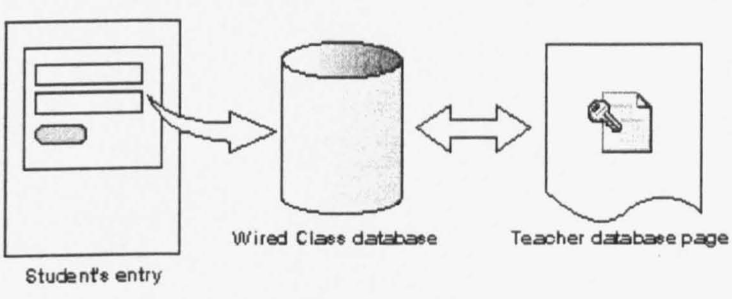
(*) Marco Janssen is a mathematician and long-distance runner.

does not mean students would work through the course materials and use other instructional elements (e.g., discussion boards and e-mail). To know whether students were actually doing the work or not, students were monitored using two methods: student tracking and student's records.

Using the tracking script, the tutor, or the facilitator, could detect every student's movement in Wired Class, from when he/she logged-in until he/she logged-out. The facilitator could know whether the student had accessed important components (e.g., the Notice Board and Modules), how long he/she spent in each component, to which component he/she moved and whether he/she responded to tutor's suggestions or not.

Students' records (e.g., self-tests, send to the teacher tasks, discussions, etc.) were made available everywhere in Wired Class. The majority of Wired Class components are interactive or two-way components. In every lesson, for example, students could participate in a discussion and answer some questions, then submit the work to the teacher. These records were stored in the Wired Class Web server and made accessible by the teacher as shown below (Figure 5-24).

Figure 5-24: Access students' records by the tutor



In a distance education context students have their own problems that differ from others in a traditional classroom, as mentioned in Chapter 2. Usually, these problems are attributed to the limitations of the distance education medium, whether written or one-way medium. Some of these problems may occur in Web-based distance education programmes. Examples of these problems in Wired Class would be:

1. the lack of student-tutor and student-peers interaction;
2. unfamiliarity with self-study planning and scheduling;

3. unfamiliarity with Web-based learning approaches;
4. the lack of suitable and sufficient learning resources; and
5. connection and access-related technical problems.

Therefore, well-planned human support and Web-based two-way interaction could overcome many of these limitations and problems that may face students over a distance. Simpson (2000) suggested two types of support that can be delivered to students over a distance: academic support and non-academic support. The first type is related to the tutorial activities, while the second one concerns counselling or organisational activities. In Wired Class, the first form of support is called instructional support and the second form called organisational and technical support. The first form was carried out by the on-line tutor, while the second one was provided by the facilitators. The importance of the separation between these two roles was to help the on-line teacher to focus on his educational duties rather than doing other tasks, which could be done by others who did not have experience in teaching the subject. The instructional roles of Wired Class teacher were to:

1. explain and answer students' questions;
2. develop and suggest learning activities;
3. maintain course materials and develop new materials as appropriate; and
4. assess students' progress and provide feedback.

Since it was supposed that students would use the course material individually, without the help of the tutor, learner-content interaction and support methods were emphasised. However, there was a role for the teacher to be in action to receive students' questions or problems then answer or provide alternative explanations as needed. This role might be one of the principal reasons that made students distinguish between the Web and computer-based instruction and feel that there was someone who could help them if they could not understand a difficult concept or answer a question. This role was not limited to answering students' questions, but it was extended to advising students to follow a specific path or to explore or experience other materials available in another place.

In addition, developing and suggesting learning activities was an important role of the on-line tutor. Learning activities, as mentioned above, varied between student-centred activities (e.g., participating in discussion boards, updating Web pages by new course-related links and conducting Web search) to activities that depended much more on the teacher (e.g., suggesting discussing topics and updating the hot topics list to be useful to the current lesson).

Also, monitoring and updating Wired Class materials was a continuous process and not limited by the design and development phase. Students' reactions, feedback and progress were the essential stimulus to maintain or update the course materials. Since the teacher was the person in contact with students, he was responsible to collect students' reactions and comments related to the construction and content of materials, allowing any revision to be done.

Lastly, formative evaluation was carried out throughout Wired Class. One of the essential roles of the teacher was gathering information about students' progress, as reflected in the formative evaluation, in order to make appropriate choices and provide feedback. Although each lesson was provided with its self-assessment questions and feedback, the teacher's role was clarifying every student's answer individually, to give a grade for every student then provide the appropriate feedback.

On the other hand, the organisational and technical roles of the Wired Class teacher were to:

1. update students' records;
2. motivate students; and
3. ensure the smooth running of the Web site

Updating students' records could be managed by the facilitator, since it is an administrative operation rather than instructional. Updating students' records involved accessing the Wired Class Web server, gathering students' marks as given by the teacher, then using the 'edit students' marks' script to inform students about their marks in each lesson. Updating students' records included collecting students' marks in and updating students' total grades, to know whether they had passed the current module or not. In addition, the facilitators were responsible for updating the Wired Class database with the names of students who dropped out of Wired Class or did not attend an acceptable number of on-line sessions.

In addition, since feelings of isolation may lead on-line students to drop out of Wired Class or not participated positively, one of the important roles of the facilitator was encouraging students to continue studying. In Wired Class, one solution was visiting students at schools and encouraging them to continue study in depth. In addition, awards were provided to students who obtained high marks in the final test and who participated positively in Wired Class activities.

Lastly, the Web, like any other medium, requires maintenance. In Wired Class the facilitators were responsible for maintaining the software and hardware used by Wired Class. Wired Class Web Server (MS PWS) was accessed remotely using Graphical User Interface (GUS) allowing the facilitator to monitor the performance and the logs file of the server. In addition, a server-side facilitator who was responsible for maintaining the Web server machine, at the University of Hull, was in touch with the facilitator at the other side. The role of the server-side facilitator was essential, since some technical problems were impossible to be tackled remotely (e.g., if the PC server switched off or crashed).

Conclusion

Many established learning platforms (e.g., WebCT, Blackboard and TopClass) and instructional authoring tools (e.g., ToolBook Instructor II and Authorware) have failed to provide an integrated package to design and develop a Web-based learning environment containing rich and interactive on-line course materials that work successfully in conjunction with other interaction and management components of the learning environment. This chapter, therefore, attempted to shed light on the theoretical and practical procedures of designing, developing and implementation of a Web-based learning environment for teaching students at a distance.

The design and development plan was based on Willis' R2D2 constructivist model for designing instruction, in which the needs of learners are defined and the purposes of the programme are investigated to see whether they are met or not. In designing for the Web it was found that Web-based learning environments require the design and integration of various tutorial (e.g., modules and tests), management (e.g., schedule and grade distribution), interaction (e.g., e-mail and discussion boards) and support (e.g., on-line library and help topics) components that work together to enhance students' performance and interactivity of learning. In designing learning activities it was assumed that students need to pass through various cognitive activities and participate in self-based and collaborative instructional tasks (e.g., self-tests and discussion boards) to construct their learning.

Developmental testing was carried out during the design and development phase to improve the design and enhance learning. Information obtained from students would help in detecting what works and what does not, and why. However, results obtained from experts gave a more comprehensive, detailed and more objective view of the design. Based on criteria and conditions of user-interface design, technical design, instructional design and navigation, experts and students provided much useful feedback which led to improvements in the design of the content and structure of the learning environment.

The design of this learning environment re-defined the traditional relationship between the tutor and students and the roles of the tutor and site facilitator. The on-line tutor could help students by explaining difficult concepts using examples or suggesting external links, encourage students to communicate, participate, meet each other on-line and submit course-related work. In addition, the site facilitator could help in the evaluation, purchase, installation and support of software and hardware as well as implementing and maintaining successful uses of technology.

Chapter 6: Methodology of Evaluation: Design and Measurement

6.1. Introduction

The purpose of this study was to design, develop and evaluate the quality and the effectiveness of a Web-based learning environment for teaching secondary school students at a distance. Since learners' perceptions and satisfaction as well as learning outcomes would be good indicators to evaluate the effectiveness of the Web and the quality of instruction (Clark, 1994 a; Bates, 1995), this study focused on investigating learners' reactions and academic success while engaged in a real Web-based distance education programme.

Furthermore, as the views of distance education experts (including on-line tutors, Web designers and developers) are important bases to point out the strengths and weaknesses of the Web-based learning environment, particularly when students are not able to provide objective feedback, tutors' and experts' views are considered as additional major indicators of the quality and effectiveness of the Web-based learning environment.

Information obtained from students could help in exploring what does work and what does not, under what conditions and with which students. However, results obtained from experts give a more comprehensive and detailed view, particularly when compared to students' perceptions and success (Leide, 1997; Inglis et al., 1999). Research questions were stated dealing with learning outcomes and students' and experts' perceptions of Wired Class. Quantitative and qualitative research methods were implemented to identify benefits and cost factors. Quantitative data were obtained using achievement tests and perception questionnaires. However, qualitative data were obtained through students' portfolios in Wired Class (e.g., length of time spent in study and interaction via discussion boards). The evaluation methodology was implemented to show, analyse and describe the effectiveness of Wired Class based on Bates' ACTIONS model (1995), as follows.

1. Access: Does Wired Class facilitate student access to new and high quality teaching and learning resources, particularly when compared with other choices?

2. Costs: What is the cost structure of Wired Class in terms of fixed costs, variable costs, recurrent costs, capital costs, unit costs and marginal cost?
3. Teaching and learning functions: How efficient are course objectives and content, course materials and resources, presentational features, teaching/learning approach, learning outcomes and time demands?
4. Interactivity and user-friendliness: How do students interact with the tutor, the content and themselves? How friendly is the learning environment in terms of ease of use, delivery methods, programming, user-interfaces, technical design, navigation and structure?
5. Organisational issues: How well is the learning environment is organised? What are the factors that influence students' perceptions and achievements?
6. Novelty: How new is this learning environment?
7. Speed: How quickly can the learning environment and learning materials be developed and updated?

Recently, Zlomislic and Bates applied the same model to assess the telelearning systems at the University of British Columbia (1999) and the Ontario Institute for Studies in Education of the University of Toronto (2000). These studies are two of six case studies in the NCE-Telelearning project entitled Developing and Applying a Cost-Benefit Model for Assessing Telelearning.

6.2. Basic assumptions

For the purposes of this study, it was assumed that:

1. The Web can be used as a medium to deliver distance education materials.
2. Distance education media affects the nature and the format of the distance education programme.
3. Distance education media are able to influence students' achievement.
4. On-line modules covered the same course topics as taught in the traditional classroom.
5. Students enrolled in Wired Class were able to use the Internet and the Word Wide Web.
6. Students and distance education experts who participated in this study answered the questions in the achievement test and questionnaires with care and honestly.

6.3. Research questions

Considering the purpose of the present research and Bates' ACTIONS model, this study attempts to answer many research questions. These questions are categorised in terms of access, costs, teaching and learning, interactivity and user-friendliness and organisational issues. Other questions related to speed and novelty of the system are addressed under these sections.

6.3.1. Access

Access is the initial factor mentioned in Bates' model; it is concerned with whether the technology and materials were accessible by students at a distance or not. Based on the ACTIONS model, three major factors influence access to Web-based instruction: demographics, standardisation and accessibility. Demographics refers to the availability of computers and Internet connection needed to access the Internet. Standardisation refers to the compatibility of Wired Class with students' hardware and software. Accessibility refers to the ease of access to learning materials and resources.

Since the purpose of this study was to design a Web-based learning environment for teaching students at a distance and evaluate its effectiveness, collecting demographic information about the availability of computers and Internet connection was beyond the scope of this study. Students were asked to respond to statements related to the compatibility of Wired Class with their computers, the ease of access to learning resources, and interaction, both with the on-line tutor and interaction with peers. Therefore, the present research attempts to answer the following main and subsidiary questions:

Q1.1: How compatible was Wired Class with students' hardware and software?

Q1.2: How accessible were learning materials?

Q1.3: Did Wired Class help students to access the resources they needed?

Q1.4. Did Wired Class facilitate student-student and student-tutor interaction?

Q1.5. How quickly can students access course materials and receive feedback from the tutor?

6.3.2. Costs

The cost structure of the medium is the second important criterion to evaluate distance education technology. Calculation of the costs of Wired Class is mainly based on the analysis of the costs of educational technology as mentioned in Section 2.11. This analysis is described in terms of production and support costs and student-related costs. The first type includes the costs of design, development and delivery of Wired Class, as well as the costs of tutoring and supporting students at a distance. These costs are quantified into fixed and variable costs, capital and recurrent costs, total cost and unit cost. The second type of cost is student-related costs (costs of access) including the costs of a computer. The questions asked were:

Q2.1. What is the cost structure of Wired Class?

Q2.2. How much does Wired Class cost in terms of fixed, variable and unit costs?

Q2.3. What are the factors affecting these costs?

3. Teaching and learning functions

Since Wired Class students were not expected to be able to evaluate many teaching and learning features of Wired Class, as mentioned in the discussion of the design of the students' questionnaire later, they served two different roles: students as participants and students as evaluators. When they served as participants, data related to the quantity and the quantity of learning outcomes was collected to evaluate the learning outcomes using achievement test results, logs and portfolios. However, evaluating other instructional features is based only on the judgement of experts. This section seeks to answer the following question:

Q3.1. To what extent does Wired Class meet the requirements of teaching and learning in terms of:

Q3.1.1. Course objectives and content;

Q3.1.2. Course materials and resources;

Q3.1.3. Teaching/learning approach; and

Q3.1.4. Learning outcomes?

4. Interactivity and user-friendliness

First, interaction was achieved through asynchronous as well as synchronous methods using e-mail, discussion boards, presentation board, personal home pages and chat rooms. However, discussion boards were the most formal and interactive place at which formal and directed course-related discussions were held regularly, as mentioned in Chapter 9 (interactivity and user-friendliness). This part attempts to answer the main research question:

Q4.1. How do students interact via discussion boards?

To answer this question, both the quantity and the quality of messages were investigated. Quantitative analysis was used to calculate the number of messages and investigate by whom they were sent, time of logons and lengths of messages. To investigate the quantity of messages sent by students and other related variables, the following subsidiary questions needed to be answered:

Q4.1.1. What is the average number of messages sent by students to discussion boards?

Q4.1.2. What is the average number of messages sent on every single discussion topic?

Q4.1.3. What is the average number of statements in messages posted by students?

Q4.1.4. At what times did students access discussion boards during studying?

Q4.1.5. Is there a difference in the level of participation between earlier and later lessons?

Q4.1.6. Is there a relationship between students' quantity of responses and tutor's level of participation in discussions?

In addition, the qualitative approach was used to analyse the discussion content according to educational criteria then draw conclusions about the educational value of this activity, as shown below (Section 6.6.3). After developing the coding system, messages were printed out and messages were analysed to answer the following qualitative questions:

Q4.2. How do students respond to discussion questions?

Q4.3. Do students meet the requirements for discussions?

Q4.4. Is there a relationship between the structure of discussion questions and patterns of responses?

Second, since the early development in computer-based multimedia applications in the early 1990s, the term 'user-friendly' has become an important concept in designing, evaluating and selecting between instructional programs. Corry et al. (1997) noted that 'computer systems designers and developers have begun to use the term user friendly to label products they believe are easy for the lay public to use' (p. 65). Smith and Dillon (1999) argued that evaluation of the user-friendliness of a Web-based course should address many issues such as the:

- Appropriateness and consistency of user interface design;
- Branching and support strategies;
- Ease of use; and
- Navigability of the site.

Accordingly, the study attempts to answer the following research question:

Q4.5. Is the Web site user-friendly in terms of user-interfaces, ease of use, programming and navigation?

5. Organisational issues

In his ACTIONS model, Bates (1995) argued that there are no significant differences between the organisational requirements for implementing different types of technologies (e.g., television, videoconferencing and computer). Often, there is a need for a team approach to design and develop learning and trained staff to run and maintain equipment, facilitate access to technology and resources and clear copyrights (Bates, 1995). However, in Web-based learning, many organisational issues would be highlighted. These include the security of the learning environment, tutors' and students' responsibilities, handling students' inputs, academic and technical support and lastly, the factors that are related to students' perceptions of on-line learning, on-line activity and academic achievement. Therefore, the present study seeks to answer the following research questions:

Q5.1. How secure is the site?

Q5.2. How are the responsibilities of the tutor and students established?

Q5.3. How is the learning environment structured?

Q5.4. How are students managed at a distance?

Q5.5. How long do students need to study the course materials?

Q5.6. What are the factors that affect students' perception and achievement in on-line learning?

6.4. Research design

Reviewing the evaluation literature has shown that evaluation of distance education technologies is carried out at two levels:

- Developmental testing; and
- Field-testing.

Developmental testing was carried out during the design and development phase to improve the programme, as mentioned in Chapter 5. However, field-testing was carried at the end of development phase and during the actual use of the programme to supply information on how the programme 'functions in reality' and prove or disprove its effectiveness, efficiency and suitability of design and materials in relation to the instructional objectives and methods employed (Romiszowski, 1986).

Research (Clark, 1994; Ertmer, 1994; Corry et al., 1997; Lockee et al., 1999) has addressed various types of information and methods to evaluate and improve instructional systems at the field testing phase (summative evaluation). Clark (1994), for example, offered a generic evaluation plan to assess distance education technology. This plan is mainly based on three levels: participants' reactions, achievement of programme objectives and evaluation of costs. He argued that participants' reactions would be revealed by inquiring into learners' feelings and impressions using questionnaires. However, achievement of programme objectives is measured by changes in learners' learning using, teacher-made or standardised tests. In addition, Dabbagh and Burton (1999) indicated that evaluation of Web-based instruction should be based on two criteria: students' ability to achieve the course objectives and the effectiveness of the course structure and organisation to support students towards that purpose.

Also, Jones et al. (1996) provided their CIAO! framework, which was revised later (Jones et al., 1998), in which they suggested a three-dimension framework to evaluate CAL programmes. This framework combines two phases: formative evaluation phase and a summative evaluation phase. The formative evaluation phase combines two dimensions: context and interactions, while the summative evaluation phase concerns learners' perceptions and outcomes (Table 6-1).

Table 6-1: The CIAO! Framework (adapted from Jones et al., 1998, p. 26)

Evaluation	Formative	Summative	
Dimension	- Context	- Interactions	- Perceptions and outcomes
Rationale	- The aims and the context of use	- Students' interactions with the software	- To assess learning outcomes and considering perceptions and attitudes
Data	- Designers' aims - Policy documents - Meeting records	- Records of student interactions - Products of students' work - Student diaries On-line logs	- Measures of learning Changes in students' attitudes and perceptions
Methods	- Interview designers - Analyse policy documents	- Observation - Diaries - Computer recording	- Interviews - Questionnaires - Achievement tests

Although Jones et al. suggested possible evaluation methods to be used in this framework, they indicated that the determination of the evaluation methods and the data needed depend on 'the rationale behind the programme' as determined by the designer. Each different rationale requires a different type of evaluation questions and techniques. Therefore, the evaluation questions that can be asked and the improvements in the programme that can be made essentially depend on the objectives of the programme.

Analysing students' interactions and reactions with the programme can provide valuable information on how and why the elements of the programme work. Therefore, since Wired Class was able to record students' work and activities (e.g., on-line logs, self-tests and interaction) critical data can be collected, and questions and problems highlighted and discussed, using students' logs, on-line questionnaires and external experts' critical comments during the development phase and actual use of the programme.

In addition, evaluating students' learning provides good indicators for changes in students' learning. According to Tuckman (1994) and Ross and Morrison (1996), the true-experiments post-test-only control group design is potentially the most useful and suitable design in the case of the present study. This design was used to implement the achievement test and diagrammed as shown below (Figure 6-1). Two groups of students are employed in this design: the experimental or treatment group receives a treatment (T1) and the control group receives the treatment (T2). In Wired Class, this design was accepted for many reasons:

1. The researcher was able to assign and manipulate experimental conditions at selected schools.
2. The researcher could be sure that students were randomly assigned in their classes without bias.
3. The researcher was able to randomly assign students and divide groups of students into control groups and treatment groups.
4. Principles and head teachers indicated that students had not studied this course before. Applying pre-tests at an earlier stage would not be tolerable or reasonable for students and class teachers, even for research purposes.
5. Head teachers at the selected schools argued that using a maths pre-test would negatively affect students' attitudes toward the experiment and the researcher.
6. Students would not be able to respond to questionnaire items without real experience in using and learning via the Web within Wired Class.

Figure 6-1: Post-test only control group design

R → T1 → **O**

R → T2 → **O**

Key: R = randomly assigned students

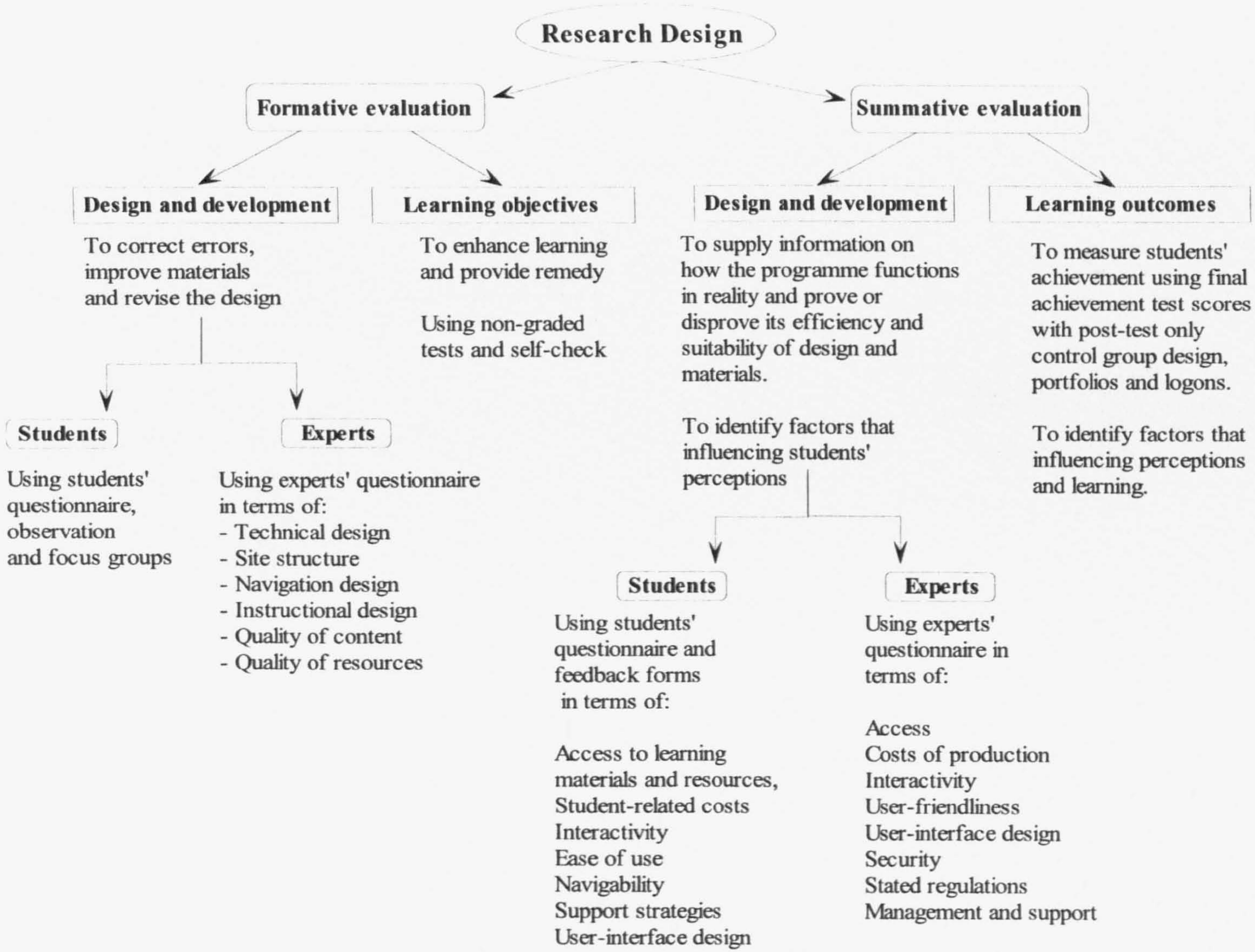
T1 = experimental treatment

T2 = control treatment

O = outcomes

In distance education settings, the most popular type of control group is the traditional class or lecture-format class in which the teacher serves as the source of information and delivery medium (Lockee et al. 1999). However, the treatment group is the group expected to learn via the Web with Wired Class.

Figure 6-2: Research design



In addition to measures of student outcomes, to achieve a more comprehensive evaluation and in-depth analysis of the effectiveness of the programme, there is a need to consult experts (subject-matter experts, instructional designers, on-line and distance educators, Web-based learning developers and administrators) to assess the success of the learning environment (e.g., Leide, 1977; Romiszowski, 1986; Thorpe, 1993; Inglis et al., 1999). Inglis et al. (1999), for example, argued that 'it may be considered important in a particular situation to call on a variety of experts' (p. 129).

These different kinds of expertise may provide useful feedback and various types of information which are difficult to obtain from student evaluation. Therefore, consulting experts was considered as a major element in the methodology of evaluation. This methodology looks at the evaluation process from two sides: evaluation of the programme itself and evaluation of the learning objectives. However, although the research design considers the field testing (or summative evaluation) of the programme as the ultimate purpose of the evaluation process, developmental testing (or formative evaluation) was considered as the preliminary stage of programme evaluation (Figure 6-2).

6.5. Selecting the sample of study

Since field-testing should begin by selecting a group of students who are ready and able to participate in the study, specifying the target population of the present study was an initial step in the design and evaluation of Wired Class. The practical considerations that affected the definition of the population are mentioned in detail in Chapter 5. The three public secondary schools selected, as shown in the earlier section, were considered as a sample of the population of study. Random selection of students at each school was made using alphabetical menus to control threats to external validity. By using random sampling, the researcher ensured that not only students with special interest in using the Internet or who had a high level of achievement or ambition were involved in the experiment.

Due to the practical circumstances of implementation (Chapter 5), only 38 students were selected to work as the treatment group. However, by the end of the study, 6 students were excluded from the treatment group results, either because they did not persevere in the experiment as was expected (2) or because they did not respond to both the evaluation questionnaire and the achievement test (4). Thus, only 32 students completed the study in the treatment group. An equivalent number (36) of students was selected from these schools to serve as a control group (Table 6-2).

Table 6-2: The sample group

School	Control Group	Treatment Group					
		Before study			After study		
		Boys	Girls	Total	Boys	Girls	Total
1. El-Maadi Experimental Language School	**8**	7	3	10	6	2	**8**
2. El-Hadayek Experimental Language School	**16**	17	1	18	15	1	**16**
3. Hafez Ibrahiem Experimental Language School	**12**	7	3	10	5	3	**8**
Total	36	31	7	38	26	6	32

6.6. Data collection: Instruments and techniques

In the earlier stages of developing Wired Class, formative evaluation (developmental testing) was carried out on a small scale to investigate the strengths and weaknesses of the programme, allowing it to be modified accordingly, as mentioned in chapter 5. At the final stage, summative evaluation (field-testing) was carried out to collect results for final evaluation, to evaluate the programme. Reviewing the literature has shown that participants' reactions and achievement are the most useful and common indicators of the effectiveness of distance education programmes. Many studies (e.g., Thorpe, 1988; Clark, 1994; Lockee et al. 1999) have pointed out that that to evaluate a distance education programme, different levels of evaluation should be used to collect data and give an exhaustive description of its effectiveness. Clark (1994), for example, indicated that two levels of evaluation that always give useful feedback are measures of:

- Participant reactions;
- The achievement of program objectives.

Although questionnaires, interviews and observations are often used to measure the quality and the effectiveness of programmes, questionnaires are most often used for reactions.

Clark (1994) suggested that is 'because they protect the anonymity of respondents and therefore, we presume, increase the candor of the responses' (p. 67).

Among the major advantages of questionnaires are that they can reach large numbers of participants from wide geographic areas at a minimum expense in time, money and effort. In addition, respondents may have enough time to reflect on their answers and check the intended case prior to responding (Mouly, 1970; Schofield, 1978; Clark, 1994). At the same time, many qualitative data can be gained using open-ended questionnaire items, analysing students' records and portfolios and monitoring student-tutor interaction. Also, observation of more than thirty students scattered over three locations would require a team of more than six observers to work daily in three different schools, which was not feasible. Moreover, the process of observation itself might affect the students' reaction to the programme. As the aim of the summative evaluation stage was to gain the perceptions and feedback of students at a distance without involving teachers in the evaluation process (without bias), a questionnaire would be the most accurate, attractive, functional, quick, accessible and economical instrument to use.

As a measure of achievement of programme objectives, achievement tests were used to measure participants' academic achievement. Brown (1983) stated that in comparing instructional approaches, the results of achievement tests, used in conjunction with other types of indicators such as students' reactions and cost effectiveness are crucial. Different teaching methods and curriculum options have very different effects on students' learning, which may be explored in evaluation. Students' achievement scores may help to answer questions such as: which of the curriculum and teaching methods choices in a given distance education programme had an impact on students' achievement? (Clark, 1994).

However, although questionnaires and achievement tests are used very frequently to collect information about the programme quality and the effectiveness, it can be argued that they are not enough to give a clear view of the results and to explore the relationship between variables involved in the programme. New technologies like the Web enable educators to collect new types of information in new ways, to analyse the different aspects of the medium. Savenye and Robinson (1996) highlighted the importance of artefact analysis, which may help to illuminate research questions.

Knupfer and McLellan (1996) call these artefacts 'portfolios' and they indicated that 'portfolios provide a descriptive measure of student work based on actual performance' (p.1209). Artefact analysis would provide the research with real facts rather than opinions about using and enjoying Web-based learning. In the case of Wired Class, many forms of artefacts, or portfolios, were available and easy to be located. Examples of these artefacts are the students' participation in discussion boards, send to the teacher tasks and presentation board and logging-in and logging-out records.

Collecting and analysing artefact data in conjunction with other instruments (e.g., questionnaires and achievement tests) would enhance the reliability of the evaluation instruments and provide valuable information for the research about the real behaviour of on-line students and how and why such behaviour occurred. Therefore, three types of instruments were used to collect the data in the present study: a questionnaire, an achievement test and participants' portfolios. Quantitative and qualitative methods were used to describe, explain and validate the results collected using the earlier techniques. Measures of central tendency, variation, percentage, correlation between variables and multiple regression were used to describe the data and present the results in meaningful ways.

6.6.1. Experts' questionnaire

An experts' questionnaire was developed to be used in the formative and summative evaluation phases, to elicit the views of distance educators, Web developers and subject matter teachers about the pedagogical and technical aspects of Wired Class.

6.6.1.1. The need and purpose of development

The review of the literature showed that for more comprehensive analysis and in-depth evaluation of the usability and effectiveness of the learning environment, there is a need to consult subject-matter expertise, instructional designers, on-line and distance educators, Web-based learning developers and administrators to assess the success of the learning environment (Leide, 1977; Romiszowski, 1986; Thorpe, 1993; Inglis et al., 1999). These different kinds of expertise may lead to various and valuable viewpoints and feedback. Inglis et al. (1999) suggested that:

'it may be considered important in a particular situation to call on a variety of experts. When this approach is used, the sponsor of the evaluation usually hands over the responsibility for selecting the criteria for evaluation to experts' (p. 129).

To evaluate the pedagogical design of a programme, for example, Romiszowski (1986) pointed out that:

'experts also inspect the materials and, in the light of their prior experience as teachers of the proposed target population, or as designers of similar materials, analyse the treatment in relation to strategies, techniques and tactics adopted by the author' (p. 405).

Nielsen (1995), also, pointed out that usually, conducting real evaluation with sufficient numbers of target users is difficult or expensive. He recommended that to test all aspects of the design, the use of inspections is the best way to 'save users'. Mack and Nielsen (1994) defined eight easy-to-apply evaluation methods that can be implemented by a single evaluator at a time in early developmental stages (formative evaluation) or in final stage after the Web site has been designed (summative evaluation). These methods are called:

1. Heuristic evaluation;
2. Heuristic estimation;
3. Cognitive walkthrough;
4. Pluralistic walkthrough;
5. Feature inspection;
6. Consistency inspection;
7. Standards inspection; and
8. Formal usability inspection (Mack and Nielsen, 1994).

Mack and Nielsen (1994) believe that the first three approaches (heuristic evaluation, heuristic estimation and cognitive walkthrough) are the most common, least costly, most flexible and reliable methods used in the evaluation process. Heuristic evaluation involves having usability experts judge whether each element follows established principles and criteria. In heuristic estimation evaluators are asked to estimate the usability and expected user performance in quantitative terms (Nielsen, 1992; Nielsen, 1994). However, cognitive walkthrough uses a more explicitly detailed procedure to simulate a learner's problem-solving process at each step through the dialogue with the program, checking if the simulated learner's goals and memory content can be assumed to lead to the next correct action (Wharton et al., 1994). Then, the aim of evaluators is to complete the learners' tasks and predict their paths.

In heuristic evaluation, evaluators go through the program several times and inspect its various interactive elements with reference to a list of design principles provided by the designer (Nielsen and Molich, 1990). However, in cognitive walkthrough evaluation, the designer creates a set of tasks and goals then asks evaluators to identify whether or not the design supports those tasks and how (Wharton et al., 1994). Cognitive walkthrough evaluation requires:

1. a general description of who learners will be and what relevant knowledge they possess;
2. a specific description of one or more representative tasks to be performed with the system; and
3. a list of the correct actions required to complete each of these tasks with the interface being evaluated (Rieman et al., 1995).

Considering the nature of this study medium and the purposes of evaluation, it was thought that an appropriate way to collect expert opinions would be to use on-line questionnaires. Oppenheim (1994) indicated that 'a questionnaire is a scientific tool and therefore must be constructed with great care in line with the specific aims and objectives of investigation' (p. 100). More specifically and in distance education settings, Clark (1994) stated an important principle in planning questionnaire structure. He proposed that:

> 'Reaction items should be divided between those that deal with the medium (e.g., ease of access, reliability or technical quality of transmission or machines, space allocation issues) and those associated with the instruction (e.g., the quality of teaching, how things learned in the program were used outside of the class)' (p. 67).

Questionnaire questions varied between closed multiple choice types and free response types. Although the need to develop the experts' questionnaire was similar to that for developing the students' questionnaire, the experts' questionnaire had more than one purpose.

First, the experts' questionnaire was designed to be used at two different stages: the development stage (formative evaluation) and the field testing stage (summative evaluation). The objective of the first stage was to obtain feedback from experts during the development phase to enhance design and learning via Wired Class (Chapter 5). However, the objectives of using the questionnaire at the final evaluation stage were to evaluate the pedagogical effectiveness and usability of the program and to verify the validity and the accuracy of the students' responses to their questionnaire.

The review of the literature of designing and evaluation of Web-based distance education programmes showed that although many studies (e.g., Bates, 1995; Bates, 1997; Marshall, 1999) have suggested various criteria to assess Web-based distance education programmes (e.g., ease of use, speed of access and interactivity) and many others have developed reliable questionnaires to evaluate distance education programmes via the Internet (e.g., Baynton, 1992; Bostock, 1998; Cheung, 1998; McAlpine, 2000; Tsai et al., 2001), the majority of previous questionnaires concerned information that could be obtained easily using other appropriate methods (e.g., achievement tests and students' logs and portfolios). For example, in his questionnaire, Hiltz (1994) asked participants about the total time they spent each week on a Web site and whether they participated actively in the Web class discussion or not. In addition:

1. The majority of questionnaires, if not all, were designed for participants, not experts, in higher education.
2. Many contributions of the Web-based learning to learning as reviewed in the literature (e.g., administration and interaction) were not assessed in these questionnaires.
3. The design, development and evaluation of Wired Class required the investigation of new issues in new ways, to reveal what variables may affect learners' participation and learning outcomes and how.
4. The learning environment designed in the present study has its own features and components that had never been evaluated in other studies.

For the above reasons, a decision was made to develop a questionnaire for this study to fulfil the criteria of evaluating Web-based learning environments, on the one hand, and to elicit experts' feedback.

6.6.1.2. Development of experts' questionnaire

The development of the experts' questionnaire was based on four phases for developing distance education assessment instruments, suggested by Harrison et al. (1991). These phases are:

- Review of the literature;
- Establishing content validity;
- Construction of the questionnaire; and
- Establishing scale reliability.

Phase 1: Review of the literature

According to Harrison et al. (1991), in the first phase of development, a review of the literature should be conducted to 'establish a conceptual definition of the various components important to the success of a distance education program' (p. 68). The review of the literature related to development of distance education programmes and design of Web-based instruction has shown that (e.g., Holmberg, 1989; Harrison et al., 1991; Reiser and Kegelmann, 1994; Bates, 1995; Cheung, 1998; Smith and Dillon, 1999) two main aspects should be considered in evaluating distance education technologies: the technical attributes of the medium and its instructional features. Many criteria were found related to the technical attributes of the medium. These criteria were categorised into three aspects, as follows:

1. Criteria related to the technical design of the site (e.g., design of user interface, quality of graphics and availability of troubleshooting).
2. Criteria related to the design of the navigation system (e.g., using clear navigational aids, using a simple hierarchy of sites and avoiding the user getting lost).
3. Criteria related to the structure of the site (e.g., availability of components such as registration, tutorials, communication and assessment and exploiting multimedia components).

Similarly, many criteria were related to the instructional attributes of the medium. These criteria were categorised into three aspects as follows:

1. Criteria related to the instructional design of the programme (e.g., responsibilities of both the students and the tutor, teaching/learning approach and assessment strategy).

2. Criteria related to the quality of the content (e.g., clarity of objectives, logical organising of the content and the accuracy of the symbols and graphics).
3. Criteria related to the quality of the resources (e.g., suitability for the learners' level and ease of access).

To collect and organise the criteria of evaluation for these two aspects (technical and pedagogical), the following resources were used:

1. Previous studies and questionnaires (e.g., Souder, 1993; Jones et al., 1995; Nitikasetsoontorn, 1996; Mcmillan, 1997; Tong, 1998; Harris, 1999) used for the evaluation of distance education media other than the Web (e.g., television, videoconferencing and computer).
2. Previous studies and questionnaires used for evaluating Web-based distance education courses (for example, Heath, 1997; Yang, 1998).
3. Earlier studies that suggested standards for designing and evaluation of Web-based instruction (e.g., Corry et al., 1997; Wilson, 1999).
4. A survey posted by Khan and Vega (1997) on four Web-based listservs (Association for Educational Communications and Technology, World Wide Web in Education, World Wide Web Development and Media Literacy) in which participants (Web developers, instructors, students, etc.) were asked to list the criteria they would consider when evaluating the effectiveness of any Web-based course.

The above review and resources have revealed many essential components that directly impact programme effectiveness. These components are:

1. User-interface design;
2. Ease of use;
3. Standardisation of design;
4. Navigation design;
5. Site structure and management.
6. Quality of course content;
7. Quality of Web resources; and
8. Teaching and learning approach.

These components, together with examples of elements comprising each component, are shown below (Table 6-3).

Table 6-3: Literature-based components of Web-based learning environments

Components	Elements of evaluation
User-interface	• Design of page appearance • Font sizes • Styles and colours • White spaces and margins • Texts, graphics and icons
Ease of use	• Suitability for students' level
Standardisation	• Compatibility • Troubleshooting and coding errors
Navigation design	• Site hierarchy • Student tracking • Navigational aids • Access to information • Links • Navigation icons
Site structure and management	• Tutorials and assessment components • Interaction components • Management components • Support components • Student's and on-line tutor's roles • Security
Course content	• Objectives • Course content • Organising lessons • Graphs, figures and formulae • Examples and exercises • Discussion topics • Multimedia objects
Web resources	• Objectives and content of Web resources • Level of Web resources • Appropriateness for the course activities • Access Web resources
Teaching and learning approach	• Student-student and student-tutor interaction • Motivation • Student-centred activities • Student's performance. • Formative assessment

Phase 2: Establishing content validity of the literature derived components

The second phase of development dealt with establishing the content validity of the literature derived components. Harrison et al. (1991) indicated that establishing the content validity of the literature derived components should receive the highest priority during the development of distance education assessment instruments. The validity of an instrument is the extent to which it measures what it purports to measure. Since questionnaires are designed to elicit information from respondents, one of the criteria for the quality of a question is the degree to which it elicits the information that the research desires (Sudman and Bradburn, 1983; Tuckman, 1994).

Van Dalen (1979) stated that to provide some confidence that the questionnaire measures the characteristics for which it was designed, one or more types of validity (e.g., content validity, criterion-related validity and construct validity) should be checked. Content validity, for example, concerns the accuracy and suitability of the questionnaire items to measure the determined criteria and it relies on experts' views and experience in the field of study. However, other types rely on the results of other similar instruments (Tuckman, 1994). Considering the conditions of the field-testing in this study, the length of the current study and the lack of other similar questionnaires at the current time, to examine construct validity, content validity would be sufficient to test the validity of the questionnaire.

To examine the content validity, the above components were verified through structured face-to-face and e-mail based interview. A panel of three distance education tutors, three Web developers, one research student in educational technology and three lecturers in educational technology were asked to review the literature derived components together with elements of evaluation, report on items they thought were essential and critical to evaluate the effectiveness of the on-line learning environment, suggest related items of evaluation of the effectiveness of on-line learning, highlight the most important aspects and recommend changes to modify the above list of components. As a result of a review of the literature (Table 6-3) and experts' comments, items related to aspects of evaluation and criteria of evaluation were drawn up, as shown below (Table 6-4).

Table 6-4: Examples of essential aspects of evaluating on-line learning

Components	Criteria of evaluation
Technical design	• Pages are attractive, well laid out, appropriate for screen appearance and consistent throughout the site, display the relevant tasks and functions, suitable for the downloading time and uncluttered with elements. • Font sizes, style and colours, white spaces and margins are used appropriately and help students to focus on the content • Texts, graphics and icons are well aligned and clearly reflect the content they represent • The overall design is suitable for students' level • The on-line help system is effective • The site uses standard and compatible with standard browsers. • No troubleshooting or coding errors are available.
Navigation	• The hierarchy of the site is simple and well organised. • Helps students keep track of where they are. • Uses clear navigational aids. • Indexing provides quick access to information. • Students can easily locate the information in the different lessons. • Links are well labelled. • Navigation icons are consistent throughout the site. • Links are minimal and simply act to connect nodes in a specified sequence
Site structure and management	• Contains the essential components of an on-line learning environment, including tutorials (modules, resources, support materials, etc.), assessment (self-assessment, tutor assessment, etc.), interaction (asynchronous and synchronous), management (registration, tracking, grading, etc.) and support (on-line library, help, etc.). • Provides appropriate tools to students who need to share and display their work. • Suitable synchronous and asynchronous interaction tools are provided to facilitate interaction. • Offer many tools to teacher to mange students at a distance. • The responsibilities of the student and the obligations of the on-line teacher are stated clearly • The Web site protects students' personal and course-related information

Components	Criteria of evaluation
Course content	• Objectives are clearly stated in each lesson. • The content is accurate and relevant to the objectives. • Lessons are logically organised in segments (e.g., examples, exercises, discussion, etc.). • The content provides real life situations and contexts to facilitate the study of abstract content. • Graphs, figures and formulae are clear and accurate. • Examples are relevant to the objectives and the content of lessons. • Discussion topics are relevant to the objectives of the course. • Multimedia objects are suitable for students' level, support course objectives and used effectively throughout the duration of the course to support the learning process
Web resources	• Easily located. • Objectives and content of Web resources are well described. • Meet learners' needs. • Appropriate for the course activities. • Well categorised.
Teaching and learning approach	• Encourages interaction between the teacher and students. • Motivates students to participate in learning activities. • Provides student-centred activities. • Student's performance is monitored throughout the learning process. • Formative assessment is founded throughout the course

Phase 3: Constructing the questionnaire

According to Harrison et al. (1991) the purpose of the third phase was to construct the evaluation questionnaire using qualitative information. To study the validity of classification and items, two on-line learning practitioners and one researcher in Web-based learning were asked independently to classify the items depending on their understanding of the conceptual definition above. The results of analysis showed that there was overall agreement among judges on the description of items and labelling of categories. As a results of these interviews:

1. User-interface design, standardisation and ease of use categories were united under one category. This category was called 'technical design'.
2. The 'quality of course content' category was divided into two sub-categories: quality of course content (statement of objectives, accuracy, suitability to students' level, etc.) and quality of course materials (organising lessons, quality of graphs and presentations, etc.).
3. The 'quality of the Web resources' category was divided into two sub-categories: 'access Web resources' and 'quality of Web resources'.

4. Open-ended questions were added at the end of each section to allow experts to add their own points of view and provide feedback about the various pedagogical and technical aspects of the learning environment.

At the end of this phase, the evaluation questionnaire consisted of six sub-categories, as follows:

1. Technical design (is the design of user-interface attractive? Does the site work without troubleshooting?)
2. Navigation design (do students get lost in the site?)
3. Site structure and management (e.g., does Wired Class provide solutions to students who need to share and display their work, does Wired Class provided appropriate solutions to students to communicate synchronously and asynchronously, etc.).
4. Quality of course content (are graphs, figures and formulae clear and accurate?)
5. Quality of Web resources (are students able to find appropriate resources? Are search engines effective?)
6. Teaching/learning approach (does the design of learning meet students' needs?)

Phase 4: Piloting the questionnaire and validity and reliability testing

The purpose of the final phase was to assess the validity and reliability of the scale with a large sample of participants. Experts who were familiar with the target learners (three Egyptian lecturers in educational technologies, two Web developers and two experienced teachers) and others world-wide agreed to be volunteer evaluators to participate in the study. An invitation message (Appendix 3) was sent to three related World Wide Web-based listservs (Table 6-5). Members were asked to contact the researcher personally and a link to more details and the on-line questionnaire, as well as username and passwords, were provided (see expert appraisal, Chapter 5).

Table 6-5: Listservs participated in the study

Name	Description [*]
WWWDEV	**World Wide Web Courseware Developers' Listserv** URL: http://www.unb.ca/wwwdev/ Estimated number of members 2000-2500 WWWDEV gives a forum for discussing ideas, sharing interesting NEW WWW on-line course sites, and generally helping each other out in this new field. This is the Home Page for that listserv.
WWWEDU	**The World Wide Web in Education List** URL: http://www.ibiblio.org/edweb/wwwedu.html Estimated number of members 2500-3000 The purpose of WWWEDU is to offer educators, webmasters and policy makers a continuous discussion on the potential of World-Wide Web use in education and to answer related questions (such as How can the structure of the Web positively affect learning and assessment?) It is targeted for use by educators, as well as webmasters and web providers, but anyone with a keen interest in the use of Web methodology in education is welcome to join.
DEOS-L	**The Distance Education Online Symposium** URL: http://lists.psu.edu/archives/deos-l.html Estimated number of members: 4000 DEOS-L is a moderated listserv that facilitates discussion of current issues in distance education. This forum now over 2,000 subscribers. Ideas, news, or job announcements posted on DEOS-L are likely to receive comments, questions, and responses from around the world. Discussions on DEOS-L include current issues in distance education, research inquiries and requests for assistance, professional networking announcements of conferences and job opportunities.

To allow experts to get a clear overview about the objectives, design and use of Wired Class, criteria of design and development, and factors related to the technical and instructional design (e.g., teaching/learning approach and the requirements), a lengthy description was provided with the questionnaire. Open-ended items as well as closed ended items using a Likert-style five-point response scale (strongly agree, agree, neutral, disagree and strongly disagree) were used and the items were scored by the following key: Strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly disagree = 1

At the end of this stage, a draft copy of the questionnaire was ready to be piloted to examine its validity and reliability.

[*] Adapted from listservs' descriptions available at their Web sites.

Experts were asked not only to rate Wired Class features, but also to judge the importance of questionnaire items. A four-point scale (High, Moderate, Low and Not relevant) associated with a scoring code (High = 100%, Moderate = 50%, Low = 25% and Not relevant = 0%) was provided to ask experts to express their views of the strengths or the weaknesses of the items. In addition, blank spaces were left below each item and sub-scale to encourage reviewers to make suggestions, if they thought any changes were necessary. Lastly, the first version of the questionnaire had two parts. The first part was a Likert-style five-point response scale (strongly agree = 5, agree = 4, neutral = 3, disagree = 2 and strongly disagree = 1) asking participants to indicate opinions about the various aspects of technical and pedagogical design of Wired Class.

To provide an index of how well the items comprising each sub-scale are drawn from a relatively homogeneous pool, first, the reliability of each sub-scale was calculated. Methodology writers insist that if a questionnaire is to be used in an experiment, its consistency should be tested. This consistency is called reliability and it should be assessed either before or during the experiment (Oppenheim, 1994). The literature addresses many approaches to estimate the reliability of an instrument. Bryman and Cramer (1997), for example, indicated two types of reliability: external and internal reliability.

> 'Internal reliability is particularly important in connection with multiple-item scales. It raises the question of whether each scale is measuring a single idea and hence whether the items that make up the scale are internally consistent' (Bryman and Cramer, 1997, p. 63).

The most common approaches are known as test-retest reliability, alternate-forms reliability, split-half reliability and internal reliability (Oppenheim, 1994; Bryman and Cramer, 1997). The test-retest method refers to the stability of the scores over a period of time. However, the alternate-forms method refers to the consistency of the scores over different forms of the instrument. The split-half method refers to the consistency of test scores over different parts of the test. The internal reliability method refers to the extent to which all the items measure the same characteristic or are inter-correlated (Gronlund, 1982).

Most estimates of reliability require the use of correlation coefficients to measure how consistently individual differences have been assessed. When correlation is 1.0, random errors must be 0.0 (Sax, 1979, p. 207). The internal reliability approach is the most widely used and a particularly important approach to measure the reliability of an instrument with multiple item scales. The objective of this approach is to answer the question: 'do all items measure the same characteristic?' (Brown, 1983, p. 83). One widely used measure of internal reliability is Cronbach's coefficient alpha. In the present study, the average of all possible split-half reliability coefficients were calculated using Cronbach's generalised formula with SPSS 9.0. In Cronbach's formula, alpha is defined as (Youngman, 1979):

$$\alpha = \frac{n}{n-1}\left[1 - \frac{\sum V_i}{V_t}\right]$$

where n is the number if items

V_i is the variance of item i

V_t is the variance of the total test scores

Experts were asked to read the full description of Wired Class, register with it as students, then go throughout its various components and use some basic functions such as building a page using Page Builder, register for e-mail address and review one lesson at least. To enable them to fill-in the questionnaire easily and quickly, the questionnaire was made accessible in on-line format from within Wired Class, with the possibility of viewing both the questionnaire and the learning environment in two separated windows.

Results of analysis

Experts' responses were collected, coded and stored in a Web-based Microsoft Access database table. The reliability of the questionnaire items was calculated using Cronbach's generalised formula using SPSS. All items were coded in the same direction and item total correlations and 'alpha if item deleted' were calculated for each sub-scale to find out to what extent each item related to the items in its sub-scale.

Responses and comments from the judges yielded useful information, which led to many modifications in the questionnaire. First, the results of analysis showed that all items, except nine, received scores 50-100% from the majority of experts (75%). These items were retained in their original form or modified, if the judges suggested that was necessary. For example, one expert argued that some technical attributes of Wired Class could be revised or proved by the designer himself without the need to judges' opinions. However, a statement like 'The site uses standard HTML tags' was retained and modified to become 'The site is based on standard HTML', as there is no standard manual for HTML tags among browsers up to now. In addition, items (5 items) that obtained 25-50% were modified, according to the judges' comments. However, items (4 items) that obtained less than 25% were eliminated, since they were not in line with the other items, the objective of their sub-scales or the principles of Wired Class evaluation.

In the technical design sub-scales, two items were eliminated from the technical design sub-scale (corrected item-total correlation <0.25). These items were as follows:

- Item 10: The discussion board design is suitable for the students' ability level;
- Item 12: The e-mail capabilities are sufficient for the class needs; and

The output for alpha suggests that the technical design sub-scale would be regarded as high internally reliable, since the coefficient is 0.84. Therefore, the technical design section of the experts' questionnaire used in this study would be accepted as a reliable instrument, as mentioned in the section on design of students' questionnaire (Table 6-6).

Table 6-6: Item-total correlation of technical design

Items	Corrected Item-Total Correlation	Alpha if Item Deleted	Items	Corrected Item-Total Correlation	Alpha if Item Deleted
1	.4188	.8326	8	.3969	.8332
2	.3761	.8326	9	.4431	.8310
3	.5626	.8221	~~10~~	.1776	.8408
4	.6095	.8189	11	.4596	.8296
5	.7226	.8119	~~12~~	.1605	.8531
6	.5864	.8212	13	.7316	.8072
7	.7357	.8086	14	.4684	.8275

Scale reliability coefficient (alpha): number of cases = 23, number of items = 14, alpha = .8373
Standardisation sub-scale coefficient: number of items = 3, alpha = .34
User-interface sub-scale coefficient: number of items = 6, alpha = .79
Ease of use sub-scale coefficient: number of items = 5, alpha = .47

Moreover, to provide further evidence of validity, another coefficient alpha reliability for each sub-scale (standardisation, user-interface design and ease of use) and Pearson correlations were computed to see how well each one contributed to the 'technical design' scale reliability. The results of inter-reliability showed that the 'user-interface' sub-scale (alpha = .79) and 'ease of use' sub-scale (.47) had moderate coefficients and the 'standardisation' sub-scale has a low reliability coefficient (.34) (Table 6-13). However, it can be argued that this low alpha coefficient is tolerable, since this sub-scale contains only three items and the parent 'technical design' sub-scale is highly homogeneous (alpha = .84) (Harrison et al., 1991). In addition, the results of inter-correlations showed that (Table 6-7) each smaller sub-scale correlates well with the 'technical design' scale and other smaller sub-scales. According to Harrison et al. (1991), this result provides at least further evidence for the consistency of the 'technical design' scale and for the convergent validity of each smaller sub-scale.

Table 6-7: Inter-correlations among technical design scale and sub-scales

Sub-scale and smaller sub-scales	Standardisation	User-interface	Ease of use
Technical design parent sub-scale	.78**	.91**	.75**
Standardisation	-	.59**	.58**
User-interface	-	-	.46*
** Correlation is significant at the 0.01 level * Correlation is significant at the 0.05 level			

In the navigation sub-scale, two items were eliminated. These items were:

- Item 1: The navigation design prevents learners from getting lost; and
- Item 9: Frames enhance the site organisation and structure.

The output for alpha suggests that the navigation sub-scale can regarded as highly internally reliable, since the coefficient is 0.81 (Table 6-8). Therefore, this sub-scale of the experts' questionnaire used in this study was accepted as reliable.

Table 6-8: Item-total correlation of navigation

Items	Corrected Item-Total Correlation	Alpha if Item Deleted	Items	Corrected Item-Total Correlation	Alpha if Item Deleted
~~1~~	~~.1217~~	~~.8252~~	6	.5158	.7937
2	.2846	.8151	7	.7689	.7576
3	.3138	.8144	8	.8030	.7523
4	.6074	.7827	~~9~~	~~.1652~~	~~.8238~~
5	.6769	.7742	10	.5266	.7920
Scale reliability coefficient (Alpha): number of cases = 24.0, number of items = 10, Alpha = .8125					

In the site structure sub-scale, only the first item was eliminated. This item was 'The site provides a publicly accessible description of Wired Class' (e.g., the aims, objectives, target learners, rating system, features of the learning environment and patterns of assessment). The output for alpha suggests that the site structure sub-scale can be regarded as high internally reliable since, the coefficient is 0.79. Therefore, the site structure sub-scale used in this study was accepted as reliable (Table 6-9).

Table 6-9: Item-total correlation of site structure and management

Items	Corrected Item-Total Correlation	Alpha if Item Deleted	Items	Corrected Item-Total Correlation	Alpha if Item Deleted
~~1~~	~~.0199~~	~~8098~~	6	7406	7356
2	3883	7803	7	4788	7703
3	3647	7832	8	7302	7305
4	5736	7588	9	3128	7996
5	6526	7478	10	3467	7843
Scale reliability coefficient (Alpha): number of cases = 23, number of items = 10, Alpha = .7901 Structure sub-scale coefficient: number of items = 5, alpha = .63 Management sub-scale coefficient: number of items = 5, alpha = .70					

Moreover, coefficient alpha reliability for each sub-scale (structure sub-scale and management sub-scale) and Pearson correlations were computed to see how well each one contributed to the 'site structure and management' sub-scale. The results of reliability and inter-correlations showed that these two sub-scales are reliable ($alpha_{site\ structure}$ = .63, $alpha_{management}$ = .70). In addition, these two sub-scales are significantly correlated with the 'site structure and management' sub-scale and with each other. This result may provide further evidence for the consistency of the 'site structure and management' scale and for the convergent validity of each smaller sub-scale (Table 6-10).

Table 6-10: Reliability and inter-correlations among site structure and management scale and sub-scales

Sub-scale and smaller sub-scales	Structure	Management
Site structure and management	.89	.95
Structure	-	.72
All correlations are significant at the 0.01 level		

In the course content sub-scale, two items were eliminated. These items were:

- Item 1: 'Problem-based situations take into account the learners' age and interests'; and
- Item 10: 'The discussion topics related to the objectives and the content of the lessons'.

The output for alpha (Table 6-11) suggests that the content sub-scale can be regarded as highly internally reliable since the coefficient is 0.78. Therefore, this sub-scale of the experts' questionnaire used in this study was accepted as reliable.

Table 6-11: Item-total correlation of the quality of course content

Items	Corrected Item-Total Correlation	Alpha if Item Deleted	Items	Corrected Item-Total Correlation	Alpha if Item Deleted
~~1~~	~~.2339~~	~~.7893~~	7	.6068	.7361
2	.3940	.7634	8	.3443	.7709
3	.6350	.7363	9	.3940	.7634
4	.4413	.7580	~~10~~	~~.0994~~	~~.7885~~
5	.6232	.7362	11	.4609	.7560
6	.5351	.7483	-	-	-
Scale reliability coefficient (Alpha): number of cases = 24.0, number of items =11, Alpha = .7766					

In the quality of Web resources sub-scale, only one item was eliminated (Table 6-12). This item was item 7: Resources offer access to information which is not usually offered in traditional school libraries. The output for alpha suggests that the resources sub-scale can be regarded as highly internally reliable since the coefficient is 0.73. Therefore, the quality of resources sub-scale used in this study was be accepted as reliable.

Table 6-12: Item-total correlation of quality of Web resources

Items	Corrected Item-Total Correlation	Alpha if Item Deleted	Items	Corrected Item-Total Correlation	Alpha if Item Deleted
1	.3873	.7088	5	.6000	.6520
2	.5073	.6805	6	.3873	.7088
3	.6321	.6463	~~7~~	~~.0185~~	~~.7716~~
4	.5260	.6767	-	-	-
Scale reliability coefficient (Alpha): number of cases = 24.0, number of items = 7, Alpha = .7282 'Access Web resources' sub-scale coefficient: number of items = 2, alpha = .56 'Quality of Web resources' sub-scale coefficient: number of items = 5, alpha = .76					

In addition, coefficient alpha reliability for the two sub-scales (access Web resources and quality of Web resources) and Pearson correlations were computed to see how well each sub-scale contributed to the 'Web resources' larger sub-scale. The results of reliability and inter-correlations showed that (Table 6-12) these two sub-scales are reliable (alpha $_{access}$ = .56, alpha $_{quality}$ = .76). In addition, these two sub-scales are significantly correlated with the 'Web resources' sub-scale and with each other (Table 6-13). Thus, although the alpha for 'access Web resources' sub-scale' was not quite high (.56), since it contains only two items, this result may provide further evidence for the consistency of the 'Web resources' scale and for the convergent validity of each smaller sub-scale.

Table 6-13: Reliability and inter-correlations among Web resources scale and sub-scales

Sub-scale and smaller sub-scales	Access	Quality
Web resources	.747**	.934*
Access	-	.460*

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Lastly, in the teaching approach sub-scale, three items were eliminated since they obtained correlations of less than 0.25. These items were:

- Item 2: The design of the course is appropriate to the experience of the target learners.
- Item 6: Learners are encouraged to construct their knowledge depending on their previous experiences.
- Item 7: The assessment techniques are appropriate for the objectives of the subject.

The output for alpha indicates that the instructional approach sub-scale can be regarded as highly internally reliable since the coefficient is 0.73. Therefore, this sub-scale was accepted as a reliable instrument. Therefore, the experts' questionnaire was accepted as a reliable instrument to evaluate the various pedagogical and technical aspects of Wired Class. After examination of the validity and reliability of the expert's questionnaire, the final version was formatted to be uploaded to the Web to be used in the summative evaluation phase of Wired Class (Appendix 3).

Table 6-14: Item-total correlation of instructional approach

Items	Corrected Item-Total Correlation	Alpha if Item Deleted	Items	Corrected Item-Total Correlation	Alpha if Item Deleted
1	.6282	.6738	7	-.1097	.7549
2	-.0135	.7547	8	.5608	.6839
3	.6974	.6559	9	.4197	.7060
4	.3131	.7181	10	.6349	.6671
5	.5220	.6912	11	.4979	.6900
6	-.0099	.7757	-	-	-
Scale reliability coefficient (Alpha): number of cases = 26.0, number of items = 11, Alpha = .7297					

6.6.2. Students' questionnaire

To collect information about students' perceptions of using and learning with Wired Class, a questionnaire with closed-ended and open-ended items was constructed. The design and development of students' questionnaire was based on the same sources of designing and developing experts' questionnaire, but with attention to the level of participants (secondary school students). Therefore, many attributes related to technical and instructional design that would not be suitable to be assessed by students were included only in the experts' questionnaire

6.6.2.1. The need and purpose of development

Whereas the concern of the experts' questionnaire was to reveal experts' views and obtain comprehensive feedback about the pedagogical and technical aspects of the learning environment, the purpose of students' questionnaire was to uncover students' reactions and satisfaction with the learning environment. Therefore, the items in the experts' questionnaire were drawn to reflect user's reactions, more than opinions. In addition, whereas experts' items were developed for experienced distance educators, on-line tutors and Web developers, students' items were developed to be simpler, easy to understand and reflect students' actual experience with the learning environment (Table 6-15).

Moreover, two other parts were added to the students' questionnaire. In the first part, questions were added to collect information about students' gender and background in using the Internet, as shown below. The second part contained open-ended questions to allow students to:

- provide their own feedback and comments on learning via Wired Class, freely and in their own words;
- refer to the features, which they most like in the learning environment, and
- refer to the features, which they most dislike in the learning environment.

Lastly, an on-line feedback form was made available throughout the eight weeks of the field testing, to encourage students to send their own feedback and report any problem they might encounter instantly. The importance of this evaluation form is that it provide an on-demand and easy-to-use evaluation tool to students to provide their feedback, instead of waiting until the end of the course.

Table 6-15: Comparison between students' and experts' questionnaire items

Students' items	Experts' items
Fonts and colours help me to read the content.	Fonts vary in size, style and colour in accordance with their functions.
I can understand the meaning of graphics and symbols easily.	The icons clearly reflect a certain notion. Captions are concise and accurately describe the images and graphs.
E-mail is easy to use.	The Web-based e-mail server is suitable for the students' level The e-mail server design is compatible with the whole design of the class.
From any page I can go to a new page or return to an old page easily.	The site design prevents the students from getting lost.
Examples help me to understand the difficult points in lessons.	Examples are relevant to the objectives and course content.
I like using the presentation board to show the class my work.	The class encourages students to provide individual work

6.6.1.2. Development of the questionnaire

The development of the students' questionnaire was based on the four phases of development, suggested by Harrison et al. (1991) (review of the literature, establishing content validity, construct the questionnaire and establishing scale reliability). The first and second phases were common between students' and experts' questionnaire. However, since the two questionnaires were different, as shown above, new validity and reliability tests were conducted (phases 3 and 4), as shown below.

Phase 3: Constructing the questionnaire

The purpose of the third phase was to construct the evaluation questionnaire using qualitative information. To study the validity of classification and items, judges who are who familiar with and have experience in teaching the target population in this study were involved. Two English language teachers, two computer teachers, three researchers in media studies and two Web developers were asked, each in his/her area of interest, to validate the questionnaire sections and validate related items to see whether they:

1. were accurate and clear in meaning;
2. elicited responses relevant to the specific predetermined criteria;
3. were relevant to the intention of their sections;
4. were appropriate to students' age, ability level and experience after using Wired Class.

A four-point scale (high, moderate, low and not relevant) was provided and judges were asked to tick one to express their views of the strengths or the weaknesses of each item. In addition, blank spaces were left at the end of each section for the judges, to make suggestions if they thought any changes were needed. The responses were coded as follows: High = 100%, Moderate = 50%, Low = 25% and Not relevant = 0%. However, although the this scale was used and the data analysed using the mean, the main intention at this stage was to collect qualitative rather than quantitative feedback, as a basis for modification of the questionnaire items.

First, the judges' comments led to re-constructing the students' questionnaire into four sub-scales: access, teaching and learning, interaction and user-friendliness. In addition, their responses and suggestions yielded useful changes. For example,

1. Five statements that each concerned more than one issue were re-written to concern one aspect only. For example, the statement 'chat is an easy and fast way to communicate with others in the class' was changed to 'chat is an easy way to

communicate with others in the class'. Judges indicated that it is a fact that chat is a real time and fast technique to be used synchronously.

2. Four statements were moved to other sections. For example, two judges suggested that the statement 'I prefer e-mail to chat rooms' should be in the instructional design section rather than the technical design section.
3. The statement, 'learning to use Wired Class is easy' was changed to 'learning to use Wired Class takes a short time'.
4. The statement, 'the starting page is attractive' was changed to 'the first page is attractive'. More than one judge commented that the terms starting page, home page or front page are not accurate and may confuse students. Therefore, the term 'first page' was used to indicate the starting page in the learning environment.
5. The statement, 'from any page I can go to another page and return to the same page easily' raised many ambiguities and was changed to 'from any page I can go to a new page or return to an old page easily'.
6. The judges indicated that it was not necessary or suitable to show section titles in the students' questionnaire (e.g., navigation, technical design, instructional design, etc.). Therefore, the questionnaire sections were separated only for the purposes of analysis, without the separation being shown to students.
7. Items that obtained scores from 25-50% were modified, if the judges suggested that was necessary. However, the items that obtained 25% or less were deleted, since they were not suitable to the objectives of the questionnaire or to the students' ability level and experience. All items that scored 50% or more remained in their original form or were modified, according to the judges' comments.

Phase 4: Piloting and reliability of the questionnaire

The purpose of the final phase was to assess the validity and reliability of scale with a large sample of participants. Since conducting a pilot study of the questionnaire before implementing Wired Class was not possible, since responding to questionnaire items requires good experience with the components and features of the learning environment, pilot testing and the internal reliability test were carried out during the field-testing of Wired Class in

Egypt (17^{th}, 19^{th} and 20^{th} of February 2000). First, using a sample of four students who participated in field study, the questionnaire was piloted to:

1. find out whether students were able to respond and give the information required;
2. discover students' ability to understand the questionnaire items, allowing questionnaire items be modified accordingly; and
3. estimate the internal reliability of the questionnaire.

As a result of the interviews with students and their comments on the questionnaire items during this first pilot test:

1. some words and expressions were changed to be more clear and understandable to the students;
2. the need was highlighted to make the questionnaire available and accessible via the learning environment; and
3. the order of some statements was changed.

Using a Likert-style five-point response scale and a larger sample of 29 students who participated in the field-testing, a second pilot test was conducted to re-validate the content and test the reliability of the instrument. The questionnaire was converted into the on-line format to be more convenient and practical to obtain data from students. Using Web-based forms (radio buttons, check boxes, scrolling text boxes, etc.) and CGI scripts, the paper and pencil format was converted into on-line format and made available from within the Wired Class site. Therefore, students could fill-in the questionnaire while reviewing the different parts of Wired Class. This on-line format was distributed quickly and without the need to further arrangements, provided a quick and accurate way to obtain students' responses, particularly to open-ended questions, was time effective since the data can be easily and quickly converted to the statistical package format (SPSS 9.0)

Overall, the implementation was more successful than the first one and students reported no significant problems in reading and understanding the questionnaire items. More than 80% of students completed the questionnaire in less than 25 minutes. However, the rest of the students (18%) completed it in less than 35 minutes. The researcher ensured that all items were coded in the same direction. Item-total correlations and alpha if item deleted for the scale and sub-scales are presented below (Table 6-16).

Table 6-16: Item-total correlations and reliabilities for of students' questionnaire

Sub-scale	Items	Corrected item-total correlation	Alpha if item deleted	Sub-scale	Items	Corrected item-total correlation	Alpha if item deleted
Access	1	.4952	.8616	User-friendliness	18	.4106	.8650
	2	.3471	.8657		19	.3433	.8655
	3	.4789	.8624		20	.3239	.8661
	4	.5730	.8591		~~21~~	~~.1950~~	~~.8683~~
	5	.3913	.8656		22	.3988	.8642
	6	.4569	.8627		23	.3705	.8649
	7	.2907	.8668		24	.4181	.8649
	8	.6773	.8596		~~25~~	~~.2010~~	~~.8750~~
Teaching and learning	9	.7118	.8582		26	.3748	.8648
	10	.3796	.8647		27	.5207	.8631
	11	.8527	.8605		~~28~~	~~.0529~~	~~.0754~~
	12	.4424	.8635		29	.4421	.8636
	13	.3740	.8651		30	.4820	.8619
Interaction	~~14~~	~~.0748~~	~~.8705~~		31	.6040	.8631
	15	.3393	.8661		32	.5788	.8590
	16	.4449	.8640		-	-	-
	17	.6040	.8631		-	-	

Scale reliability coefficient (alpha): number of cases = 29, number of items = 32, alpha = .8682
Access sub-scale coefficient: number of items = 6, alpha = .7755
Teaching and learning sub-scale coefficient: number of items = 5, alpha = .6192
Interaction sub-scale coefficient: number of items = 4, alpha = .4160
User-friendliness sub-scale coefficient: number of items = 15, alpha = .7270

The two columns that present the item-total correlations give an indication of the correlation between each item and rest of the items in the questionnaire. It is generally agreed that correlations in the range 0.35 to 0.65 are useful and statistically significant beyond the one- percent level, while correlations less than 0.25 is not useful and are statistically non-significant (Brown, 1981; Brown; 1983; Bryman and Cramer, 1997). Therefore, a decision was made to eliminate items that showed an inter-item correlation of less than 0.25. These items were:

- Item 14: I like using the presentation board to show the class my work
- Item 21: When I am studying with Wired Class I know where I am in the site (in which lesson, page and task).
- Item 25: The tool bar makes it easy to run programs and access lessons.
- Item 28: The pages are simple and not crowded with too much information.

The output for alpha (Table 6-3) shows that the students' questionnaire can be regarded as having high internal reliability since the coefficient is 0.87. In addition, reliabilities for sub-scales are quite high, indicating stability for the scale and sub-scales, except interaction sub-scale since it contains few items. In addition, it was found that each sub-scale correlates well with the parent scale and there is positive inter-correlations among the four sub-scales, showing that there is a high degree of commonality among the for sub-scales (Table 6-17). According to Harrison et al. (1991) this provides further evidence for the consistency of the students' questionnaire and for the convergent validity of each sub-scale. Therefore, the questionnaire used in this study was accepted as a reliable instrument (Appendix 1).

Table 6-17: Inter-correlations among sub-scales

Sub-scale	Teaching and learning	Interaction	User-friendliness	Parent scale
Access	.737	.277	.570	.852
Teaching and learning		.333	.615	.843
Interaction			.677	.613
Friendliness				.888
All correlations are significant at the 0.01 level				

6.6.3. Students' achievement test

When two methods, or more, of instruction are compared, as was the case in the present study, achievement test scores are a useful criterion to measure the effectiveness of the medium associated with the instructional design of learning (Clark, 1994). Therefore, an achievement test needed to be designed to 'provide an estimate of a student's overall level of knowledge in a given content area' (Brown, 1983, p. 212). Brown (1981) argued that decisions about the effectiveness of instructional approaches could be made by administering a test at the end of the programme, or each unit, to determine whether the students have mastered the material or not, then compare the scores to those of other students.

When students' scores are interpreted on the basis of others' scores, the test is called a norm-referenced test. However, when scores are interpreted on the basis of a standard of mastery, the test is called a content- or criterion-referenced test (Brown, 1983). In a comparison between norm-referenced and criterion-referenced tests, Popham (1975) stated that:

1. Norm-referenced tests measure broad skill areas sampled from a variety of textbooks, syllabi and the judgements of curriculum experts, however criterion-referenced tests measure specific skills which make-up a designated curriculum.
2. Items of norm-referenced tests vary in difficulty; however, the items which test any given skill in criterion-referenced tests are parallel in difficulty.

Tuckman (1985) believes that norm-referenced tests are useful for summative evaluation and for public information value (e.g., to evaluate a new instructional programme). However, criterion-referenced testing is more useful for formative evaluation and description of student progress. At the same time, many educators believe that norm-referenced and criterion-referenced tests are not different kinds of tests. Bertrand and Cebula (1980) , for example, argued that 'many items on the standardized achievement tests are nearly word for word the same as those on criterion-referenced tests designed by teachers. The important difference lies not in the items of the tests but in the interpretations of their answers' (*) (p. 195). The last point of view is confirmed by Popham (1981) who argued that 'if you were to be given a particular test, for example, a test of mathematical computation skills, it might be impossible for you to discern merely from inspection of the test itself whether it was norm- or criterion-referenced' (p. 25).

In general, since using the criterion-referenced approach would provide useful information about the level and the type performance, and since diagnosing and measuring students' performance in specific behaviours would provide more comprehensive understanding of students' learning, both the norm-referenced approach and the criterion-referenced approach were accepted as appropriate measurements at the summative evaluation phase, to compare the performance of the Wired Class students with those of the traditional class.

6.6.2.1. Constructing students' achievement test

Although some standardised tests were available and related to the intended course content, it was found that such tests had been designed to be used with the content of the whole curriculum and to be administered at the end of the academic year. Therefore, it was

(*) Bertrand and Cebula referred to the norm-referenced tests as standardised tests.

more useful to the purpose of the present study to construct a valid and reliable achievement test to cover the objectives of the selected topics only (Chapter 5). Reviewing the literature (Gronlund, 1982) has shown that two critical factors influence the construction of achievement tests:

1. The validity of the content outline on which test items are based; and
2. The selection of test items that reflect the list of instructional objectives for the content.

To ensure content validity, it was essential to develop a content outline that covered the subject. In addition, planning the test required determining the objectives of the subject. The subject content and its objectives were stated at the earlier stages of designing and developing Wired Class to guide instructional design, as shown in Chapter 5. Using the analysis and the percentages assigned to the categories of the content as shown below (Table 6-18), the objectives that needed be measured were specified, allowing several items to be selected and drawn.

Table 6-18: Weights of instructional objectives (based on Table 5-3, Chapter 5)

Content/objectives	Recall	Conceptual Structures	Skills	Problem Solving
Total number of objectives	4	12	13	8
Percentage	11%	33%	35%	21%

Having determined the weight for each type of objectives, it would be possible to achieve the desired weighting in the test. However, since the present course has many objectives, measurement of which would require a quite lengthy test, 'we could randomly sample the desired objectives, although some diagnostic information will be sacrificed using this procedure' (Brown, 1981, p. 29).

The second step in planning the test was considering the types of items that should be included. Marshall and Hales (1971) stated that the consideration of this factor cannot be separated from the consideration of the instructional objectives of the course. Therefore, questions used in the maths test were categorised into two main types (Pennsylvania Department of Education, 1998):

1. Closed-ended questions (e.g., multiple-choice, true-false and matching questions): This type of question is used to measure a broad range of skills. Students must carry out some process in order to arrive at their answers then respond by choosing one answer only.
2. Open-ended questions: Open-ended tasks, or free response, are useful for measuring students' problem-solving skills in mathematics. This type of question requires the student to show how he/she arrived at an answer and the thinking process used.

Considering the above two types of questions and their purposes, Bloom's taxonomy of educational objectives and the nature and the objectives of the subject content (Chapter 5), the following types of questions were used to develop the students' achievement test.

1. Multiple-choice;
2. True-false;
3. Completion; and
4. Free response.

For example, the test used the true-false type for low-level questions requiring recall of facts and principles, by asking students to choose whether the statement is true or false (e.g., the graph of the linear function is a line that intersects the origin). In addition, free-response questions that measured high-level objectives, e.g., that required application of principles, were used (for example, does the point $(-1, 10)$ lie on the line of the equation $5x+ 2y = 15$? Why? Is this point a solution to this equation?). At the same time, the interactivity and flexibility of the Web as a two-way medium associated with using interactive HTML/CGI-scripts, in particular, were considered in preparing, formatting, distributing and handling test results.

In addition, many guidelines and suggestions concerning students' level and the nature of the medium were taken into consideration in development of the test items (e.g., measure the important objectives of the lesson, measure the low-level as well as the high-level learning outcomes, be varied in their types, be independent of other items, etc.).

As the course included two modules (Module 1 and Module 2), the summative maths achievement test was divided into two parts; each part was designed to be applied on completion of the relevant module. The number and types of questions were included in the initial version of the test are shown below (Table 6-19) below.

Table 6-19: The type and the number of questions included in the initial version of achievement test

Type of Question	True-false	Multiple-choice	Completion	Free response	Total
Part 1	3	2	7	4	16
Part 2	2	1	1	7	11
Total	5	3	8	11	27

6.6.2.2. Validation of the test

In terms of achievement, the validity of a test is defined as the extent to which it measures achievement of the intended objectives (Marshall and Hales, 1971; Gronlund, 1982). Hopkins and Stanley (1981) indicated that 'the validity of a test can be viewed as the accuracy of specified inferences made from scores' (p. 76). The review of the literature has shown that although there are many approaches to assess the validity of a test (e.g., content validity, criterion-related validity and construct validity), the most common and relevant type of validity in measurement of academic achievement is content validity (Gronlund and Linn, 1990; Tuckman, 1994). The main question in testing the content validity is how well do the test items represent the domain of knowledge or skills taught?

To check content validity, 'the researcher must present some evidence which provides confidence that a test measures the precise characteristics for which it was designed' (Van Dalen, 1979, p. 135-136). Therefore, six qualified experts (four maths teachers and two university lecturers in maths education) with experience in teaching the curriculum were asked to comment independently on the extent to which the test items presented a representative sample of the content that the test was designed to measure. In addition, they were asked to comment on the suitability of the items in terms of level of difficulty and cognitive skills to be measured. As a result of testing the validity, three questions were re-formatted to be easier and more objective and one question was eliminated, since it was considered too difficult for students to answer.

6.6.2.3. Piloting the test and items analysis

To conduct a statistical analysis for the test items and estimate the reliability of the test, a pilot study was carried out using a representative sample of the target population. Estimating the time needed to answer the test and discovering any problems that might arise while administering the test were other important objectives considered in the pilot study. To conduct the pilot study, a sample of 32 students [*] who studied the intended subject was selected randomly from the same schools, as would be participating in the main study. Students were told that their answers would be used for research purposes only and their scores would not be added to their records.

The first procedure following collection of students' responses was to carry out item analysis. Item analysis was used to compare between the performance of students in each item and the total score using the following two procedures (Tuckman, 1994):

1. Subdividing students based on total scores into three groups: high-third scores, middle-third scores and low-third scores.
2. Identifying the number of high-third and low-third scores who pass each item.

The major purposes of this process were to estimate the discrimination power and the difficulty of each item, allowing items to be retained, modified or eliminated. The item discrimination power refers to the extent to which an item can distinguish between the upper group and lower group of students and the item difficulty refers to the extent to which an item can be answered correctly by any student (Tuckman, 1994). The index of difficulty and index of discriminability for each item were calculated using the following two formulae:

$$1)\ \text{Index of difficulty} = \frac{\text{number who fail an item}}{\text{total number in both groups}}$$

$$2)\ \text{Index of discriminability} = \frac{\text{number of high - third who pass an item}}{\text{total number in both groups who pass the item}}$$

(Tuckman, 1994, p. 195)

[*] This group of thirty-two students did not participate in the main study. They were selected only to answer the test, to enable item analysis to be conducted and reliability checked before administering the test to the control and treatment groups.

The results of item analysis of the two parts of the achievement test (26 questions) were computed as shown below (Table 6-20).

Table 6-20: Item analysis of the achievement test from among a group of 32 students

Question	Index of Difficulty	Index of Discriminability	Question	Index of Difficulty	Index of Discriminability
1	.50	.73	**14**	~~.68~~	.86
2	.36	~~.64~~	**15**	.64	.75
3	.59	.89	**16**	.59	.89
4	.45	.75	**17**	.50	~~.63~~
5	.41	.69	**18**	.36	.79
6	.41	.69	**19**	~~.27~~	~~.56~~
7	.36	.79	**20**	.41	.69
8	.50	.73	**21**	.41	.69
9	.36	~~.64~~	**22**	~~.27~~	~~.63~~
10	.45	.83	**23**	.45	.75
11	.45	.75	**42**	.45	.67
12	.45	.75	**25**	.41	.69
13	.64	.88	**26**	.36	.71

As shown above, 5 out of 26 questions did not have satisfactory discriminating power, in that the index was less than two-thirds (0.67). These items were 2, 9, 17, 19 and 22. At the same time, two items (19 and 22) were too easy, because less than one-third (0.33) of students answered them incorrectly. Moreover, one question only appeared to be too difficult (item 14) because more than two-thirds of students (0.68) answered it incorrectly. However, this question could be accepted as not too difficult, since its index of difficulty was only slightly more than (0.67) and it had a high power of discrimination (0.86). So, this question was retained.

Taking the values of both index of difficulty and index of discriminability into account, questions 2 and 9 (in Test 1) and questions 17, 19 and 22 (in Test 2) were eliminated, since they had neither reasonable difficulty (between 0.33 and 0.67) nor satisfactory discriminability (0.67 or more).

6.6.2.4. Test reliability

Although item analysis contributes to the estimation of the internal reliability of the test, a separate estimation of reliability was carried out. As mentioned in Section 6.1.3.2, using SPSS with Cronbach's formula, alpha, the item total correlation and reliability of the two parts of the achievement test were estimated as shown below (Table 6-21).

Table 6-21: Item-total correlation and alpha if item deleted of students' achievement test

Question	Corrected item-total correlation	Alpha if item deleted	Question	Corrected item-total correlation	Alpha if item deleted
1	.4119	.8502	12	.3498	.8570
2	.4741	.8486	13	.3019	.8530
3	.4373	.8496	14	.4453	.8494
4	.3435	.8520	15	.5381	.8442
5	.4316	.8499	16	.6291	.8402
6	.6548	.8441	17	.3084	.8548
7	.3697	.8514	18	.5117	.8455
8	.4993	.8471	19	.3273	.8524
9	.4026	.8505	20	.5068	.8456
10	.7247	.8350	21	.4135	.8497
11	.3811	.8510	-	-	-
Scale reliability coefficient (Alpha): Number of cases = 32.0, Number of items = 21, Alpha = .8549					

As shown above, the items had correlations in the range 0.31 to 0.72, which is considered as useful and statistically significant beyond the one- percent level (Bryman and Cramer, 1997). The output for alpha indicates that the achievement test can be regarded as highly internally reliable, since the coefficient is 0.86. Therefore, the achievement test used in this study (Appendix 2) was accepted as a reliable instrument. The final version of the test included twenty questions of different types, as shown below (Table 6-22).

Table 6-22: The type and the number of questions included in the final version of the achievement test

Type of Question	True-false	Multiple-choice	Completion	Free response	Total
Part 1	3	1	5	3	12
Part 2	1	1	4	3	9
Total	4	2	9	6	21

6.6.3. Students' portfolios

For more comprehensive understanding of students' learning, the Wired Class environment included various components to monitor learners' on-line behaviour and capture and record a wealth of data. Monitoring on-line learners and collecting related data while they are navigating through the Web site is known as 'Web tracking' (Nielson, 1995). Web tracking would reveal very useful data about the extent to which every component was used (how many times), the nature of use (success or failure), the outcomes of use, who used it, when and from where (the computer IP address).

In the design of Wired Class, provision was made for capturing and recording student's participation using side-server scripts, allowing all entries to be stored in the Wired Class Web server to be analysed later. For example, the average time spent in a lesson was calculated using logging-in and logging-out time and the time spent in each lesson or part (e.g., examples and discussion board). In addition, analysing student's e-mail messages, discussion topics and 'send to the teacher' task would provide useful information about the student's progress in each lesson and the problems he/she faced. This data, in conjunction with the data from the questionnaire and the achievement test, would reveal useful information and support and assist interpretation of students' and experts' opinions on specific attributes of the learning environment.

The data collected from Wired Class components were:

1. Time of logging-in and logging-out;
2. Interaction with the tutor and peers (via e-mail, discussion boards and chatting rooms);
3. Participation in learning activities ('send to the teacher' tasks, presentation boards, personal pages, Web search, etc.).

Student-tutor interaction and student-peers interaction are the most common /effective activities expected to occur during on-line learning and provide useful information to answer the research question: how do students interact in Wired Class (Section 6.3)? Although interaction was achieved through asynchronous as well as synchronous methods (using e-mail, discussion boards, presentation board, personal home pages and chat rooms) discussion boards were the most formal and interactive place at which formal and directed course-related discussions were held regularly, according to the instructional design of Wired Class (Chapter 5).

To analyse students' messages, both the quantity and quality of messages was investigated. Quantitative analysis was used to calculate the number of messages and investigate by whom they were sent, time of logons and length of messages. In addition, the qualitative approach was used to analyse the discussion content according to educational criteria, to enable conclusions to be drawn about the educational value of this activity. To analyse students' responses, a coding system was constructed based on research in computer conferencing and discussion content analysis by Mason (1991), Henri (1991), Fulford and Zhang (1993) and Berge (1997). Mason (1991), for example, suggested many questions to analyse students' responses, for example:

- Do they build on previous messages?
- Do they draw on their own experience?
- Do they refer to course materials?
- Do they refer to relevant materials outside the course (Mason, 1991)?

However, Henri (1991) categorised and coded students' responses in discussion boards using a more practical and comprehensive model for better understanding of the content of messages. This model highlighted five dimensions of the learning process exteriorised in students' messages. These dimensions, their definitions and indicators to them, are shown below (Table 6-23).

Table 6-23: Henri's analytical framework (Henri, 1991, p.125)

Dimension	Definition	Indicators
Participate	Compilation of the number of messages or statements transmitted by one person or group	Number of messages Number of statements
Social	Statement or part of statement not related to formal content of subject matter	Self introduction Verbal support "I'm feeling great..."
Interactive	Chain of connected messages	"in response to Celine..." "As we said earlier..."
Cognitive	Statement exhibiting knowledge and skills related to the learning process	Asking questions Making inferences Formulating hypotheses
Metacognitive	Statement related to general knowledge and skills and showing awareness, self-control, and self-regulation of learning.	"I understand..." "I wonder..."

Considering Mason's earlier typology and Henri's analytical framework, on the one hand, and students' level, the nature of the subject and the objectives of Wired Class discussion boards, on the other, these two approaches were adapted to build a new three dimensional model. These dimensions are participation, interaction and cognitive and content-related. Participation indicators provide information about the number of messages sent by students to every single discussion board, length of messages and time of posting. This information could help in identifying the type of discussion topic (e.g., low-level discussion topics, moderate-level discussion topics and high-level discussion topics) in which students are most active and clarifying the importance of on-line tutor participation in student participation. In addition, the qualitative analysis of student-peers interaction shows how students worked together and exchanged their ideas to learn and construct their own learning. However, the cognitive and content-related dimension describes what is said about the subject and how it is said. This analysis, in relation to the cognitive tasks assigned in discussion topics, makes it possible to evaluate the level of information processing and thinking applied by learners and how this contributed to their learning.

This model would be more appropriate to the nature of the subject, students' experience and the technical features of Wired Class discussion boards. The dimensions of this model and their indicators are shown below (Table 6-24). After the development of the coding system, messages were printed out and each message was divided into units of meaning. These units were analysed in the light of interaction and cognitive and content-related indicators to the answer the research question: How do students interact in Wired Class? The results of the analysis, in conjunction with the results from the achievement test and perception questionnaire, would provide useful information about the contribution of on-line interaction to student learning and success in on-line learning (Chapters 9 and 10).

Table 6-24: An analytical framework for discussion messages

Dimension	Indicators	Code
Participation	· Number of messages per student in every discussion topic	Part_num
	· The total number of messages per student in the course	Part_tot
	· Number of messages in earlier lessons	Part_ear
	· Number of messages in later lessons	Part_lat
	· Lengths of message per student (in statements)	Part_len
	· Number of statements directly related to learning per student	Part_stat
	· Time of logons	Part_tim
Interaction	· Self-introduction	Int_sel
	· Statements that social in nature	Int_soc
	· Statements that comment in another message	Int_com
	· Repeating information in another message	Int_rep
	· Responding to the tutor's views or advice	Int_tut
	· Responding to accept others' views and opinions without explanation	Int_acc
	· Responding to accept others' views and opinions with more explanation	Int_acex
	· Other statements that are social in nature	Int_soc
Cognitive and content-related	· Providing solution without explanation	Cont_soly
	· Providing solution with explanation	Cont_soln
	· Providing more than one solution	Cont_sol
	· Asking question related to the discussion topic	Cont_askr
	· Asking question unrelated to the current discussion problem	Cont_asku
	· Asking for more clarification	Cont_clar
	· Judging the relevance of solution	Cont_judg
	· Repeating information contained in the course materials	Cont_repm
	· Repeating information contained in the discussion topic	Cont_repd
	· Drawing conclusions	Cont_conc

6.7. Cost analysis

Although the costs involved in Web-based learning are different from those involved in other technologies, the costs of Web-based distance education could be calculated in terms of fixed capital costs and variable operating costs, as mentioned in Chapter 2. To conduct the cost analysis, first, the resources required to design and deliver the on-line learning environment and their costs/market prices were identified.

Second, the mathematical modelling approach (Chapter 4) was used to calculate the capital fixed costs, variable current costs and unit cost per student. This approach was used because it is simple, easily quantifiable, helps in decision making, helps to evaluate different alternatives depending on a particular case and can be expressed in a variety of ways (Cukier, 1997; Diacogiannis, 1994). In addition, it is suitable to answer the research questions about the cost structure of Wired Class, fixed and variable costs, capital and recurrent costs and unit cost, and to investigate the nature of the fixed and variable costs of Wired Class.

To analyse the costs of the programme, the costs are described in two terms:

- Production and support costs; and
- Student-related costs.

Production and support costs include the costs of design of the learning environment, development and delivery of its elements, including the costs of software, hardware, development, updating, tutoring and supporting students at a distance. However, student-related costs are the costs of students having access and receiving instruction.

6.8. Conclusion

In this chapter, the research questions and design, the sample of study and the methodology of evaluation were described. This methodology was based on the research problem, which necessitated a generic framework to evaluate the quality and the effectiveness of on-line learning. This framework took into account students' reactions, to the pedagogical and technical features of the programme, and achievement of learning objectives. In addition, the methodology considered experts' opinions as a basis for evaluation of the on-line learning environment. According to Holmberg (1989), there is 'no doubt that expert opinions can thus influence courses in a very useful way' (p.175).

Quantitative and qualitative methods (student achievement test, student perception questionnaire, expert questionnaire, content analysis of students' portfolios and cost analysis) were used to evaluate the strengths and the weakness of the learning environment. Bates' (1995) ACTIONS model (Access, Costs, Teaching and learning functions, Interactivity and user-friendliness, Organisational issues and Speed) is used as a comprehensive framework to report and discuss the results of evaluations, in the next four chapters.

PART THREE

RESULTS, DISCUSSIONS, CONCLUSION AND IMPLICATIONS

Chapter 7: Results on Access and Costs

7.1. Access

According to the ACTIONS model, access is the first criterion considered in deciding whether the technology, learning resources, the tutor and peers are accessible by students at a distance or not. Based on the ACTIONS model, three major factors influence access to Web-based instruction: demographics, standardisation and accessibility. Demographics refers to the availability of computers and Internet connection needed to access the Internet. Standardisation refers to the compatibility of Wired Class with students' hardware and software. Accessibility refers to the ease of access to learning resources, the tutor and peers within the learning environment.

Since the purpose of this study was to design, develop and evaluate a Web-based learning environment for teaching students at a distance, collecting demographic information about the availability of computers and Internet connection at schools was beyond the scope of this study. However, to assess the standardisation and accessibility of the programme, students were asked to respond to statements related to the compatibility of Wired Class with their computers and the ease of access to learning resources, the tutor and peers. Therefore, this section attempts to answer the following research questions:

Q1.1: How compatible was Wired Class with students' hardware and software?

Q1.2: How accessible were learning materials?

Q1.3: Did Wired Class help students to access the resources they needed?

Q1.4. Did Wired Class facilitate student-student and student-tutor interaction?

Q1.5. How quickly can students access course materials and receive feedback from the tutor?

7.1.1 Results on access

Responses in this section were based on a five-point Likert scale and students' responses to open-ended questions. First, in terms of compatibility, more than 93% of students indicated that Wired Class was running smoothly through their computers. Although students reported some access problems, they indicated that they did not experience problems in accessing and viewing HTML pages or running scripts and programs. However, students did not show enough satisfaction with the accessibility of Web resources; only around 56% of students indicated that resources could be accessed easily. Moreover, 59.38% of students found that search engines were not effective in locating course-related information (Table 7-1).

Table 7-1: Students' responses to standardisation and access learning resources

Statement	Response Distributions					% Choosing SA or A	Mean	Std. Deviation
	SA	A	N	D	SD			
Wired Class works in my computer without any problem	20	10	2	0	0	93.75	4.56	0.6189
Using the search engines, I can find what I am looking for on the Web	4	7	2	14	5	34.38	2.72	1.3255
I can access 'Links' under lessons easily	9	9	4	7	3	56.25	3.44	1.3664

Students commented that they liked the learning environment because it is easily accessible and they could access and use many useful Web-based tools easily (e.g., e-mail, grades, etc.) and find a vast amount of course related information

1. 'It allowed me to access my grades directly;
2. 'It allows me to answer exercises at home and send them to the teacher';
3. 'I like to access web pages'; and
4. 'I like to access homework and anything on the web'.

However, on the negative side, many others reported that they experienced difficulties to get connected to the ISP server via school LAN and to access external Web resources, as shown below.

1. 'Access to the Internet is a problem because the computer room is crowded and the [dial-up server telephone] line is often busy';
2. 'The computer crashed many times';

3. 'I was unable to access the links';
4. 'not much information from links';
5. 'Links do not go to [remote] Web sites'; and
6. 'I couldn't do site search on the web'.

In terms of access to the on-line tutor and peers, a high majority of students (96.88%) indicated that they did not feel that they were isolated from the tutor during studying. More interestingly, 87.5% of students found the discussion boards were a very useful place for interaction and information exchange with classmates in Wired Class. However, on the other hand, the majority of students showed negative perceptions toward using e-mail as an individual tool for asynchronous student-student interaction. About 60% of students disagreed and strongly disagreed that e-mail is an easy way to communicate with other students in Wired Class (Table 7-2).

Table 7-2: Students' responses to access to the tutor and peers

Statement	Response Distributions					% Choosing SA or A	Mean	Std. Deviation
	SA	A	N	D	SD			
I feel that the teacher is near to me whenever I am studying.	20	11	1	0	0	96.88	4.59	0.5599
Using e-mail, I can contact anyone in Wired Class easily.	5	4	4	14	5	28.13	2.69	1.3305
Discussion board is a good place to meet and talk to my classmates.	18	10	2	1	1	87.50	4.34	0.9708

Students' comments implied that they did not feel much geographical isolation from the tutor due to his regular messages and they appreciated his help and support.

> 'The online teacher is very good. He gives me a lot of lessons and examples and helps me to understand these lessons'.
>
> And
>
> 'I liked Wired Class because when I don't understand or have a question about something I can ask Mr [...]'.

In addition, although not many students participated in discussion boards, as shown in interactivity results in Chapter 9, students preferred discussion boards to e-mail as a course-centred interaction approach. A student expressed that:

> 'I liked communication with classmates through the discussion board. It is really nice'.

Second, feedback from a student who did not think that using e-mail is a good method for student-student interaction indicated that:

> 'To contact my classmates I have to use the e-mail but only few students get into email and use it. Contacting them is very difficult'.

In terms of speed of the system, students (90.63%) indicated that they could submit their questions and course-related tasks and receive feedback from the teacher very quickly and at any time (Table 7-3):

1. '[Wired Class] makes information access and communication with the tutor so fast'.
2. 'I like the quick response from the tutor'.

However, only 59% of students found that the speed of connection was high. They complained that:

1. 'When accessing the internet loading is slow'.
2. 'the internet connection is slow'.

Table 7-3: Students' perceptions of the speed of the system

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
I can access Wired Class quickly.	10	9	3	8	2	59.38	3.53	1.3437
I can submit my work and receive a reply quickly from the teacher.	20	9	3	0	0	90.63	4.53	.6713

More specific access-related issues emerged from the experts' questionnaire, as shown below (Table 7-4). In terms of standardisation, the majority of experts found that Wired Class was designed using standard HTML tags and that its design took into account the differences among Web browsers, allowing it to be accessible and interpreted by a variety of Web browsers without troubleshooting or coding errors. In addition, although experts doubted the appropriateness of student searching the Web, they agreed (86%) that the search engines were powerful and suitable for learners' level. Lastly, about 60% of evaluators thought that the volume of graphics and HTML pages did permit downloading in a reasonable time.

Table 7-4: Evaluators' responses to access: standardisation and access Web resources

Statement	Response Distributions					% Choosing SA or A	Mean	Std. Deviation
	SA	A	N	D	SD			
The site is based on standard HTML	25	9	0	7	0	83.00	4.27	1.1186
The site is compatible with standard browsers	26	4	6	5	0	73.20	4.24	1.1131
Size of graphics and the number of pages are suitable for the downloading time	7	17	12	5	0	58.54	3.63	0.9153
Resources are easily located	0	4	11	0	0	26.70	3.27	0.4577
Powerful as well as suitable search engines are available for learners	10	3	2	0	0	86.67	4.53	0.743

Useful comments regarding compatibility and access to Web resources, using open-ended questions, came from evaluators. Two evaluators criticised the use of 'style sheets' and Java applets to add interactivity to Web pages, as they argued those features might not work properly with old versions of browsers.

> 'I test compatibility using IE 4.0 and Netscape 4.5 to ensure cross-browser usability. I also test at 640x480 and 800x600 screen resolution - which when you are using frames is critical. Features such as style sheets and Java can make a web page interactive, but if the user's browser does not support them, then the user will end up feeling frustrated'.

And

> 'What about a style sheet then? I know they have compatibility problems with older browsers and all that stuff'.

In addition, an evaluator noticed that Wired Class was designed using MS Front Page, which is more suitable to produce pages to be viewed using MS IE 4.0+ rather than Netscape 3.5+.

> 'One issue to consider is how important cross-browser compatibility is for your users. I realize the importance of this can vary. Front Page pushes you to make pages that work best in IE'.

Lastly, a mathematics teacher criticised the use of more than one search engine, without indicating the most suitable search engine for the subject, as follows.

> 'What is the best search engine, or rather, which engine is best for what? If you wanted to search for information in mathematics, would one engine over another be better for this?'

7.1.2 Discussion of access results

The above presentation of results shows that evaluating the accessibility of a Web-based learning environment requires evaluating three access types of access:

1. Access to the environment elements (standardisation);
2. Access to external Web resources (access of resources); and
3. Access to the tutor and peers (interaction).

The purpose of the first type (standardisation) is to find whether Wired Class Web site was easily accessible and working appropriately in students' computers or not. However, the purpose of the second and third types (accessibility and interaction) is to know whether external Web resources, the tutor and classmates were accessible or not.

In terms of standardisation, first, it should be considered that one of the major design and distribution problems that faced CAL developers was the compatibility of the program with users' software and hardware. Often, designing courseware required production of more than one version (e.g., for MS Windows and Macintosh) to serve a wide range of users with different operating systems. At the same time, the same version would have to be available using different storage media to be compatible with users' hardware (e.g. 3.5 inch disks, 5.25 inch disks and CD-ROMs).

However, although this type of storage problem does not occur in Web-based instruction, due to the rapid development in Web-based technology, Web-based courses cannot be made totally accessible. Therefore, the goal was to make Wired Class as accessible as possible by presenting the content in straightforward formats and standard styles rather than utilising up-to-date technology, on the one hand, and to make it easy to download, on the other.

At the same time, it was impossible to develop very simple HTML documents to avoid access problems. Creating a document, which only contains text and hypertext links (no graphics or scripts), to be accessed using any browser, may 'deprive' students of many interactive capabilities of Web-based technology (e.g., style sheets, Java Applets, Java Scripts, ActiveX and plug-ins of various products).

Therefore, students and schools who do not have the latest versions of browsers or plug-ins (e.g., Flash or Dreamwever) installed in their machines to view the content of specific products may not be able to view information that is presented in these formats. This problem highlighted the importance of making sure that students did not experience any difficulty in 'receiving' instruction, whatever software and hardware they had.

Judging by students' and experts' feedback, this goal was achieved by using standard HTML pages with a minimum number of Java scripts and Java Applets to add interactivity to instruction; these were found to be compatible with all students' and experts' software and hardware. The only problem with Java language, for example, is that 'new features are added periodically and this raises incompatibility problems with Web browsers and their Java Interpreters' (Hakkinen, 1998). Similarly, although ActiveX is a very promising programming language and it was easy and very cost-effective to use it in Wired Class, since it relies on MS Visual Basic 5.0, which was used to develop the CGI scripts, it is supported by MS Internet Explorer browsers only (see Chapter 3). In other words, students who have Web clients other than MS IE would not be able to view the content of pages at all. However, both MS Internet Explorer and Netscape Communicator browsers support Java Scripts and Java Applets.

Using Wired Class logs, it was found that users who used the following Web browsers did not report any incompatibility or bugs, whatever the user platform was:

1. Netscape Navigator 3.x

2. Netscape Communicator 4.x
3. Internet Explorer version 3.x
4. Internet Explorer version 4.x
5. Internet Explorer version 5.x

According to a recent review by Smith (1999), these browsers are used by more than 97.5% of Web users (Table 7-5). However, it was very difficult to obtain information about the compatibility of Wired Class with other browsers (2.5%) since records indicated that no users accessed Wired Class using other browsers. This means Wired Class is nearly 100 % compatible with users' browsers.

Table 7-5: The popularity of Web browsers (adapted from Smith, 1999)

Browser type and version	Popularity (%)
MS Internet Explorer 5.x	24.9
MS Internet Explorer 4.x	44.7
MS Internet Explorer 3.x	3.6
Netscape Communicator 4.x	22.0
Netscape Navigator 3.x	2.3
MS Web TV	1.4
Other	1.1
Total	100

Moreover, although Wired Class pages were generated using MS Front Page 98, which is more compatible with MS Internet Explorer browsers, all the pages were tested using both MS IE 4.0+ and Netscape 3.0+ browsers. In addition, the content was served using text and still and animated pictures without the need to install specific products to view the content. No audio or video capabilities were required in students' computers to hear or see the information presented in audio or video formats.

Since the above results show that Wired Class was of an acceptable standard and compatible with students' hardware and software and no standardisation problems were reported, whatever the specifications of their operating systems and clients, then it could be concluded that:

1. Standard HTML language (HTML 3.0), which is 100% compatible with all Web clients and standard Java and Java Scripts, constitutes the best way to make sure that pages are

compatible with students' browsers. The table below (Table 7-6) shows that Web browsers interpret the latest HTML tags (particularly Dynamic HTML) differently and do not support all types of scripts.

Table 7-6: Browsers' compatibility (adopted from CNET, 2000)

Browser	Java	Frames	Tables	Plug-ins	Font size	Font colour	Java Scripts	Style sheets	GIF89	DHTML
Explorer 4.0	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Explorer 3.01	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Explorer 2.0			✔		✔	✔				
Explorer 1.0			✔		✔	✔				
Mosaic 3.0			✔		✔	✔				
Mosaic 1.0										
Navigator 4.06	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Navigator 3.0	✔	✔	✔	✔	✔	✔	✔		✔	
Navigator 2.0	✔	✔	✔	✔	✔	✔	✔		✔	
Navigator 1.1			✔		✔					
Opera 3.5		✔	✔	✔	✔	✔	✔		✔	
Lynx		✔	✔							

2. Compatibility is essential, not only between different browsers, but also between different versions of the same browser. New versions of browsers have features (e.g., Cascading Style Sheets and Dynamic HTML, or DHTML) that are not available to older versions of the same browser. To reach the largest possible audience and to take advantage of DHTML, Web based instruction should be designed in a way that takes advantage of the advanced features of DHTML, while still maintaining compatibility with older browsers.
3. Using standard user-side and server-side programming languages (Java Scripts, Java and CGI Scripts) may be more useful than using cutting-edge technology (e.g., ActiveX, Flash, Shockwave, etc.) which requires additional software (plug-ins) to be downloaded and installed in the users' machines. For example, regarding playing Director movies, Macromedia declared that:

> 'The Shockwave player is a system-level component that plays Director movies. Shockwave uses a plug-in to work with Netscape Navigator, and an ActiveX control to work with Microsoft Internet Explorer for Windows 95, 98, and NT' (Macromedia, 2000).

This incompatibility with operating systems (e.g., Macintosh, OS2 and UNIX) and Web browsers may demolish one of the essential features of Web technology, at least at the current time.

4. Although a screen resolution of 640×480 displays less material than a resolution of 800×600, frames, pages and graphics should be optimised to be viewed in Netscape Navigator 3.0+ or Internet Explorer 4.0+, at a recommended resolution of 640×480 pixels.
5. Since the operating systems affect how colours are displayed, only 216 colours that display consistently on both PCs and Macintosh computers could be used.

In terms of speed, the results showed that the low-speed Internet connection and limited bandwidth affected the time spent in downloading course materials to students' browsers. This result highlighted the importance of enhancing the communication and networking infrastructure and using faster Internet connection types (e.g., faster dedicated-line networks, ISDN and wireless connections) and high-speed Web servers to serve a large number of users.

In addition, although Wired Class students were provided with powerful public search engines, as rated by experts, to seek for course-related information and 'links' to Web resources, which are tutor-compiled lists of appropriate sites collected, evaluated, commented and categorised by the tutor, students' ratings and comments on this feature showed that students did not benefit very much from searching the Web or even following well-selected Web links.

Comments from experts and students indicated that using public search engines (e.g., Google, Yahoo, Altavista, etc.) to seek for course-related information, may not be useful to students. Students claimed that they could not find appropriate information on the Web using the search engines provided. Moreover, experts believe that search engines should be chosen very carefully with the subject (like mathematics) and students' level and needs in mind, otherwise, students may waste their on-line time.

However, it is noticed that students found 'Links' more appropriate and useful than search engines to look for course-related information, support students' inquiries and save on-line studying time. This result is in line with the results that emerged from the 10th GVU public survey (1999), approved by the World Wide Web Consortium (W3C) which showed that the majority of users prefer and use links provided by other Web sites (called portals) rather than using search engines to seek for information themselves.

In other words, it could be argued that although the Web is considered as a huge archive of materials with very powerful, fast and massive databases based search engines, students, particularly at early stages, might encounter problems to find appropriate learning resources. Therefore, designers should pay more attention to developing strategies like 'subject-specific directories' or 'topic hot lists'. These directories or lists must be accessible and appropriate for both students' level (e.g., middle school, secondary school, higher education, etc.) and the subject to be taught (e.g., mathematics, language, etc.). One of the advantages of subject-specific directories is that the search results are more limited than those of the public search engines.

More interestingly, Lilla and Hipps (1999) highlighted the importance of a combination of both subject-specific directories and search engines, which they called 'hybrids'. The importance of hybrids is that they collect and categorise Web sites in a logical or subject-based structure, so the user avoids the 'false hits' that can occur with search engines. The advantage of these hybrids is that they allow students to do all of their information gathering from a single desktop connected to millions of computers all over the world via the Internet (Green, 1997).

In a distance education context, Birmingham et al. (2000) indicated many advantages of hybrids (who called them 'digital archives') as they:

1. reduce geographic, organisational and time barriers of distance;
2. enhance collaborative and group-based activities;
3. provide access to collections of information in multimedia formats that is not available to off-campus students;
4. allow users to personalise or customise information access and representation; and
5. provide information at any time and in any place (Birmingham, 2000).

However, since the majority of on-line digital archives or hybrids were not prepared and archived with middle and secondary school students in mind, students may still face access and refining problems. Therefore, students at a distance need to learn effective strategies to evaluate the quality and the accuracy of course-related resources on these directories. For example, students can check whether they are the target audience of the site or not, whether the site is newly updated or has been left without updating for a long time, the author's qualifications and the institution that hosts the site (e.g., academic 'ac or edu', commercial 'co or com' or organisation 'org') to determine the source of the content and its objectives.

One of the worst features of providing learners with remote or out of server links is 'dead' or 'broken links' (links that do not go to remote Web sites). In Wired Class, students reported that they found error messages instead of the resources they had been forwarded to. According to GVU's 7th (1997) and 9th (1999) WWW User Surveys, in 1997 about 50% of Internet users reported broken links as their main problem in navigating the Web. In 1999, this problem had become worse and no immediate solution had emerged. Broken links may occur for many reasons. The Web server that hosts the document may be down or the page may have been deleted, moved or renamed. Currently, the only solution to this problem is for links to be regularly checked by the site facilitator or a link checker program. At the same time, feedback links or forms should be provided so learners can report broken or difficult to follow links immediately.

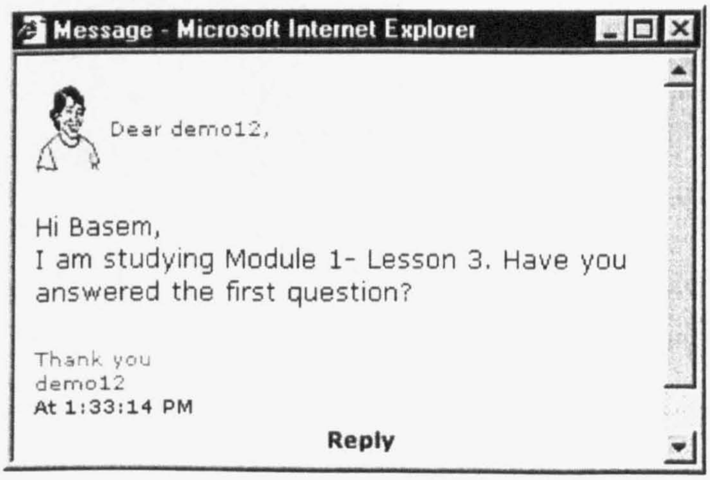
Third, in terms of access to the tutor and peers, since distance education is characterised by the geographical separation between the learner and institution, interaction between the distance learner and the tutor and among learners might not be achieved easily. However, since interaction may promote positive feelings towards the distance education programme (see Chapter 2) and prevent students from feeling socially and academically isolated from the tutor, assessing learners' perceived interaction with the on-line tutor and peers was the third essential factor to determine how accessible was Wired Class.

In designing Wired Class it was proposed that quick student-tutor and student-student interaction might break the feel of isolation between the student and the tutor. Students' feedback supported this belief when it was found that a large majority of them felt that they were not far from the tutor and he was able to respond and answer their questions in a reasonable time, as well as providing them with useful feedback and support via e-mail and discussion boards.

However, students did not find e-mail a useful and quick method of interaction with classmates. The reason, as mentioned by students, is that students did not access their e-mails regularly, check for new messages and then respond to others' messages, due to lack of interest and time. In addition, using e-mail, it is difficult for many students to contact each other and talk about the subject without guidance and support from the tutor. More interestingly, the results above showed that students found discussion boards more suitable than e-mail to access and interact with peers, and more so than individual messaging. Possibly, the reason is that students often find classmates' messages in discussion boards and read and reply to their ideas that focus on well-selected and course-related topics.

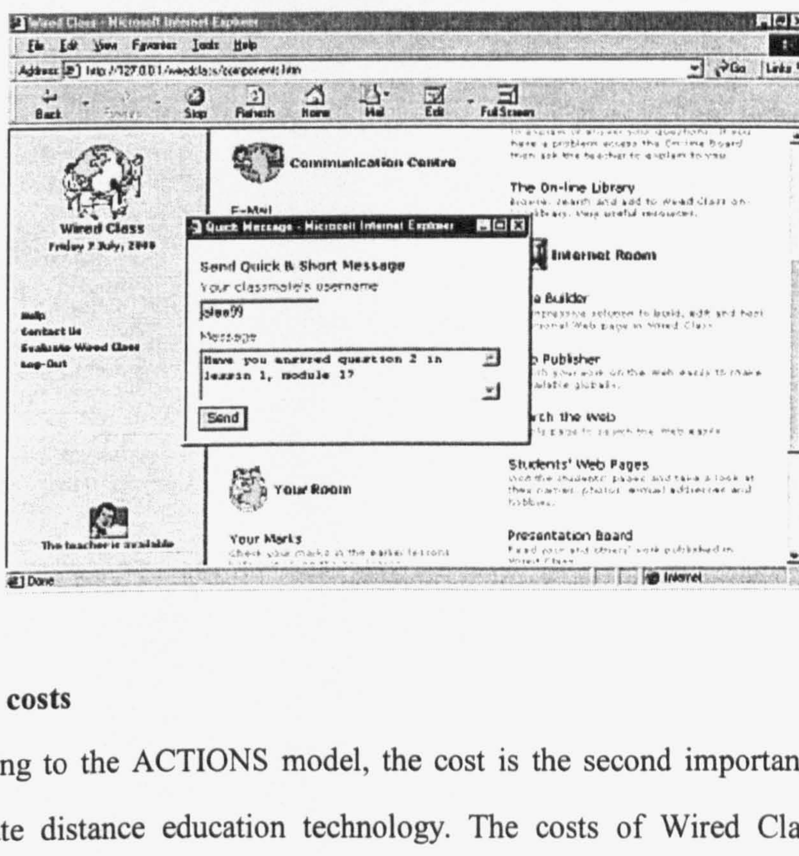
The last finding highlighted the need to look for a more reliable means of communication for individual interaction in on-line learning environments. This means of communication should encourage and facilitate interaction among students when they are studying on-line. To achieve this purpose, a new asynchronous interaction tool called 'Quick Messenger' was designed in this study to run in the Wired Class Web server. With Quick Messenger, students do not need to check their e-mail before or during study. To send a new message, the student only needs to check the on-line students' page to know who is on-line. Using his/her username, a student can send a quick message to anyone within Wired Class (Figure 7-1 a).

Figure 7-1 a: Quick Messenger



When the other party receives the message, a 'flashing' alert icon appears at the bottom of the left-hand menu allowing the student to know that a message has arrived. Therefore, the student can read and reply directly by clicking on the 'Quick Message' icon to open the message in a small pop-up window. The advantage of the pop-up window style is that it allows students to read incoming messages without the need to close the main window or move to a new page. In addition, the receiver can reply instantly by clicking on 'Reply' at the bottom of the pop-up window (Figure 7-1 b). The limitation of Quick Messenger is that students can receive and send messages only to Wired Class students who are on-line.

Figure 7-1 b: Quick Messenger



7.2. Results on costs

According to the ACTIONS model, the cost is the second important criterion to be used to evaluate distance education technology. The costs of Wired Class were mainly estimated using the activity-based costing approach advocated by Rumble (1997). In this approach, the costs of the components of the programme are separately estimated based on the availability of dependable information on the costs of each activity type. This estimation was described in terms of development and support costs and student-related costs (access costs). Each of these costs was quantified into fixed and variable costs, capital and recurrent costs, total cost and unit cost. To estimate the costs of Wired Class, mathematical modelling was used as the most useful approach in a single cost analysis project, since the variables of the model depend on the particular case.

This section intends to answer the following research questions:

Q2.1. What is the cost structure of Wired Class?

Q2.2. How much does Wired Class cost in terms of fixed, variable and unit costs?

Q2.3. What are the factors affecting these costs?

7.2.1. Development and support costs

In the present study, it was assumed that the on-line course was created from existing print-based course materials, the cost of this printed version was equal to zero and there was no need to develop new resources or to purchase copyright clearance. In this case, the development and support costs were the costs of:

1. purchasing a Web server machine;
2. purchasing a Web server software;
3. server connection;
4. domain name registration;
5. HTML editor (Front Page 98), programming language package (Visual Basic 6.0), photo editor (Paint Shop Pro 7.0) and CGI package (VB5-CGI);
6. adopting the course materials into the on-line format;
7. writing the course content in the on-line format;
8. developing the components of the learning environment (interaction tools, management tools, etc); and
9. tuition, administration and technical support.

These costs are either fixed costs or variable costs. Fixed costs are student-independent costs and could be capital costs (overhead costs) or recurrent costs (yearly- or monthly-based). Capital costs are the costs of purchasing the Web server hardware and software, designing of course materials and constructing the components of the learning environment. Recurrent costs are the costs required to run the learning environment, including the costs of domain name registration, maintaining the learning environment, tuition, administration and technical support. The costs of Web server hardware, in conjunction with its software, were considered as fixed costs, since they could serve a large number of students without the need to be upgraded.

However, although these costs seem to be fixed, they do not behave as fixed costs with any number of students, as upgrading may be needed as enrolments increase. Therefore, they are called 'semi-fixed costs'. In addition, two types of fixed costs were considered: module-dependent costs and lesson-independent costs. Module-dependent costs are the costs of the design and development of course-related components (e.g., lesson pages, mathematical formulae and graphs, discussion boards, teaching aids, etc.). Module-independent costs are the costs of the design and development of the non-tutorial components of Wired Class, irrespective of the number of modules implemented in Wired Class (e.g., interaction and administration tools).

Using spreadsheets, development and support costs are broken-down, as shown below 7-7). For comparison purposes, two models were examined to deliver on-line materials: purchasing a Web server model (model a) and renting a virtual Web server model (model b). In Wired Class, the first model was implemented to host and deliver the learning environment. However, first, it should be mentioned that although actual costs are used in all estimations below, the trend rather than the figures is more important to understand the cost effectiveness of on-line learning.

Table 7-7: Design, development and delivery costs of Wired Class

Fixed and variable costs	Activity	Unit	Number of units	Unit cost (£)
Capital costs	Web server (hardware & software)	£	1	3000 *a* (100 *b*)
	Programming language package	£	1	395
	Photo editor	£	1	70
	CGI scripts package	£	1	80
	Domain name registration	£	1	18
	HTML editor	£	1	99
	Maths Grapher	£	1	45
Module dependent elements	Rewriting course content for the Web (lesson, examples, self-tests, exercises, send to the teachers tasks, on-line discussion topics and Web links)	Screen pages	252	C1
	Writing HTML pages, including writing HTML pages and layout and hyperlinks design	HTML pages	252	C2
	Designing and developing graphics	Graphics	126	C3
	Designing interactive graphs and scripts	Graphs	13	C4
	Adapting & programming Java and Java Scripts	Code lines	330	C5
	Programming CGI scripts	Script code line	4420	C5
	Designing and developing on-line tests, including writing HTML pages and layout and hyperlinks design	HTML pages Graphics CGI script code line	9 9 60	C2 C3 C4
	Revising course materials by content experts	Pages	252	C5
Module-independent elements	Designing interaction tools (e.g., chat and discussion boards), including writing HTML pages and layout and hyperlinks design	Pages Graphic Script line	29 5 130	C2 C3 C4
	Developing administration tools (logging-in and logging-out, grading, etc.), including writing HTML pages and layout and hyperlinks design.	Pages Graphic Script line	14 7 190	C2 C3 C4
	Developing support tools(on-line board, teacher today page, on-line help, etc.), including writing HTML pages, layout and hyperlinks design.	Pages Graphic Script line	169 112 80	C2 C3 C4
	Testing by experts	Pages	212	C5
Total Fixed costs		£		
Variable costs	Tuition, support and assessment	Hour/day	2	C6
Recurrent costs	Site maintenance	Hour/week	2	C7
	Running the Web server Maintenance [a] Connection [a] Virtual Web server (rent) [b]	Hour/week £/month £/month	2 500 50	C7
Total variable and recurrent		£/week		
Total costs				

a Purchasing a Web server model
b Renting a virtual Web server model

In the spreadsheet associated with the above table, the quantities of resources (e.g. number of pages, graphics and scripts and hours of development) and their costs (C1, C2, C3, C4 and C5) were estimated in the light of the current market development costs and guiding rules defined by Ling et al. (2000). These guiding rules (Table 7-8) are used to provide only an estimation of the number of units (hours, pages, scripts, graphs, etc.) of costs. However, figures are based on the current market price and can be modified as appropriate to suit any particular cases using the spreadsheet associated with the above table. The rules and requirements for the various tasks below assume that to re-write the course materials to be suitable for on-line delivery, a content developer may be able to generate 2-4 screens per hour. However, a content expert can review and update 8-10 screens per hour. These rules can be modified to suit a particular case.

Table 7-8: Rules-based estimates for design and development costs

Cost contributor	Measure	Productivity rule	Requirement per the course	Cost/hour
Rewriting course content for the Web	Pages/hour	3	252	10
Writing HTML pages	HTML page/hour	5	464	10
Designing and developing graphics	Graph/hour	3	252	15
Designing interactive graphs and scripts	Interactive graph/hour	2	13	20
Adapting & programming Java, Java Scripts and CGI scripts	Script code line/hour	10	5210	20
Revising course materials and design by content and design experts	Page/hour	9	464	20
Tuition and support	Hour/day	2 [*]	40	10
Site maintenance	Hour/day	2	16	10
Web server maintenance [a]	Hour/week	2	16	10
Web server connection [a]	£/week	125	£1000	-
Virtual Web server (rent) [b]	£/week	12.5	£100	-

[*] This time estimation is based on 32 students, studying one course, two times a week and for 8 weeks.
[a] Purchasing a Web server model
[b] Renting a virtual Web server model

Based on the above estimation rules, the capital, fixed, variable and total costs of Wired Class were estimated for purchasing a Web server model and renting a virtual Web server model, as shown below (Table 7-9). In addition, the percentage of each cost was calculated in relation to the both models. The results show that the capital costs of establishing an on-line learning environment using a purchased Web server is £3,707. This cost could be reduced to only £807 if a virtual Web server was used. Virtual servers share a Web server and high-speed Internet connection with other organisation to reduce the capital costs of the programme, rather than purchasing and maintaining a server. By sharing a Web server and a high-speed connection, a significant saving can be made on capital and recurrent costs of hardware, software, support and maintenance. Currently, the cost of a virtual hosting system is less than 3% (£100) of the capital costs of establishing a Web server. In addition, recurrent costs (£50-£200) are only 2% of the current costs of running a Web server, depending on the type of the server, speed on connection and the number of users anticipated to access the server each day.

However, in the first model, using a Web server, and also e-mail server, cost is based on the size of enrolment and the number of students expected to access the Web site simultaneously. For example, powerful PC running MS Windows with 200-400 MHz, 4 GB hard drive space and 32 MB would be suitable to serve up to 200 hundred students using a MS Personal Web server. However, these specifications would not be appropriate to serve a much larger number of students (e.g., 1000-5000 students). In this case, using a powerful NT or UNIX system with a small or large business Web server software is required. This type of hardware and software is quite expensive in comparison with the Wired Class Web server.

The fixed costs of Wired Class (capital costs + development costs) is equal to £18,369, for 'model a', and £15,469, for 'model b'. The highest cost incurred in designing and developing Wired Class (whether developing course-independent components or interactive learning materials) was the cost of developing interactive elements (e.g., HTML forms, CGI scripts, animations, etc.). This means that the total cost of a Web-based programme is mainly based on the type and the quality of learning materials. The use of advanced multimedia, and perhaps the streaming capabilities of the Web with audio and video, increases the fixed cost of the programme. These capabilities should be used only if they are necessary and required to achieve the course objectives.

The variable costs of Wired Class are the costs of tuition, site maintenance, Web server maintenance and server connection. Assuming that the on-line tutor needs to spend two hours daily to manage the class, respond to students' questions, and receive, mark and send feedback to students' submitted exercises and 'send to the teacher' tasks at £10 per hour, that the tutor spent 80 hours in eight weeks, and in addition, to update students' records and course materials, the tutor/Web site developer spent 2 hours per week (16 hours during the course), the total cost of tuition, support and site maintenance is £960.

However, assuming that the cost of server connection was £500/months for two months and the rent of a virtual Web server was £50/month for two months, the recurrent cost of running the server is £1,040 for 'Model a' and only £100 for 'Model b'. The total cost of Wired Class is calculated as follows:

Total cost = Fixed costs (capital costs + development costs) + Variable costs (tuition and support costs and server costs)

Using spreadsheets, these costs are calculated , as shown below.

Table 7-9: Costs of Wired Class

Type of costs	Costs (£)	%
Capital costs	3,707 [a] 807 [b]	18.20 [a] 4.88 [b]
Course-dependent development costs	12,347	-
Course-independent development costs	2,315	-
Total development costs	14,662	74.32 [a] 92.28 [b]
Total fixed costs	18,369 [a] 15,469 [b]	93.11 [a] 97.36 [b]
Tuition, support and Web site maintenance costs	960	-
Server maintenance and connection re-current costs [a]	1,040	5.11
Virtual web server re-current costs [b]	100	.60
Total costs [a]	20,369	
Total costs [b]	16,529	
a Model a: Purchasing a Web server b Model b: Renting a virtual Web server		

To estimate the unit cost, the cost per student study hour was found appropriate for cost comparison purposes, bearing in mind the small scale of the present study and for a new medium like the Web (Cukier, 1997). In addition, Rumble (2001) indicated that the most appropriate method to estimate the unit cost is the approach suggested by Hülsmann (2000), which is based on the time that the student spent studying the learning materials. He indicated that this approach can be used by separately dividing 'the cost of developing and delivering a given medium by the number of student study hours the medium gives rise to' (Rumble, 2001).

In Wired Class, the unit cost per student study hour was estimated by looking only at the costs of developing course materials, supporting students and delivery of course materials. Since Wired Class students spent the average time of 10 hours and six minutes to study the course materials (43.28 minutes×14 lessons=10.10 hours) (see Chapter 10), the unit cost of Wired Class varies between £1,264 and £1,357, according to the type of Web server, as shown below (Table 7-10). However, in this estimation, the costs of module-independent (or non-tutorial) components (such the interaction and management tools) and the capital costs of establishing the learning environment (such as the Web server and development software) were not considered in the estimation. According to Hülsmann (2000), these components of the system can be used to serve a huge number of courses and for many purposes without alteration. To consider these costs, the total number of students likely to be enrolled over a number of years (3-5 years) and the life-cycle of the course materials should be considered in the cost analysis, as shown below in the discussion.

Table 7-10: Unit cost per student study hour (costs in pound)

Type of costs	Model a	Model b
Development costs	12,347	12,347
Tuition and support costs	960	960
Delivery costs	1,040	100
Total costs	14,347	13,407
Student study time	10.10 hours	
Unit cost	1,420.50	1,327.43

a Purchasing a Web server model
b Renting a virtual Web server model

7.2.2. Student-related costs (access costs)

According to Hülsmann (2000) 'the use of the Internet also transfers distribution (or, more strictly, reproduction) costs from the institution to the student' (p.13). These including the costs of purchasing computers, Internet connection and phone calls. However, student-related costs are mainly based on the type of Internet connection and place of access. Usually, there are two options for students at a distance to access the on-line learning: using the school's local area network (LAN) or from home, using a regular telephone line. In this study, students accessed Wired Class using their school LANs. The costs of this type of connection are estimated in terms of capital and recurrent costs. The various elements of student-related costs are represented below (Table 7-11).

Table 7-11: The elements of student-related costs

Type of cost	Using school LAN	Cost (£)
Capital costs	LAN with shared modem (infrastructure and computers for 6 students)	16,000
	Network printer	400
	Web clients	0
	Textbooks	10
Recurrent costs	Network operation and maintenance	10% of the LAN cost per year
	Connection charge per minute	.02

Dial-up connection over an analogue telephone network lines is always used to connect school LANs to the Internet. In this way, schools only pay the telephone charges for local calls. Using a school LAN with shared modem, 6 students could access Wired Class at the same time. Considering the market price of computers, LAN with shared modem and printer (to be shared among 6 PCs) as shown above (Table 7-11), the capital cost of access Wired Class via a school network is £16,410. Assuming that Wired Class students (32) used the same school LAN of 6 units to access Wired Class, this means that the call charge for accessing the two modules is £57.60. However, the total recurrent cost of access is £284.30.

It is also possible to calculate the cost of accessing Wired Class from home, as shown below (Table 7-12). Using home access, the recurrent cost is the cost of subscription to a dial-up service plus the local telephone call charge. At the current time, dial-up fees vary between free of charge and £7.00 per month, depending on the current market price. At the same time, many Internet service providers (ISP) offer free access telephone numbers for customers, or local telephone rates (2p per minute). The capital cost per student to access Wired Class from home using a computer with modem (56 Kbps), personal economic printer and telephone line is £690. Assuming that:

1. the computer at home will be used only to access Wired Class;
2. two hours per week are required to access and use Wired Class; and
3. the local call rate is 2p per minute and the dial-up maximum fee per month is £7.00, the recurrent cost of Wired Class per student is £24.80 and the total cost is £714.80.

Table 7-12: The costs of accessing Wired Class from home

Type of costs	Elements	Cost (£)
Capital costs	Computer with modem	600
	Printer	80
	Web client	0
	Textbooks	10
	Total	690
Recurrent costs	Dial-up subscription per month	7
	Call charge per minute	.02

In this regard, two evaluators commented on student-related costs, as follows:

> 'It's crazy to read a text on-line. The resolution is bad. The time can get quite expensive, particularly if you have large graphics'.

Another evaluator agreed with the above point of view. He explained that:

> 'A personal reservation with on-line web based environments is the financial implication for students of the necessity of working whilst connected to the telephone system. Without an off-line reader capability large phone bills can soon be run up by being on line for long periods. That is certainly a particular consideration for the category of undergraduate students in my own studies, those with disabling long term health problems who in many cases work within the constraints of low income'.

These two comments highlighted the relatively high cost of call charges and the importance of offering an off-line version of the course materials and software to be used locally to reduce the costs of Internet connection. In addition, the first evaluator emphasised the need to minimise the size of graphics and pages to reduce downloading time for students who may use their home telephone to access the Internet. To avoid high recurrent costs as a result of paying for phone calls, such a strategy is suggested later in the discussion.

7.2.3. Discussion of cost results

- **Development and delivery costs**

According to Hülsmann (2000), to look at cost-effectiveness of the learning environment and the unit cost per student, 'we need to consider not just the costs of developing materials and supporting students, but also the total number of students likely to be enrolled over a number of years. Only with this information can we work out a cost per student' (p. 9). By increasing the number of students being taught or looking at the total number of students over the course life-cycle, it is likely to find some economies of scale in on-line learning, since the capital fixed costs of development do not increase proportionately with increasing enrolment (Ling et al., 2000), as investigated below.

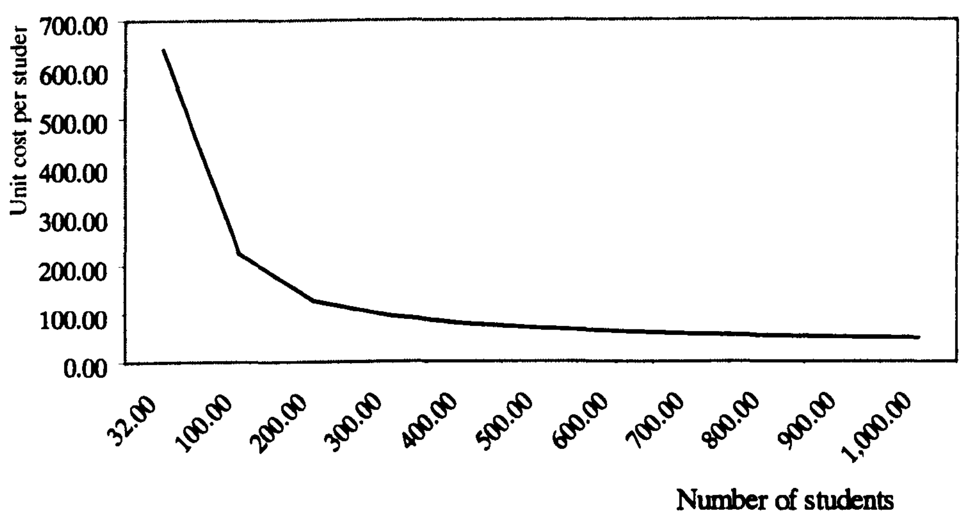
First, when the number of students is low (32 students), the unit cost is £641 per student. However, increasing the number of students to 100 students reduces the unit cost to £225 per student . Using the unit cost formula, the unit costs for different numbers of students is calculated as shown below (Table 7-13).

Table 7-13: The unit cost per student with increasing the number of students

Number of students	32	100	200	300	400	500	600
Total cost	20,529	22,569	25,569	28,569	31,569	34,569	37,569
Unit cost per student	641.53	225.69	127.85	95.23	78.92	69.14	62.62

The economies of scale curve (Figure 7-2) shows that as the number of students rises (from 32 to 1000), the unit cost per student falls. However, the proportion of decline in costs (slope of the curve) is not constant. When the number of students is very low (32 students), the proportion of decline is very high (high slope). Then, as the capital costs of establishing the learning environment (e.g., costs of the Web server, development programs, support and management tools, etc.) and developing learning materials is spread over a growing number of students, the rate of decline slows. The reason is, as the number of students increases, the variable costs (costs of tuition and support, site maintenance and server connection and maintenance) increase and contribute more significantly to the total cost of the programme. However, this contribution depends on the proportion of the fixed costs to the variable costs. If the fixed costs are higher then variable costs, the possibility of obtaining economies of scale increases and the curve will flat out to the right.

Figure 7-2: The unit cost per student with increasing the number of students



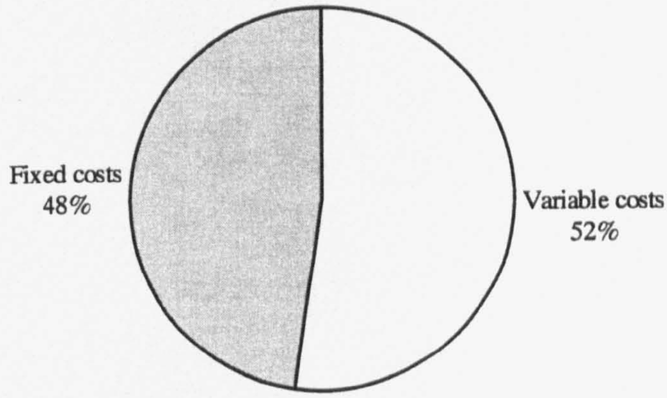
To estimate the proportion of the fixed costs to variable costs, the fixed costs and variable costs over the course life cycle (10 sessions), with the same number of students, are estimated. The analysis of costs shows that the initial capital and fixed costs of purchasing and installing hardware and software, costs of establishing the environment and costs of materials development are spread over the course lifetime (s1 to s10), making only the tuition, support, maintenance, and connections costs to rise (Table 7-14).

Table 7-14: The variable and fixed costs over the course life-cycle

Costs (£)	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	Total
Capital costs	3,707	0	0	0	0	0	0	0	0	0	3,707
Materials development	14,662	0	0	0	0	0	0	0	0	0	14,662
Tuition & Web site maintenance	960	960	960	960	960	960	960	960	960	960	9,600
Server maintenance & connection	1,040	1,040	1,040	1,040	1,040	1,040	1,040	1,040	1,040	1,040	10,400
Variable costs	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	20,000
Fixed costs	18,369	0	0	0	0	0	0	0	0	0	18,369
Total costs	20,369	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	38,369

These ongoing costs over the lifetime of the course would increase its total variable costs dramatically and reduce the ratio of variable costs (£20,000) to fixed costs (£18,369), so economies of scale cannot be achieved easily. In other words, when the variable costs are higher than the fixed costs, or at least the ratio of the variable costs to fixed costs is small, due to the approximation of the fixed costs to variable costs, the potential for obtaining economies of scale is minimal (Figure 7-3).

Figure 7-3: The proportion of variable costs to fixed costs



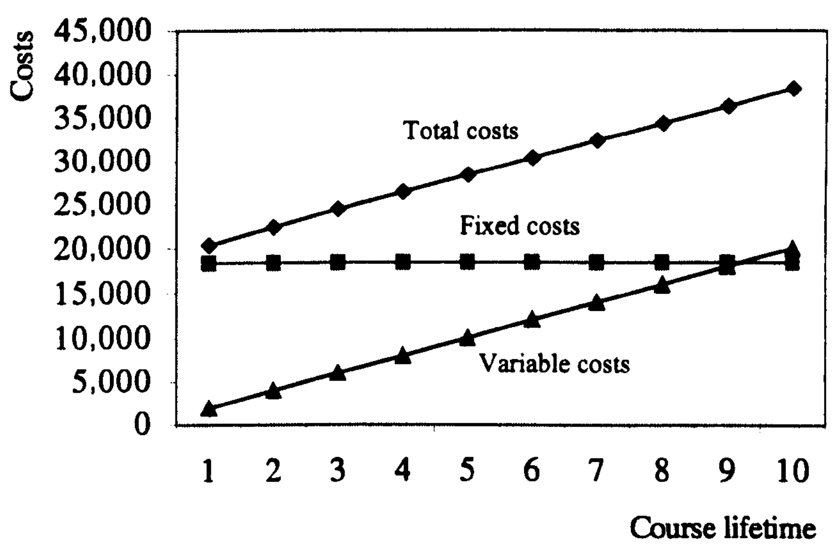
Based on the analysis of the variable and fixed costs over the course lifetime, the cumulative variable, fixed and total costs of Wired Class are calculated using spreadsheets (Table 7-15). The behaviour of both the variable and fixed costs and relationship between them are represented, as shown below (Figure 7-4). This figure shows that although the fixed cost is constant throughout the course, the variable cost slopes directly with the number of students. In reality, due to significant contribution of tuition and support costs, which are higher than traditional tuition costs, this can significantly increase the total costs of the programme and affect 'the economy of scale idea that has always underpinned large-scale distance education systems' (Trentin, 2000, p. 24).

Table 7-15: The cumulative fixed, variable and total costs over the course lifetime

Cumulative Costs (£)	s1	s2	s2	s4	s5	s6	s7	s8	s9	s10
Fixed costs	18,369	18,369	18,369	18,369	18,369	18,369	18,369	18,369	18,369	18,369
Variable costs	2,000.	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000
Total costs	20,369	22,369	24,369	26,369	28,369	30,369	32,369	34,369	36,369	38,369

However, the intersection of the variable costs and fixed costs lines marks a point where the variable cost is equal to the fixed cost of the programme. This point indicates that after enrolling a specific number of students, or running the course for a long period with the same number of students, the variable costs grow to be higher than the fixed costs. After this point, significant economies of scale cannot be achieved because of the cost of tuition and support. Therefore, considerations other than economies of scale need to be taken into account to reduce the contribution of the variable costs to the total costs of the programme.

Figure 7-4: The relationship between the variable, fixed and total costs of Wired Class

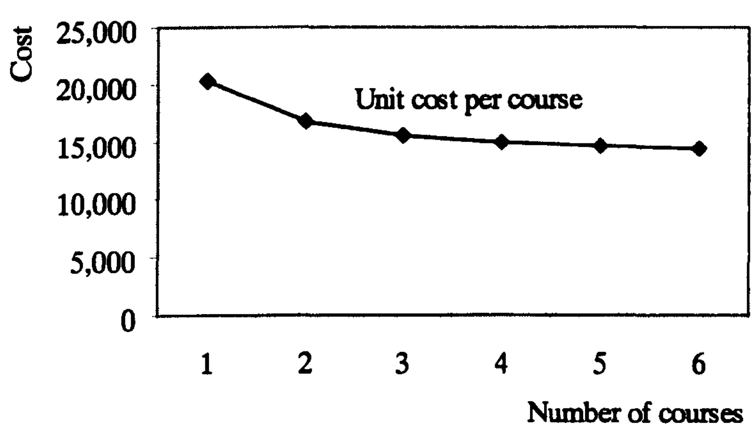


One approach that can be taken into account to reduce the variable costs of on-line learning environments is to add more courses to the on-line class. Adding more lessons to the same server eliminates the additional costs of module-independent components (such as interaction and support tools), distributes the capital costs of hardware and development software (e.g., Web server, e-mail server and HTML editor) over more courses and reduces the unit cost per lesson. Assuming that an additional five courses, similar to the Wired Class course, are added to the same learning environment using the same Web server, the results (Table 7-16) show that as the number of courses increase, the unit cost per lesson falls. However, the rate of decline is not constant and slows as more courses are added (Figure 7-5).

Table 7-16: The unit cost per course with increasing the number of courses

Number of courses	Course 1	Course 2	Course 3	Course 4	Course 5	Course 6	Total
Fixed and capital costs	3,707	0	0	0	0	0	3,707
Course-dependent elements	12,347	12,347	12,347	12,347	12,347	12,347	74,082
Course-independent elements	2,315	0	0	0	0	0	2,315
Tuition and support	960	960	960	960	960	960	5,760
Server costs	1,040	0	0	0	0	0	1,040
Total costs	20,369	13,307	13,307	13,307	13,307	13,307	86,904
Cumulative total costs	20,369	33,676	46,983	60,290	73,597	86,904	-
Cost per course	20,369	16,838	15,661	15,072	14,719	14,484	-

Figure 7-5: Increasing the number of courses reduces the unit cost per course



However, although the above estimations assume that increasing the number of students and courses in the on-line class does not add any additional fixed costs, except for that of developing materials, and most cost items remain fixed regardless of the number of students, Web server and connection costs do not behave as fixed costs with any number of students. In reality, the Web server and e-mail server used determine the number of students who can access the Web site simultaneously. For example, powerful PC running MS Windows with 200-400 MHz, 4 GB hard drive space and 32 MB would be suitable to serve up to 200 students using a MS Personal Web server. However, these specifications would not be appropriate to serve a much large a number of students (e.g., 1000-5000 students). In this case, using a powerful NT or UNIX machine with a large business Web server software is required. This type of hardware and software is quite expensive in comparison with the Wired Class Web server or small business Web servers.

Specifically, up to the delivery capacity of the Web server, the costs of the Web server and Internet connection behave as fixed costs (Figure 7-6). However, beyond a certain number of students and courses, additional cost would be added. These costs would again remain fixed up to the capacity of the new server and connection line. Examples of semi-fixed costs of Web servers are shown below (Table 7-17).

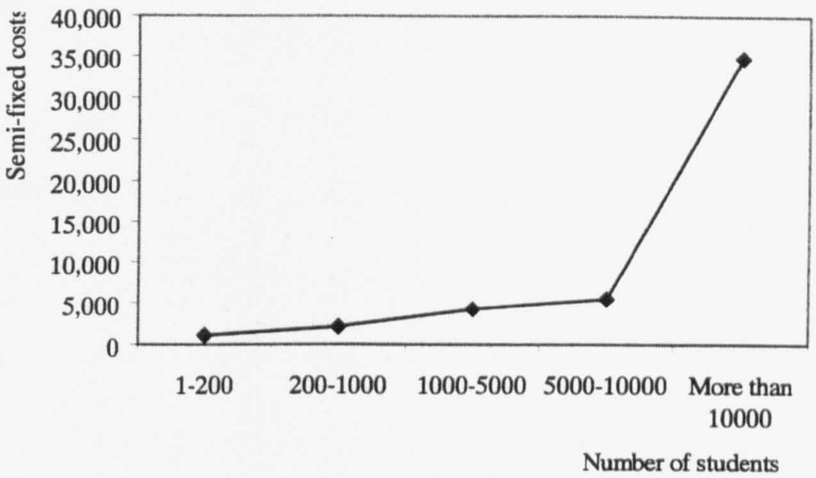
Table 7-17: Semi-fixed costs of on-line learning

Number of students	**1-200**	**200-1000**	**1000-5000**	**5000-10000**	**More than 10000**
Server Hardware	IBM PC	IBM Netfinity 5000 PIII/650 128MB 971YEUK	COMPAQ PROLIANT 3000R PIII/600 154260-031	COMPAQ PROLIANT 3000 PIII 550 NOHD 126747-032	COMPAQ PROLIANT 8000 XE-550 RACKMOUNT 303900-031
Costs (£)	1,000	1,599	2,500	3,550	32,000
Server Software	Personal web Server	MS Exchange CAL 5.5 WinNT CPUP MLP 20 7	NOVELL GROUPWISE 5.5 25 USER CD-ROM 00662644171968	MS Exchange Server V5.5 UPG STD TO ENT V5.5 25U	NOVELL GROUPWISE 5.5 250 USER CD-ROM
Costs (£)	90	500	1,770	2,000	2,840
Total (£)	1,090	2,099	4,270	5,550	34,840
* Costs are based on current market price					

Another approach to reducing the variable costs of on-line learning is to look at the tutor-related costs. The results of variable cost analysis (Table 7-10) show that there is a significant relationship between the tuition and support costs and the variable costs of the learning environment. In Wired Class, only two hours of tuition a day (£800) accounted for 40% of the variable cost of the programme for 8 weeks. This means that reducing the human tuition and support time by 50% (for example) could cut the variable cost of the programme by 20%.

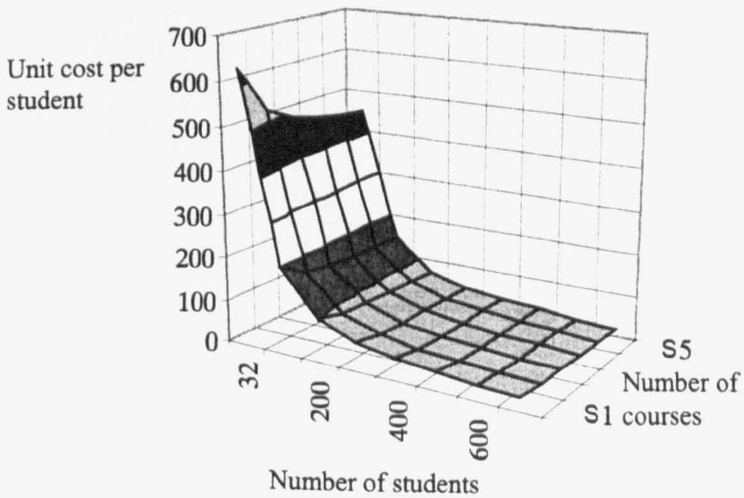
However, although reducing student-tutor interaction and relying on more self-instructional materials and peer support could reduce the tutor-variable cost, it was argued that 'to provide students with a quality education, students need to be given the opportunity for person-to-person interaction. The goals of improving efficiency and improving effectiveness, both of which have been seen to be important in distance education, may therefore, to a certain extent, compete' (Inglis, 1999, p. 225).

Figure 7-6: The semi-fixed costs of the Web servers



Considering the above two approaches to reduce the unit cost per student, it can be concluded that the unit cost of a Web-based learning environment like Wired Class can be minimised to some extent by increasing enrolment per year, adding more courses to the learning environment to cover the fixed capital costs and extending the course life without alteration, with minimum variable costs. For example, teaching the Wired Class course to 700 students with an additional 5 similar courses would reduce the unit cost from £636 to £20.69 per student. Using spreadsheets, the unit costs of different numbers of students and courses are calculated and the relationship between these two factors and the unit cost per students is represented, as shown below (Figure 7-7).

Figure 7-7: The relationship between the unit cost per student and the number of students and courses



- **Costs of access on-line learning using a school LAN**

Although the capital cost of establishing a school LAN is relatively high, this type of connection has many advantages for schools and students, such as:

1. Sharing a single phone line allowing schools to save money on telephone calls;
2. Sharing resources and computers;
3. Monitoring and supporting students; and
4. Ease of maintaining the system.

However, using a simple LAN, with shared modem and telephone line, by 6-12 students, using dial-up offers a low bandwidth connection, which is not suitable to access multimedia resources and sophisticated Web sites. Therefore, new ways were considered to improve the bandwidth and reduce the connection cost.

In the last few years, many protocols and architectures have been invented to provide high-speed and cost-effective connection to the Internet using school LANs. Rothstein (1994) suggested five Internet-networking cost models. These models were suggested to describe the path that many schools can follow. Rothstein stated that:

> 'It is highly conceivable that a school will begin its connection through the low-cost dialup option described in model one. As the school builds expertise and develops a need for greater capability, it will upgrade to a higher model. The fifth model presents the costs for putting a PC on the desktop of every student with a high- speed connection to the Internet' (Rothstein, 1994).

These five models with their current costs and architecture are described below (Table 7-18).

First, although these models are simply presented, Rothstein (1994) assumed that by their simplicity, they could 'provide a less obstructed view of the overall costs for the network'. These models construct a cost-benefit curve for networking schools. This curve is vital for setting a good national policy on connecting schools to the Internet.

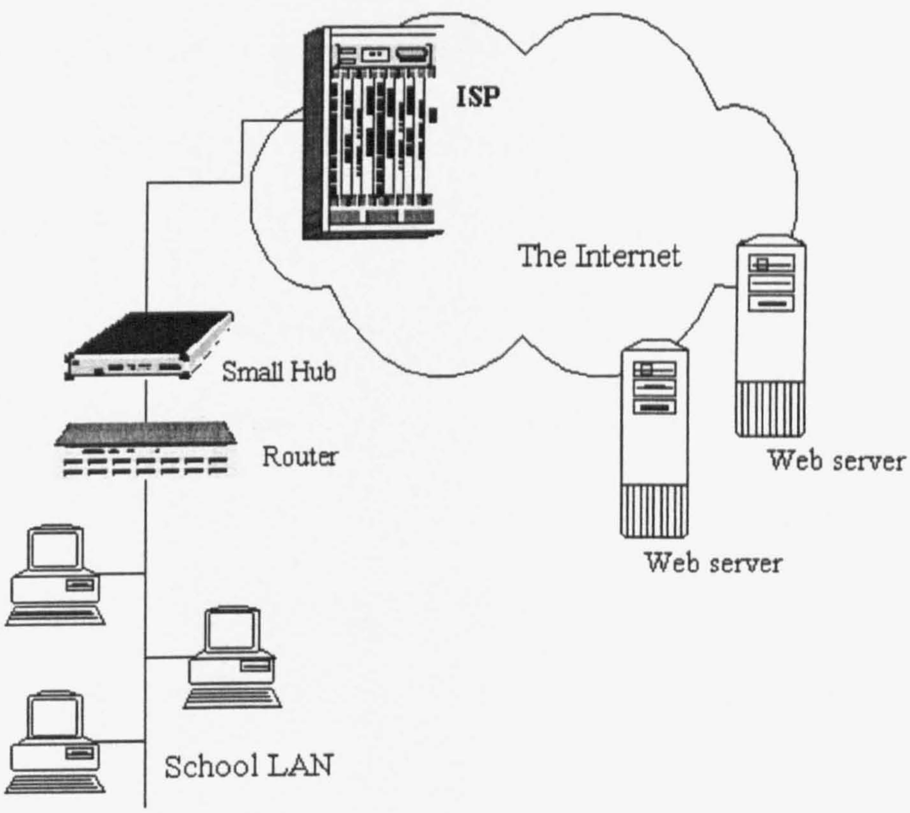
Table 7-18: Internet-networking cost models

Models	Description	Cost-benefit	Cost
Model 1: Single PC Dialup	Represents the most basic connectivity option for a school. The school has no internal LAN within the building. There is a single connection to the district office over a modem (56 Kbps) and standard phone line. Only one user may use the connection at any time.	The lowest cost option for schools and it was only provided as a comparison to the other models. - Computer with Modem (£600) - Telephone line rent (£5 per month) - Internet connection (£7 per month) - Call charge (2p per minute)	Capital: £600 Recurrent: £12 + call charge per month
Model 2: LAN with Shared Modem	The primary difference between this model and first model one is the existence of the LAN within the school. By connecting the modem to the LAN, every computer on the network has access to the Internet. However, this model supports only a few users at a time.	There is a low cost for the LAN. This model assumes the use of copper wire as the medium for the network since it is the most affordable and scaleable option for schools. This model is relatively low-cost model for schools. - 6 Computers (6× £600) - LAN modem (£65) - Copper wires (£100) - Internet connection (£7 per month) - Telephone line rent (£5) - Call charge (2p per minute)	Capital: £3,765 Recurrent: £12 + call charge per month
Model 3: LAN with Router	The primary difference between this model and the former one is the existence of a router in place of the modem. With the router, multiple users of the LAN may access the Internet concurrently. The bandwidth is suitable to access multimedia resources and sophisticated Web sites.	The router allows multiple users of the system allowing the infrastructure to be extended. There are additional dialup lines to accommodate remote access. There are major retrofitting costs for the electrical system, climate control system and better security. Support and training costs are higher since there are additional users of the system. - LAN for 6 PCs (£13,000-16,000) - Router (£100-200) - Connection to Hub 56 Kbps (£100 per month) - Retrofitting (network adapter) (£85) - Call charge (2p per minute)	Capital: £13,185-£16,285 Recurrent: £200 + call charge

Models	Description	Cost-benefit	Cost
Model 4: LAN with Local Server and Dedicated Line	The primary difference between this model and the former one is the existence of a file server at the school. The on-site server allows much of the information to reside locally at the school. This feature provides better performance since much of the information does not need to be fetched over the network. Additionally, the local server allows school administrators to exercise greater control over the information to flows in and out of the school. In this model, higher speed links from the school enable the use of limited video, graphical and text-based network applications.	In this model, virtually the entire school is supported on the network. As a result, the training program is extensive and the support team is well staffed. The costs of the connection to the Internet are also higher due to the larger bandwidth connection. There are major retrofitting costs for the electrical system, climate control system and better security. - LAN structure (£18,000-£20,000) - File server up to 100 PCs (£600-£1,400) - Connection to hub (82p per minute) - Router and CSU/DSU (channel service unit/digital service unit) Interface card for the leased line (£150-£200) - Retrofitting (network adapter) (£85)	Capital: £18,835-£21,685 Recurrent: 82p per minute + phone call charge
Model 5: Ubiquitous LAN W/Local Server and High-Speed Line	This model represents a full, ubiquitous connection to the NII. In this model, there is a PC on the desktop of every student and teacher. There is a high-bandwidth connection to the school to support large numbers of concurrent users of the system. This model supports the full suite of audio, graphics and video applications available over the Internet.	In this model, the entire school is supported on the network. A very large piece of this model is the expenditure for PCs on every desktop. Assuming 500 students, there is a need to Purchase 450 new PCs. Since the network is ubiquitous, the training program is extensive and the support team is well staffed. The costs of the connection to the Internet are also higher due to the high-speed line going into the school. The file server is larger in order to accommodate the large amount of networked PCs. - LAN structure (£18,000-£20,000) – File server up to 100 PCs (£600-£1,400) - Router and CSU/DSU Interface card for the leased line (£150-£200) - Major Retrofitting (£100-£150) - Connection to hub (82p per minute - Leased line rental (£200 per month)	Capital: £18,835-£21,685 Recurrent: Monthly leased line rental + connection to hub per minute

Second, it is obvious that the capital and recurrent costs of using LAN of the high-level models (models 4 and 5) meet the activities of Web-based distance education, expand the bandwidth and perform well to support thousands of simultaneous students, the technical requirements and high-cost may be challenges for schools and students. The recurrent costs, which are usually of greater significance than the initial capital costs, require additional funding for maintenance and administration (Warren and Seaton, 1996). However, the low-level models (models 2 and 3) have low capital and recurrent cost, are easy to be managed at schools and their performance can be enhanced by replacing the traditional analogue telephone lines by high-speed lines from the school to the Internet service provide (ISP), as shown below (Figure 7-8).

Figure 7-8: Low level school LAN with router and small hub



In this case, two types of current fees need to be paid: a routing fee and a line fee. The routing fee is a monthly or yearly fee paid to the ISP. The line fee is the cost of a line from the school to the ISP, which is usually provided by the local phone company. Connection cost depends on the type of connection (low-or high-speed). The high-speed connection to the Internet requires using 'leased line' to link the school LAN to the ISP. Fees for the leased line range from £200 per month (56 Kbps) to thousands of pounds per month for high-speed connection (1,544 Kbps). In addition, the cost of installation depends on the distance between the school LAN and the phone company.

Another high-speed connection but with relatively lower cost is 'Integrated Services Digital Network' lines (ISDN). This type of connection provides rates of up to 128 Kbps, at a cost that is higher than the cost of using old telephone services, that lower than the cost of leased lines. ISDN lines are offered for individuals and small organisation in many countries.

In addition, unlike leased lines, which are paid for 24 hours a day, 7 days a week regardless of their use, the ISDN user is charged like a standard phone line user. However, at the same time, additional cost is incurred to install a 'synchronous interface' (currently from £400 to £800) in a routing computer.

A LAN with shared modem or router (LAN models 2 or 3) of 12 machines serving for 5 hours a day, 5 days a week, offers 300 hours of Internet access per week or 10,800 hours per academic year (36 weeks). The unit access cost using a school LAN to provide maths education for one academic year via Wired Class for years one (3.45 hours/week), two (4.5 hours/week) and three (6 hours/week), with 36 students is £5.04 per hour. Then, the unit cost per student in Wired Class is £71.59.

One solution to reduce access costs is to reduce the on-line time spent by students. Although Wired Class modules were designed to enhance the interaction between the learner and course materials, offering a copy of course materials for off-line study, or a combination of both of them, is necessary to reduce the cost of telephone calls, as evaluators commented. In this regard, the basic content, examples and exercises should be made available in a 'printer-friendly' or PDF (Portable Document Format) version to be printed and used while the learner is off-line. In addition, successful CAL programs (e.g., drill and practice, simulation, calculators, etc.) can be offered for downloading and running locally in the learner's machine.

Lastly, in comparison with the conventional education system and other distance education media, the Web provides many possibilities for decision makers to save in terms of capital costs and recurrent costs. For example:

1. Although the capital cost of establishing Wired Class is relatively high, savings can be made when running courses for five years with minor updates.
2. There are no software costs or annual licence fees, as for CAL courseware.

3. There is no need to pay for using additional communication channels between students and the tutor (e.g., using post or telephone).
4. Updating the course materials is relatively less costly than other media and does not require re-producing or distributing the programme (e.g., printed textbook, television programmes and courseware).
5. There is no need to pay for travelling or accommodation at a distant campus.
6. A huge number of free and useful resources are available on the Web. These resources are designed and maintained by academic institutions or qualified individuals to be integrated with the course content or to support learning.
7. Since students at a distance can access the programme from anywhere in the globe, the delivery costs of Web-based distance education are lower and can be disregarded in comparison with other media (e.g., long distance calls, television and satellite), which use highly costly equipment to transmit and receive the programme.

Chapter 8: Teaching and Learning Functions

Introduction

This chapter attempts to answer the question:

Q3.1. To what extent does Wired Class meet the requirements of teaching and learning in terms of:

Q3.1.1. Course objectives and content;

Q3.1.2. Course materials and resources;

Q3.1.3. Teaching/learning approach; and

Q3.1.4. Learning outcomes?

Since Wired Class students were not able to evaluate many teaching and learning features of the course, as mentioned in the discussion of designing students' and experts' questionnaires in Chapter 6 (Sections 6.6.1.1; 6.6.2.1), the evaluation of many features of learning in this chapter is based only on the judgement of experts. Students served only as participants, not as evaluators. When students served as participants, data related to the quantity of learning outcomes was collected using an achievement test to assess the learning outcomes.

8.1. Results related to course objectives and content

To assess the effectiveness of the design of course content, only, experts were asked to assess the objectives and the quality of course content (Table 8-1). On the positive side, about half of evaluators agreed that the content and related examples were accurate and relevant to both the learning objectives and the learners' needs. A maths teacher commented that:

> 'As a teacher of maths, I think this class material is well organised and relevant to the level of most students in beginning maths classes'.

Another two experts agreed with the maths teacher above:

'This site is incredibly useful for students. Modules contain well-developed lessons. Explanations and the practice material and extra resources seem also very helpful'.

And

'Good use of content to achieve learner growth'.

On the negative side, evaluators claimed that course objectives were not clearly stated in each lesson. A maths teacher argued that:

'The maths objectives should be clearly stated to quickly and easily develop lesson plans'.

In addition, the results showed that the content did not provide sufficient examples in real life situations and the number of exercises was not enough for practising and learning abstract content. Providing a limited number of examples and exercises may give the feeling that students studying from the classroom textbook. A maths teacher indicated that:

'More practice exercises are needed, particularly in the earlier lessons. Students need to feel that more than one textbook was used. Examples are practical and realistic'.

Table 8-1: Evaluators' responses to the objectives and content

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The objectives are clearly stated in each lesson	6	2	2	14	0	33.3	3.00	1.3188
The content is sufficient, accurate and relevant to the objectives	5	8	5	2	4	54.1	3.33	1.3726
The content is developed in accordance to the needs, knowledge and experience of the target learners	4	6	14	0	0	41.7	3.58	0.7755
The content provides real-life examples and situations to facilitate the study of abstract content	3	6	7	7	1	37.5	3.13	1.1156
Examples are relevant to the objectives and the content of lessons	6	7	11	0	0	54.2	3.79	0.8330
Ample exercises are available for practising	5	3	0	9	7	33.3	2.58	1.5581

8.2 Discussion of course objectives and content

Developing the content for distance learning was the first and most important step in conducting the on-line course. However, converting the students' textbook content to Web pages would make them no more than a digital version of the textbook and not suitable for independent study at a distance. Therefore, considerable time was spent in converting the original content to on-line format. For example, in discussion topics and examples, the content was presented as a means or resource to an end, rather than as an end in itself.

At the beginning of many lessons, basic/new concepts and definitions were presented to students to help them acquire and construct new meaning. Moreover, discussion boards offered the chance to them to clarify their learning and understand others' views. In addition, the pedagogical principles of constructivism (e.g., social interaction, interactivity and students control) were implemented to motivate learners and enhance learning (using different types of resources and exploration tools like graphical calculators) to achieve high-order objectives (using problem solving situations).

Since the objectives of each lesson were not clearly presented to students throughout the content of each lesson, the evaluators were not satisfied with the statement of course objectives. The importance of stating course objectives is that it helps both the teacher and students to plan, suggest and develop course activities, as well as evaluating learning outcomes. In addition, this issue was highlighted since the content was not structured or translated into traditional fixed learning steps, as in the behaviourist approach.

Second, in terms of the quality of content, although the maths content was recognised as accurate, and able to serve the objectives of learning and interesting to students, re-writing the content for the Web, with constructivist epistemology in mind, required adding more debates and problems to challenge students, encourage discussion and exchange information among students.

Third, using various well-selected, real-life examples for distance students could help students to focus on the new concepts being presented and to understand difficult issues, by applying them in new ways. According to students' and evaluators' responses, although examples were relevant to the objectives and the content of lessons, more real-life examples were needed to offer the chance to students to use and practise new concepts and skills and bring the subject into a content which they could understand.

In addition although the exercises were very useful and relevant to students' ability level and expectations, in the evaluators' opinions, there were insufficient exercises provided for practice at the end of each lesson. Therefore, more exercises were needed, particularly for students who study at a distance. However, in Wired Class, to meet this need, many Web resources contained various self-tests and exercises were linked to certain lessons and students were asked to visit these sites for more practice, if needed.

8.3. Results related to course materials and resources

To investigate students' satisfaction with the course content and resources, students were asked to rate the design of course content and materials (Table 8-2). The results showed that students appreciated the way the lesson content was broken into chunks (lesson, further examples, self-test, links, discussion and send to the teacher). They thought that this approach made lessons simple and easy to follow. One student commented that breaking down lessons into chunks and providing link to each chunk allowed him to access any part without restarting from the beginning.

> 'the buttons [or links] to all sections [or chunks] are good. This allows me to read all sections quickly'.

In terms of clarity, more than 87% of students indicated that graphs, figures and mathematical formulae clearly presented the content. In addition, most students enjoyed interaction with the content (via hyperlinks, CGI forms and interactive graphs) and responding to the self-tests.

Students commented that:

1. 'Your animation graphs are really nice';
2. 'The graphs and animations are excellent'; and
3. 'I liked the readings and graphs of Wired Class'.

Table 8-2: Students' responses to the quality of course materials and resources

Statement	Response Distribution					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
Dividing each lesson into parts (lesson, examples, self-test and exercises) helps me to study and understand its content.	13	13	5	1	0	81.25	4.19	0.8206
The graphs and mathematical formulae are clearly presented.	10	18	3	0	1	87.50	4.1250	0.8328
I like the way in which the lessons are presented (links, self-tests, interactive graphs).	18	11	2	1	0	90.06	4.4375	0.7594

In addition, evaluators were asked to respond in depth to seven statements concerning the design of course materials and resources (Table 8-3). Responses and comments from evaluators indicated their appreciation of the approach used to organise and represent the content in chunks and using images to represent mathematical formulae. In terms of the quality of content, the majority of evaluators (79.1%) indicated that lessons were logically organised in segments. An evaluator indicated that:

> 'It is a brilliant idea to organise the content into segments (lesson, exercise, etc.), very helpful to on-line students'.

Also, mathematical graphs and formulae were clear and accurate (54.1%). However, an evaluator criticised the use of images to display formulae when he asked whether multimedia objects and graphics are used effectively or not. He said:

> 'I thought it is useful to use plain text and graphics. Equation editors tend to be a painful experience; so I use photo programs to yield good looking GIFs. But these programs will fill your hard disk'.

In addition, evaluators argued that the course content did not exploit the multimedial capabilities of the Web to enhance the learning process. For example, an evaluator commented that

> 'As a teacher of online math classes, I think you need to improve understanding through interactive multimedia objects'.

In terms of the quality of resources, evaluators (66.7%) indicated that resources were logically categorised (and the objectives and content of resources were well-described

(86.7%). However, less than 40% of evaluators believed that resources were appropriate for the learners' needs and course activities.

Two experts indicated that, overall, the 'Links' section and the on-line library introduced students to useful Web resources:

1. 'Good collection of maths links. Very useful!';
2. 'The links to web sites were excellent'.

However, two judges criticised the quality of content and the level of information provided by these sites:

1. I found many good web sites but they are difficult to read. I like sites that have pictures and fun things'; and
2. 'I think these class resources are above the level of high school students'.

Table 8-3: Evaluators' responses to the quality of course materials and resources

Statement	Response Distributions					N	% Choosing SA or A	Mean	Std. Deviation
	SA	A	N	D	SD				
Multimedia objects are used effectively throughout the duration of the course to support the learning process	3	3	6	7	5	24	25.0	2.67	1.3077
Lessons are logically organised in segments (e.g., examples and self-test)	14	5	5	0	0	24	79.1	4.37	0.8242
Graphs, figures and formulae are clear and accurate	5	8	8	3	0	24	54.1	3.62	0.9696
Resources are suitable for the learners' level	3	3	8	0	1	15	40.0	3.47	1.0601
Resources are appropriate for the course activities	1	3	8	3	0	15	26.7	3.13	0.8
Resources are logically categorised	4	6	5	0	0	15	66.7	3.93	0.7988
Objectives and content of resources are well described	7	6	2	0	0	15	86.7	4.33	0.7237

8.4. Discussion of course materials and resources

First, although the design of learning in Wired Class is based on constructivist epistemology, there was a need to organise the course content in a 'conventional' and flexible way. To achieve this goal, each lesson was segmented into many parts (the lesson, further examples, self-test, exercises, etc). Every part was logically segmented into further small chunks, each representing one concept, skill or problem. This style of design was found very useful by both Wired Class students and evaluators.

In addition, designing back and forward hyperlinks became easier with using this approach. For example, instead of being asked to go back and study a specific concept or example, the learner would be advised to go back only to a specific section (e.g., examples or discussion topic). In other words, this approach facilitated interaction between the tutor and students and made it easy for the tutor to send feedback.

Although an evaluator suggested that it would be better to rename lessons (in the left-hand expanded menu) by their names (e.g., linear functions) instead of as 'the lesson' title, the expanded menu was designed only to display the names of the segments (e.g., lesson, further examples, etc.) to familiarise students with the construction of the modules. However, each page was titled by the lesson's name, in the upper left-hand frame, allowing students to know the name of the current lesson.

Second, in terms of the quality of visuals (including figures and graphs), Wired Class used images in GIF format to display figures, graphs and mathematical formulae. Using this format, still and animated images of reasonable resolution and small size were generated for the Wired Class. Although there are many other approaches to generate and display mathematical formulae in HTML pages, at this time, GIFs were found to be more cost-effective and represented good-looking and accurate formulae. Other approaches (e.g., HTML maths tags, Java formulae generators, Java Scripts and browser add-ins) provide inaccurate results, have large size components and require a long time for downloading or need additional software to be added to the Web browser. However, the only drawback of using images (in GIF or JPEG format) was the large amount of disk space they took up in the Web server.

Third, in terms of the quality of Web-based resources, although Wired Class offered many well-selected, organised and described resources for learners, the feedback from evaluators, as reflected in their questionnaire, revealed that many resources were above the ability level of learners and did not cover the intended topic comprehensively. In addition, despite the ease of use and enormous Web resources, finding and integrating these resources in the school curriculum was not an easy task, particularly for young students. Using search engines and directories to find documents that have exactly what the students need, on the one hand, and match the learning objectives, on the other, was very time consuming and required many skills and filtering of the resources, as mentioned in the section on the results on access (Chapter 7).

Moreover, the experience gained during developing Wired Class materials and resources emphasised that the successful use and integrating Web resources in learning environments would require more than just seeking for appropriate information and linking it to the relevant lessons. Resources should be analysed and considered from the earlier stages of instructional design, not at the later stages.

Lastly, Wired Class received much criticism because of the lack of multimedia objects used throughout the course materials to support the learning process. In Wired Class, the use of this type of multimedia objects was limited by:

1. students' type of connection and hardware capabilities;
2. the high costs of developing audio and audio elements; and
3. the nature of the subject matter, which is heavily based on text, symbols and graphs.

However, at the same time, low cost and more efficient hypermedia objects were used throughout the course, content including animated GIFs images and interactive Java applets. These media captured the interest of students (the buttons to all sections are good, your animation graphs are really nice, etc.) and illustrated many abstract concepts in the subject matter.

8.5. Results related to teaching/learning approach

In this section, the evaluation is based on the judgement of experts only. However, students were used as evaluators and participants to assess the effect of this approach on learning outcomes, as shown in the next section. First, evaluators were asked to evaluate, rate and comment on the implementation of the main principles of the constructivist approach in learning (Table 8-4).

The results showed that student-teacher interaction (using send to the teacher tasks, ask the teacher and teacher's page), student- student interaction (using discussion boards and presentation board) and student-content interaction (using interactive input forms, hyperlinks, and interactive learning aids) were facilitated successfully through the design of course content and activities by:

1. challenging the student's thinking to play an active role in assimilating knowledge;
2. facilitating interactivity by enabling students to work co-operatively;
3. providing students with active problem-solving situations to construct their own knowledge;
4. encouraging students to present, discuss and evaluate their work and peers' work;
5. implementing student-centred activities throughout the course;
6. monitoring students' on-line activities and performance and guiding them during learning; and
7. using formative evaluation to assess students' progress.

However, although evaluators believed that discussion board is a good tool for peer interaction, an evaluator argued that students should take more opportunities to suggest and construct their own discussions:

> 'Many discussions but students have to be able to open new discussions on their own'.

However, evaluators' comments showed that Wired Class implemented and supported many constructivist principles by engaging students in problem solving activities, encouraging them to exchange ideas and explore their own path rather than encouraging students to master learning objectives in a behavioural/linear approach.

> 'Possibly a good feature of Wired Class is that it can support a constructivist approach to learning [...] specifically, each module takes a constructivist approach, building first principles rather than the more behaviourist model which predominates across the Web'.

However, an evaluator commented that the design still has many elements of behavioural learning (linear approach):

'I can see elements of constructivism throughout the site and I think the basic design is behavioural in the way it is broken down into individual elements'.

Table 8-4: Evaluators' responses to the teaching/learning approach (N=21)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The design of course content challenges the student to play an active role in assimilating knowledge	8	5	5	3	0	61.90	3.86	1.1084
The design of learning provides many opportunities for interactivity by enabling students to work co-operatively	7	7	4	3	0	66.67	3.86	1.0623
Discussion boards are well utilised to improve learning	6	3	7	4	1	42.86	3.43	1.2479
Students are engaged in active problem-solving situations to construct their own knowledge	5	8	3	2	3	61.90	3.48	1.3645
Students are encouraged to present and discuss their work and evaluate the works of peers	12	7	1	1	0	90.40	4.43	0.8106
Student-centred activities are implemented throughout the course	5	6	7	3	0	52.40	3.62	1.0235
Student's performance and progress are monitored throughout the learning process	12	6	0	2	1	85.70	4.24	1.1792
Formative assessment is well utilised in the course	12	7	2	0	0	90.40	4.48	0.6796

8.6. Discussion of teaching/learning approach

The purpose of this section is to investigate whether the teaching/learning approach was implemented successfully or not, and how. If this approach was implemented successfully, this would mean that there is a high possibility for meaningful learning to occur. Overall, the feedback obtained from experts indicated that the constructivist epistemology was found appropriate to design interactive instruction for on-line learning. In addition, they argued that constructivist approach might be more effective than behavioural approaches, particularly when the principles of constructivism were implemented successfully

First, according to constructivists, learning can be done successfully when students participate in individual as well as social activities, encounter and solve problems, interact with others, exchange information and evaluate their understanding. These activities allow students to construct their own learning in a meaningful way. The results showed that, in Wired Class, there were many opportunities to engage students in these activities. For example, according to evaluators' feedback, Wired Class offered and combined many successful elements of constructivism to facilitate interaction via e-mail and discussion boards and search for on-line resources.

In addition, problem-solving and social interaction are the two most important constructivist factors considered in designing learning. According to evaluators' comments, the design of learning exploited the nature of the subject by involving students individually in many real-life problem-solving activities through self-tests, exercises and discussions. Through social interaction, students could learn others' points of view and assess their own understanding. According to evaluators' comments, discussion boards would be one of the most useful tools for conversation, if they used effectively in constructing the meaning and correct any misunderstanding. However, the major drawback of Wired Class discussions was that they were presented as separate chunks at the end of each lesson and students need to be advised to take more active role by suggesting discussion topics and participate more positively.

However, although evaluators criticised the implementation of elements of the behavioural approach, in a constructivist learning environment, it could be argued that learning mathematics requires this type of learning, that begins by learning basic facts and concepts as well as constructing new meanings and solving problems. In designing the maths modules, it was necessary, in many lessons, to commence them by recalling or introducing new and essential concepts in small chunks, followed by self-answered questions.

8.7. Results related to learning outcomes

To assess the learning outcomes of Wired Class, students were used as evaluators and participants. First, using students as evaluators, they were asked whether they had learned from the course, understood the content and could answer the exercise tasks easily (Table 8-

5). Students (56.3%) believed that this course helped them to understand the subject matter and they were able to answer maths problems easily after studying each lesson. Four comments provided by students (all of them were positive) indicated that they were totally satisfied with the learning they achieved within Wired Class.

1. 'The course is excellent and better than the [conventional school] book';
2. 'Very good program. I learned a lot';
3. 'Please, more modules, I will use this Web site'; and
4. 'This is a good class. I'm happy that I have attended it'.

Table 8-5: Students' perceptions of perceived learning

Statement	Response Distributions					% Choosing SA or A	Mean	Std. Deviation
	SA	A	N	D	SD			
Wired Class helps me to learn and understand this subject.	6	12	0	10	4	56.3	3.19	1.4013
I can answer exercises easily after studying each lesson.	4	12	3	12	1	50.0	3.19	1.1760

Second, using students as participants, two issues were investigated:

1. The overall achievement of Wired Class students compared to traditional classroom students; and
2. The quality of learning outcomes of Wired Class students compared to traditional classroom students.

To assess the effectiveness of Wired Class in the treatment group's learning, a two-part achievement test was administered to the two groups at the middle and the end of the experimental study. To compare between the two groups' achievement scores, the test was considered as a norm-referenced test and the means of the two groups were compared using the mean and t-test.

Using SPSS, the mean and the independent samples *t*-test were used to investigate the central tendency and the significance of the difference between the means of the treatment and control groups in the achievement tests. The independent samples *t*-test was used since it was assumed that the population was normally distributed, the data were interval in nature and there was one independent variable (teaching method) and one dependent variable (students' achievement).

Levene's test for quality of variances was used to estimate the standard error of the difference in means of the population. 'Levene's test' is a one-way analysis of variance on the absolute deviation scores of the groups where the group mean is subtracted from each of the individual scores within that group' (Bryman and Cramer, 1997, p. 144).

The overall view of the achievement test scores for both the control group and the treatment group is presented in a histogram depicted with its normal curve which describes the distributions of students' scores (Figures 8-1 a; 8-1 b). The mean values for each group are indicated with dashed lines hitting the score axis. The figures show that the distribution of scores for each groups is negatively skewed (-0.46 and -0.42 respectively) and the scores tend to cluster to the maximum score.

Figure 8-1 a: The scores distribution and mean of the control group

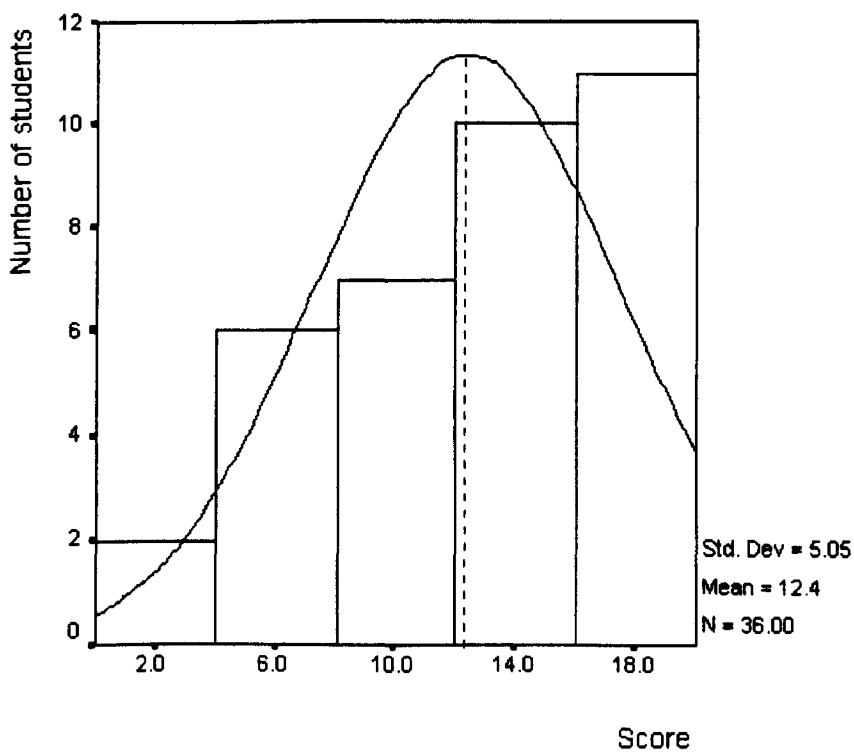
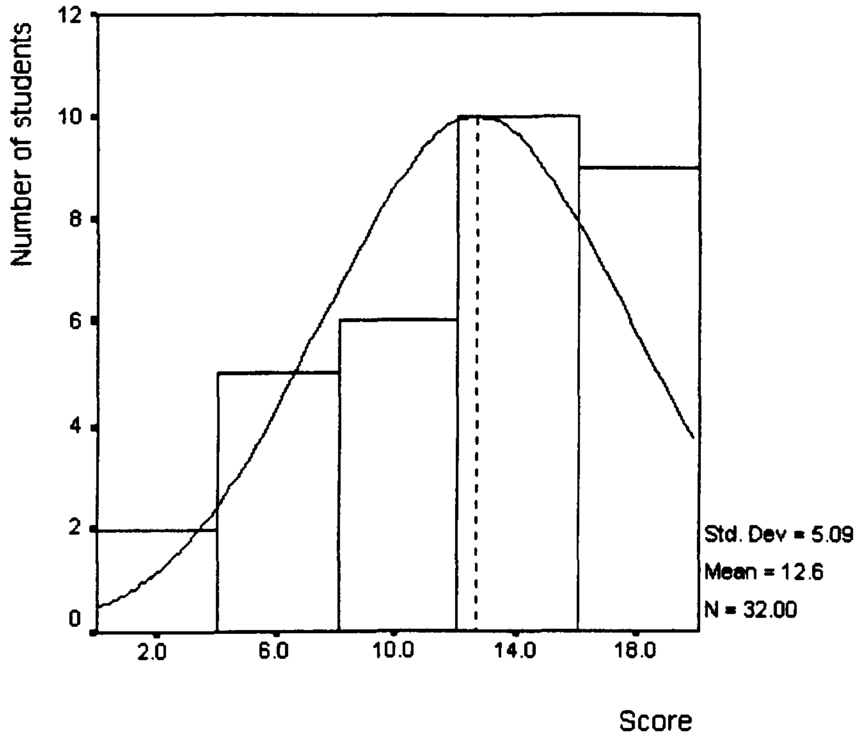


Figure 8-1 b: The score distribution and mean of the treatment group



The mean of the achievement test score for the control group was 12.36 (61.81%) and for the treatment group 12.59 (62.97%), a difference of 0.23. The numbers of cases in the two groups, together with their means, standard deviation and standard errors, are shown below (Table 8-6).

Table 8-6: The mean and the standard deviation of the control and treatment groups

Group	N	Mean	Std. Deviation	Std. Error Mean
Control	36	12.3611 (61.81%)	5.0549	0.8425
Treatment	32	12.5938 (62.97%)	5.0934	0.9004

A *t*-test of independent samples, using the students' scores in the achievement test as the independent variable, was used to determine the potential statistical significance of the differences. Using Levene's test, the difference between the variances of the two groups was statistically significant, since the value of Levene's test was 0.019 (Table 8-7). Consequently, the t value based on unequal variances was considered. This was non-significant with a two-tailed value of 0.851 at 0.05 level of confidence. Therefore, it is concluded that there was no significant difference in mean achievement between control and experimental groups.

Table 8-7: Independent samples t-test

Variance	Levene's Test for Equality of Variances		*t*-test for Equality of Means				
	F	Sig.	*T*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	.019	.8915	-.189	66	.851	-.2326	1.2325
Equal variances not assumed			-.189	64.95	.851	-.2326	1.2331

Although the norm-referenced approach is useful for comparison purposes, comparing between students' mean scores is not sufficient. Obtaining the same/different means does not mean the two groups are similar/different in achieving high/low level objectives, and students' scores in a norm-referenced test do not provide a detailed view of students' performance or describe their performance in terms of what they know and what objectives they have mastered.

Criterion-referenced assessment tells us how well the treatment group achieved the stated goals, rather than just telling how their performance compares to that of the control group. Therefore, a criterion-referenced assessment was used to describe and compare the control and treatment groups in the light of the mastery of different learning objectives covered in the test.

Considering the types of learning objectives defined in Section (5.1.3), on the one hand, and the weight of each objective in the achievement test as mentioned in Section (6.2.1.), on the other, students' scores were assessed on the basis of four types of objectives: recall, conceptual structure, skills and problem-solving. The criterion-referenced scores were presented in terms of the percentage of students who have mastered each objective. Fifty and eighty cut percent (as the most common cut percents) are used to report students' achievement. Since this research aims to compare between two groups, even criterion referenced test results could be evaluated on a comparison basis (Tuckman, 1994).

To investigate students' scores and compare between the two groups, scores were obtained and compared using percentages, the mean and *t*-test in each objective. In this section, students' results are reported using the percentages of the treatment group students who mastered each objective at the 50% and 80% cut scores. The percentages of the control group students follow in brackets. First, 65.63% (66.67%) of students obtained 50% or more in the recall objective as covered in the achievement test. However, 28.13% (19.44%) of students mastered this objective at 80% cut score. Second, 59.38% (63.89%) of students obtained 50% or more in the conceptual structures. However, only 28.13% (36%) of students mastered this objective at 80% cut score. Third, 78.13% (72%) of students obtained 50% or more in the skills. However, 46.88% (53.13%) of students mastered this objective at the 80% cut score. Fourth, 68% (66.67%) of students obtained 50% or more in the problem-solving objective. However, 21% (28.13%) of students mastered this objective at the 80% cut score (Figures 8-2; 8-3).

Figure 8-2: Percentages of students achieving the learning objectives at 50% cut score

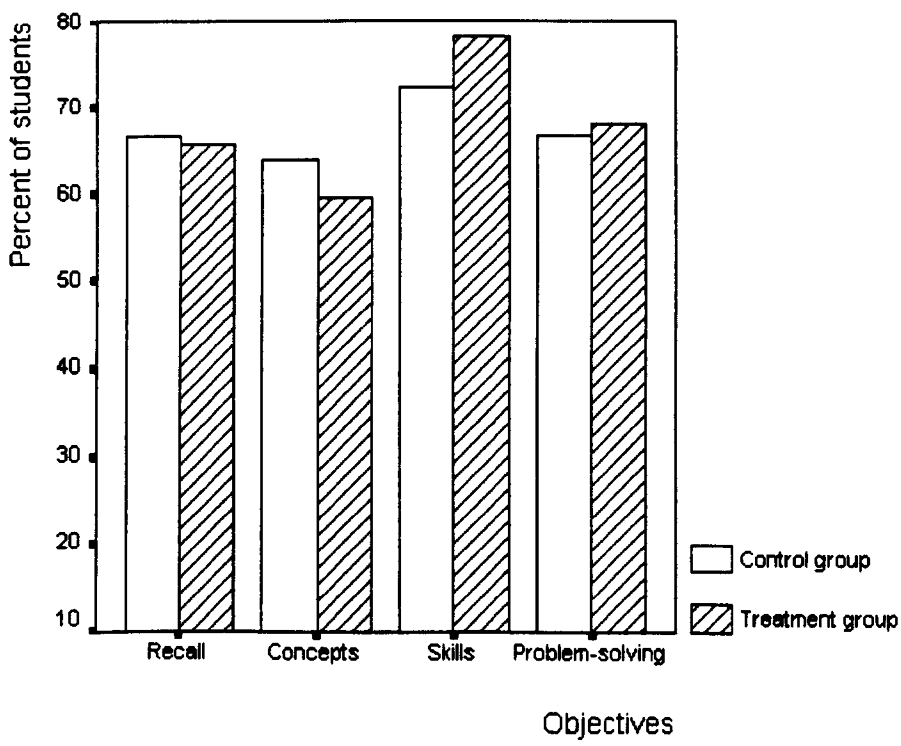
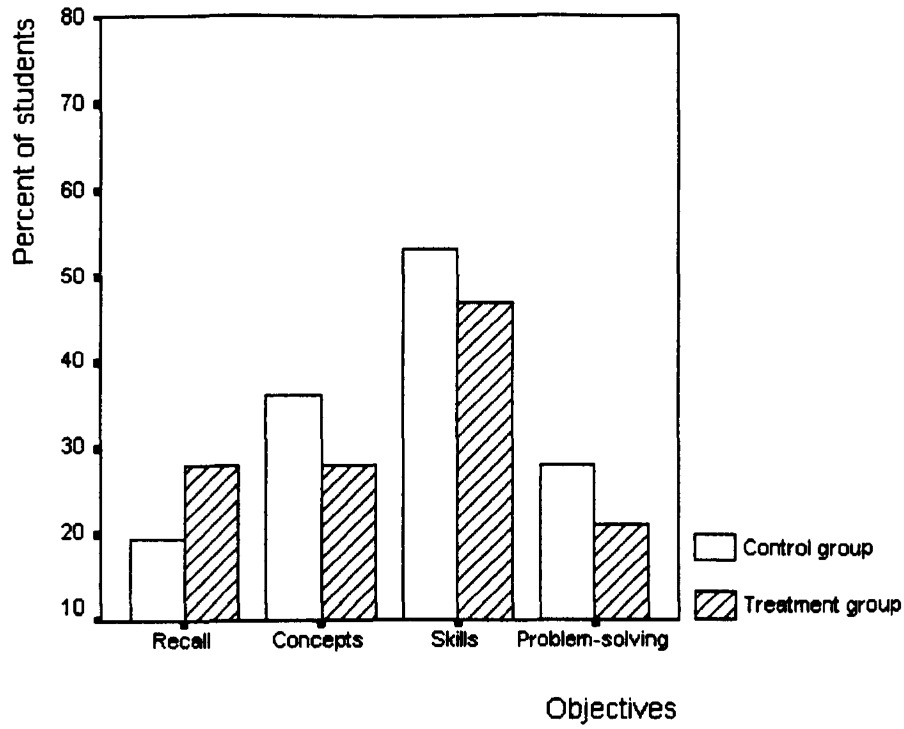


Figure 8-3: Percentages of students achieving the learning objectives at 80% cut score



As shown in Figure (8-2), the area in which the lowest percentage of students who achieved the objectives at the 50% cut score was conceptual structure. However, the majority of students achieved the skill objectives, followed by the problem-solving and recall objectives. Figure (8-3) shows that the area in which fewest students mastered the objectives at the 80% cut score was the problem solving, followed by recall, conceptual structures and skills.

Table 8-8: The mean and the standard deviation of the control and treatment groups

Objectives	Group	N	Mean	Std. Deviation	Std. Error Mean
Recall	Treatment	32	61.46	31.8029	5.6220
	Control	36	62.04	24.1066	4.0178
Conceptual structure	Treatment	32	55.58	34.3631	6.0746
	Control	36	57.78	29.5146	4.9191
Skills	Treatment	32	66.99	23.6124	4.1741
	Control	36	66.67	27.9908	4.6651
Problem-solving	Treatment	32	59.57	26.9868	4.7706
	Control	36	57.64	26.4369	4.4061

Although the percentages of students who mastered the learning objectives differed between the two groups, considering Levene's test for equality of variances, the *t*-test results indicated that there was no statistically significant difference between the means of the control and treatment group students in the four learning objectives (Tables 8-8; 8-9). The research question, 'Does the quality of learning outcomes differ between Wired Class students and traditional classroom students? is answered 'no'.

Table 8-9: Independent samples *t*-test

Test		Levene's Test for Equality of Variances		*t*-test for Equality of Means				
Objectives	Variances	F	Sig.	*T*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Recall	Equal variances assumed	2.649	.108	-.085	66	.932	-.5787	6.7995
	Equal variances not assumed			-.084	57.473	.934	-.5787	6.9101
Conceptual structure	Equal variances assumed	2.225	.141	-.283	66	.778	-2.1946	7.7464
	Equal variances not assumed			-.281	61.546	.780	-2.1946	7.8165
Skills	Equal variances assumed	.878	.352	.051	66	.959	.3255	6.3232
	Equal variances not assumed			.052	65.834	.959	.3255	6.2599
Problem-solving	Equal variances assumed	.035	.852	.298	66	.767	1.9314	6.4861
	Equal variances not assumed			.297	64.728	.767	1.9314	6.4941

8.8. Discussion of learning outcomes

In the last few decades, much research has been done to compare the effectiveness of different types of media in students' achievement as the most important variable, particularly for decision-makers. Often, the research outputs are represented in terms of students' perceived learning and the actual achieved learning. In terms of students' perceived learning, students believed that the course was a very useful and efficient way of learning. In addition, the results obtained from the achievement test confirmed that learning via Wired Class could be as effective as face-to-face teaching in the traditional classroom. These results seem to be in-line with Clark's (1994) conclusion that:

> 'Distance learning media are vehicles that transport instruction to students. The choice of vehicle influences the important outcomes of student access, and the speed or cost of the delivery but *not* the learning impact of the instruction that is delivered to the consumer' (pp. 65-66).

However, judging students' achievement using only norm-referenced scores was not enough. Criterion-referenced scores were used to investigate students' ability to achieve lower- as well as higher-order learning objectives (e.g., recall and problem solving). Although the results indicated that there were no significant differences between the overall scores of the control group and treatment group in lower- and high-order learning objectives, it was found that there were observable differences between the percentages of control group and treatment group students who mastered recall, conceptual structure, skills and problem-solving objectives at the 80% cut score. This high percentage of students who obtained scores of 80% (or more) in high-order objectives was found in the control group. However, Wired Class students made progress only in the recall objective, as a low-order objective of maths education.

Interpreting the above results and the effect of Wired Class on learning outcomes requires understanding of how it was used to deliver instruction, the teaching/learning approach used and the learning objectives. In addition, it requires analysing students' logs and understanding the factors that affected learning. These procedures are very useful in understanding the above results and improving the design of further distance education environments, as shown below.

In Wired Class, learning was designed in a richer and more informative way than teaching in the traditional classroom. Students could access new and different types of Web resources, solve algebraic problems using interactive graphical calculators and graphs, discuss the results with each other, communicate with the tutor and receive immediate feedback.

In addition, course content was accessed and learned in a flexible way in which students had control over the sequence or path of learning. They could choose, skip or ignore a specific topic, example or such activity. In addition, students had many Web resources to access and use in learning, and were given opportunities to construct their own meanings using discussion boards and interactive graphical calculators and active images, interact with the material and their classmates and evaluate their learning using 'self-tests' and 'send to the teacher' tasks. According to many recent studies (e.g., McAlpine, 2000; Smith-Gratto 2000), exploiting the principles of constructivism may enhance the Web-based learning experience, support learning of high-order objectives and motivate learners more than other traditional approaches (e.g., tutorials and behaviourism approaches).

Although the Web has greater capability to support instruction using constructivist principles (e.g., social interaction and problem-solving activities, searching for and verifying information, constructing individual understanding, etc.), as reflected on the writing of Strommen and Lincoln (1992), Bannan and William (1997) and Smith-Gratto (2000), many difficulties faced the Wired Class students in exploiting constructivist learning. For example, first, an important attribute of constructivism is encouraging students to explore and construct their own meaning by providing open-ended topics for discussion and information exchange. However, most students did not participate actively in these tasks, as discussed in detail in the next chapter.

Second, although Wired Class facilitated open-ended exploration of resources, most resources were found not suitable to students. In addition, they did not allow students to focus on the learning objectives or find the information that fitted into their existing experience in the subject, as mentioned above. In addition, although most of Web resources were selected and evaluated by the tutor, students might not have the skills to find and perceive the right information they need to use in their learning.

Third, since social interaction is an essential principle of constructivism to exchange information, construct meaning and carry out complex mental processes (such as problem solving), implementing this principle successfully is necessary to achieve high-order objectives. In Wired Class, quantitative and qualitative analysis of students' messages revealed that when students did not participate positively and the number of messages was significantly lower than expected, the content of messages was superficial (such as repeating information in other messages, rather than commenting, accepting or rejecting others' views and opinions with or without explanations, judging the relevance of solutions provided by others or drawing conclusions were rarely performed, etc.), the quality of both social and cognitive interaction among students was very poor and no actual benefit was gained from implementing constructivist approach.

According to students' perceptions, the on-line tutor and the auto-feedback system were more effective than other approaches in providing feedback and support. This support was as effective as the traditional classroom in helping students to learn new concepts and improving students' ability to achieve recall objectives, rather than high-order objectives (such as problem-solving). Therefore, it was not surprising to find that there was no significant difference between the two groups in overall achievement or achievement of low-order and high-order learning objectives.

Chapter 9: Interactivity and User-friendliness

9.1 Interactivity

This section attempts to answer the main research question: How do students interact via Wired Class? To answer this question, first, quantitative analysis was used to account for the number and lengths of students' messages and analyse by whom they were sent, time of log-on and the relationship between the number of messages and other interaction and instructional factors, such as the tutor's participation and cognitive demands of discussion topics.

Second, a qualitative analysis approach was used to analyse the interaction content according to educational criteria, then draw conclusions about the educational value of this activity. To analyse students' responses, a coding system was constructed based on research in computer conferencing and discussion content analysis (Mason, 1991; Henri, 1991; Fulford and Zhang, 1993; Berge, 1997). After development of the coding system, messages were printed out and each message was divided into units of meaning. These units were analysed in relation to communication and content to answer the research questions, as shown below:

9.1.1. Results of quantitative analysis

Although interaction between the tutor and students and among students was conducted through asynchronous as well as synchronous channels using discussion boards, e-mail and chat rooms, the initial analysis of students' logs showed that discussion boards were the only place in which informative, formal, regular and directed course-related interactions were held. Although chat rooms offered the opportunity for real-time interaction and could help students to clarify their understanding of a topic instantly (Smith-Gratto, 2000), they were not implemented successfully in Wired Class.

Wired Class records and students' feedback revealed that conducting and facilitating synchronous interaction via chat rooms required planning and determining the time of chatting in advance using other medium, such as e-mail. However, since students are different in their abilities and rates of progress, it was difficult for many of them to manage their time to join real-time discussions about a particular topic. In addition, students could not arrange for chat sessions themselves, since they could not find peers who had time for real time conversation or who were interested in the same discussion topic, as shown from students' feedback below.

In addition, problems of access to chat rooms, occasional Internet connection problems and speed of conversation were very confusing to many students, according to students' feedback (see results of user-friendliness) and chat transcripts below. One chat transcript, for example, showed that while the tutor, or a student, was asking a question and responses were scrolling-down on the screen, other students seemed to be very engaged in thinking about and typing replies to previous entries. Those students confused others and affected the flow of chat, since contributions related to different issues were being sent concurrently.

In this chat session, the tutor sent an e-mail message to a group of twelve students asking them to join a chat room already opened by the tutor to talk about issues in functions and graphs. The tutor began by asking students to provide examples of functions. The purpose was to help students and introduce them to elementary functions, their graphs and their applications to real life situations. The chat transcript below shows that only eight out of twelve students logged on and participated successfully in the conversation. In the 25 minute session, the number of messages sent by the tutor was 8 out of a total of 26 messages, representing more than 30% of the total number of messages, and only two main question were asked.

Teacher @ 9:38:41 AM > We learned that the first thing to understand is that a function is a pairing of two sets of numbers. To each number in the first set there corresponds exactly one number in the second set. Do you have any question about what I said?

Mohamed @ 9:40:25 AM > yes I understand

Hussin @ 9:42:33 AM > ok

Teacher @ 9:43:45 AM > Who can give me example of a function?

Abbd Elrahman @ 9:46:18 AM > y = 2x

Hijazi @ 9:46:20 AM > y=5x+7

Regan @ 9:47:48 AM > one y for each x

Nader @ 9:49:39 AM > y= 6x

Teacher @ 9:50:30 AM > That is right, and what is the range of a function?

Hijazi @ 9:51:53 AM > Numbers that go out the function are called the range

Magdi @ 9:52:45 AM > linear function y = mx + c

Teacher @ 9:53:15 AM > Excellent, consider the simple function y=2x, who can give the range? (domain = 0,1, 2, 3, 4)

Mohamed @ 9:53:26 AM > y= 2-9x

Elhamy @ 9:54:25 AM > 0,2,4,6,8,10

Regan @ 9:54:11 AM > (0,0), (1,2),(2,4),(4,8)

Teacher @ 9:55:24 AM > That is right, well done. But I need more students to participate in this discussion. Please don't repeat what other said.

Teacher @ 9:55:45 AM > Magdi gives us a linear function, can you tell us what is the slope and y-intercept.

Hussin @ 9:57:14 AM > 2,4,6,8,1

Elhamy @ 9:57:39 AM > the function y=2/x+1

Magdi @ 10:02:57 AM > m is the slope and c is the y-intercept

Nader @ 10:05:34 AM > The y-intercept is the value c

Teacher @ 10:06:44 AM > Excellent!

Mohamed @ 10:06:02 AM > 2,4,6,8, slope = m y-intercept = c

Regan @ 10:11:13 AM > The x-intercept for this function is where y=0

In addition, multiple teacher's questions and students' responses occurred simultaneously, while the continued flow of students' responses to previous questions might be difficult for students to understand and follow. Therefore, during the eight weeks period of study, most planned chat sessions were interrupted or cancelled and students were asked to visit discussion boards to participate in asynchronous conversations.

Furthermore, since e-mail was used in personal asynchronous interaction between the tutor and students and among students, on the one hand, and since students reported significant problems of access to others via e-mail, as mentioned above (see results of access, Chapter 7), on the other, analysis was conducted only of students' participations in discussion boards to answer the question:

Q4.1. How do students interact via discussion boards?

To answer this question, the following subsidiary questions needed to be answered:

Q4.1.1. What is the average number of messages sent by students to discussion boards?

Q4.1.2. What is the average number of messages sent on every single discussion topic?

Q4.1.3. What is the average number of statements in messages posted by students?

Q4.1.4. At what times did students access discussion boards during studying?

Q4.1.5. Is there a difference in the level of participation between earlier and later lessons?

Q4.1.6. Is there a relationship between students' quantity of responses and tutor's level of participation in discussions?

Consequently, a table representing students' usernames, the number of messages sent by every student in every lesson and the total number of messages posted was drawn up. Using this table, it was possible to calculate the number of messages in the first module (earlier lessons) and the second module (later lessons), the number of statements in each message and the total number of statements per student. Considering the nature of the learning subject, any algebraic term, operation, formula or algorithm was considered as a statement.

However, investigating students' perception of asynchronous interaction via discussion boards revealed that although the majority of students (87.5%) agreed or strongly agreed that they were enthusiastic to use and participate in discussion sessions, only about 62% of students believed that discussion boards helped them to exchange and learn useful information from peers. Therefore, the quantitative analysis and qualitative below would be useful to reveal whether students were really interested in using discussion boards or not and how useful was peer-interaction via discussion boards. In addition, the relationship between students' perception of peer interaction (Table 9-1) and achieved interaction with peers, as shown below, is investigated in the next chapter (organisational issues).

Table 9-1: Students' perception of interaction via discussion boards

Statement	Response Distributions					% Choosing SA or A	Mean	Std. Deviation
	SA	A	N	D	SD			
Discussion boards help me to learn from my classmates' ideas.	5	15	6	6	0	62.5	3.60	.9791
I like to participate in the discussion boards.	23	5	2	2	0	87.5	4.84	.3689

1. The average number of messages sent by students during studying in Wired Class

In Wired Class, twelve discussion topics were suggested by the tutor and students. Results from Wired Class records showed that students responded to the discussion boards while studying with Wired Class by sending a total number of 136 messages. Assuming that every student in Wired Class (32 students) should participate by sending at least one message to each discussion board, this number (136) represents only 35.42% of the predicted total number of messages (384) that should be sent to the discussion boards (Table 9-2). In other words, the average number of messages sent by each student throughout Wired Class was 4.25, compared with the ideal total of 12.

Table 9-2: The total number of messages posted to the discussion boards

Number of students	Total number of messages assumed to be sent	Actual total number of messages sent by students	Percent
32	384	136	35.42%

Students' participation in discussions varied from ignoring the discussion to positive and regular involvement. The minimum number of messages per student sent to the discussion boards was zero. However, three students posted between seven and nine messages during studying in Wired Class (Table 9-3). Table 9-4 shows that the majority of students posted between two and six messages. Only one student did not participate in the discussion board.

Table 9-3: The minimum and maximum number of messages per student

	N	Minimum	Maximum	Mean	Std. Deviation
Number of messages per student	32	0	9	4.25	2.0161

Table 9-4: The number of messages per student

Number of messages per student	Frequency	Percent of students
0	1	3.13
2	7	21.88
3	4	12.5
4	5	15.63
5	6	18.75
6	6	18.75
7	1	3.13
8	1	3.13
9	1	3.13

2. The number of participants in every single discussion board

For a more accurate picture of students' level of participation in discussion boards, and since a student would send more than one message, the number of messages and participants in every single discussion board was counted. The results revealed that students' level of participation in the discussions varied from one lesson to another and the number of students who participated in any given discussion board varied between 6 and 16 (Table 9-5). In other words, the number of students who participated in a single discussion topic was, at most, only 50% of students. In addition, the results show that many students (4 students) participated in discussions by sending more than one message (2 messages).

Table 9-5: The number of messages per discussion topic

Discussion topic		Number of messages	Number of participants	Percentage of participants (N=32)
Module 1	Lesson 1	12	11	34.37%
	Lesson 2	8	8	25.00%
	Lesson 3	7	7	21.88%
	Lesson 4	6	6	18.75%
	Lesson 5	9	8	25.00%
	Lesson 6	8	8	25.00%
	Total	50	48	Mean = 25%
Module 2	Lesson 1	12	11	34.37%
	Lesson 2	14	14	43.75%
	Lesson 3	15	15	46.88%
	Lesson 4	14	13	40.63%
	Lesson 5	16	16	50.00%
	Lesson 6	15	15	46.88%
	Total	86	84	Mean = 43.75%
Total	12	136	132	

3. The difference in the level of participation in discussion boards between earlier and later lessons

The results in the above section (Table 9-5) show that the level of participation in discussion boards varied greatly from the first module to the second module and from one lesson to another. The number of students who participated in the first lesson in the first module was relatively high (11 students). This number decreased to 6 students in lesson 4. In the second module, the number rose again to 11 students in the first lesson and increased to 16 in the fifth lesson. In general, the level of participation in discussion boards increased between earlier and later lessons (Figure 9-1). The mean number of messages per discussion topic increased from 8.33 in Module 1 to 14.33 in Module 2. Furthermore, the dispersion was reduced from 2.88 in the first module to 1.36 in the second module (Table 9-6). Overall, while only 26% of students participated in the first module, about 45% of students participated in later discussion boards, as shown above (Table 9-5).

Figure 9-1: Students' level of participation in earlier and later lessons

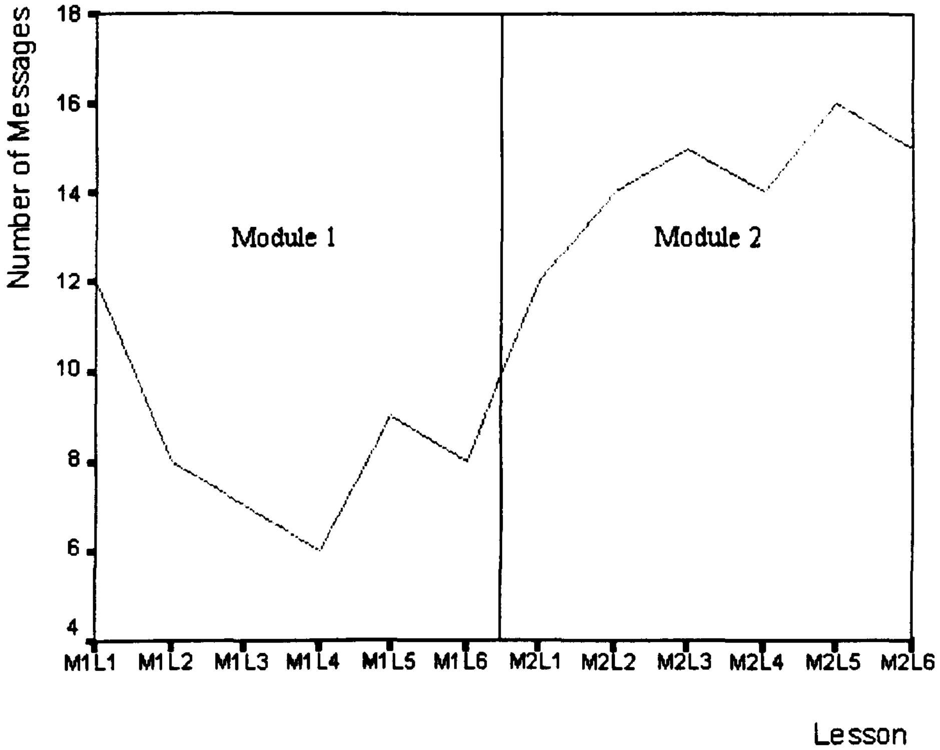


Table 9-6: The average number of messages per lesson in the first and second module

Module	Mean	Std. Deviation
Module 1	8.33	2.8810
Module 2	14.33	1.3663

Using the number of student participations in the first and second module, a *t*-test of independent samples based on equal variances was used to test whether the difference in means between earlier and later lessons (Module 1 and Module 2) is significant or not. The results (Table 9-7) show that there is a significant difference between earlier and later lessons in the number of messages posted to discussion boards at the 95% confidence level.

Table 9-7: Independent-samples test for the number of messages per students in earlier and later lessons

Levene's Test for Equality of Variance		*t*-test for Equality of Means				
F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
0.488	0.501	-5.934	10	0.00	-6.00	1.0111

4. The average number of statements in messages

The initial review of participants' messages showed that the average length of messages was less than expected from this activity. However, considering the nature of mathematics, topics of discussion, the ability level of the period of study, this length would be acceptable. The number of statements in messages ranged from one to five, with the majority of students posting between two and three statements per topic, as shown below.

> 'Decreasing the value of x decreases the value of y and I notice that the graph is a line'.

> 'I found the same results. The slope is positive if $a>0$. The slope is negative if $a<0$'.

> 'It is not a simple question. Did you use the grapher to graph this function? If yes how? I can't use it. But it is a line'.

The number of statements posted by students per discussion topic during the eight week periods of study varied from 1 to 5 statements. However, the average number of statements was 1.76, causing the dispersion around the mean to be quite large (0.86) (Table 9-8).

Table 9-8: The number of statements posted per discussion board

Total number of statements	Minimum	Maximum	Mean	Std. Deviation
220	1.00	5.00	1.7600	0.8651

The frequencies and percentages of statements posted to discussion boards show that 84% of messages contained only one or two statements (Table 9-9). Only one student sent one lengthy message of 5 statements.

Table 9-9: The number of statements per message

Number of statements	Frequency	Percent
1.00	57	45.6
2.00	48	38.4
3.00	14	11.2
4.00	5	4.0
5.00	1	0.8
Total	220	100.0

5. The difference in the number of statements between earlier and later lessons

Although the number of messages increased from 50 messages in the first module to 86 messages in the second module, the number of statements was still less than two statements per message (Table 9-10).

Table 9-10: The mean for the number of statements per message

Modules	Number of messages	Mean for the number of statements	Std. Deviation
Module 1	50	1.5641	0.7538
Module 2	86	1.8372	0.9057

A *t*-test of independent samples, using the number of statements in the first and second module, was used to determine the potential statistical significance of differences. Assuming that the variances between the two groups are equal (Levene's test is non significant) the results show that there was no significant difference between the number of statements in discussion boards in earlier and later lessons (Table 9-11).

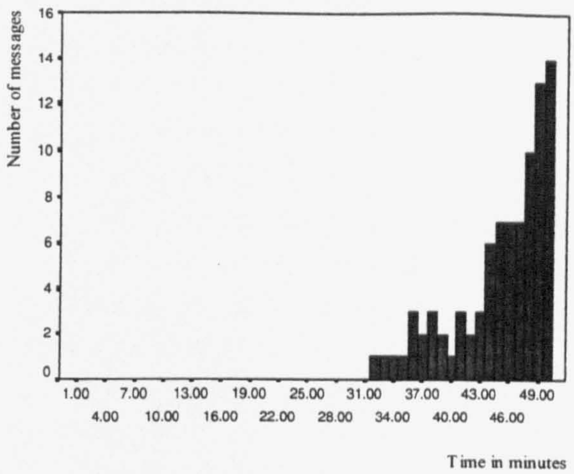
Table 9-11: Independent samples *t*-test for the difference in the number of statements in earlier and later lessons

Levene's Test for Equality of Variances		***t*-test for Equality of Means**				
F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
0.413	0.522	-1.642	123	0.103	-.2731	0.1663

6. Time of access

Since discussion boards were designed to show the sender's name, date and time of sending, it was possible to know at what time students accessed the discussion boards. Analysis of discussion logs showed that around 65% of students who responded to discussions participated on the day of studying the lesson concerned. However, the rest of the students (35%) responded after one or two days. The majority (85%) of those students who responded on the same day accomplished this task in the last 10 minutes of the learning session (Figure 9-2). About 50% of them responded in the last 1-3 minutes. However, only 15% of students were able to manage their learning session and time well enough to respond to the discussion boards before or during other tasks (e.g., accessing external Web resources or doing self-tests).

Figure 9-2: Time of access to discussion boards



7. The relationship between students' level of participation and tutor's participation in discussions

The number of messages sent by the tutor to discussion boards was 19 out of a total of 155 messages, which represents 12.3% of the total number of messages. Initial analysis showed that increasing the number of messages sent by the tutor increased the level of students' participation in discussions. To investigate the significance of this relationship between the number of students' messages and tutor's level of participation in discussions (Table 9-12), the correlation coefficient (Pearson's *r*) was calculated to indicate the direction and the strength of the relationship. The results showed that Pearson's *r* for the relationship between students' level of participation in discussions and number of tutor's messages (0.635) was significant at the 0.05 level (Table 9-13).

Table 9-12: The number of messages sent by students and the tutor to discussions

Discussion topic		Number of messages sent by students	Number of messages sent by the tutor
Module 1	Lesson 1	12	2
	Lesson 2	8	1
	Lesson 3	7	1
	Lesson 4	6	0
	Lesson 5	9	2
	Lesson 6	8	2
	Total	50	8
Module 2	Lesson 1	12	1
	Lesson 2	14	2
	Lesson 3	15	2
	Lesson 4	14	1
	Lesson 5	16	3
	Lesson 6	15	2
	Total	86	11
Total	12	136	19
Tutor contributions equal to 12.3% of the total message volume			

The results show that the more participation there was from the tutor, the more messages were posted by students (Module 2: Lessons 3, 5 & 6) and the lack of the tutor's presence in person, and lack of interaction with the tutor via the discussion boards might be one of the factors, though not the only one, that negatively affect the quantity of students' messages. In other words, the non-appearance of the tutor (Module 1: Lesson 4) might have been interpreted by students as non-involvement or absence, rather than giving them the chance to think and negotiate meaning, as discussed below.

Table 9-13: The relationship between students' level of participation and tutor's participation in discussions

Correlation	Tutor's participation	Sig. (2-tailed)
Participation in discussions by the tutor and students	$r = 0.635$	0.027
Correlation is significant at the 0.05 level (2-tailed).		

9.1.2. Results of qualitative analysis

Since it is not enough to obtain an accurate picture of students' participation by counting only the number of messages and statements, the purpose of this analysis is to reveal patterns of responses in order to assess how well students responded to discussion topics and worked together, and whether there was any relationship between type of responses and other variables of learning in Wired Class. This section addresses the following three questions:

Q4.2. How did students respond to discussion questions?

Q4.3. Did students meet the requirements for discussions?

Q4.4. Is there a relationship between the structure of discussion questions and patterns of responses?

To answer these questions, qualitative analysis of students' messages was conducted in terms of interaction and cognitive and content-related elements. First, statements which were interactive in nature were coded and categorised according to the interaction indicators (Table 9-14). However, since these statements which related to interaction could be content-related in nature at the same time (e.g., responding to accept or reject others' views and opinions with more explanation) these statements were considered again in analysing patterns of cognitive and content-related responses.

Content analysis revealed that responses which were interactive or socially oriented in nature made up 19.09% (42) of the total number of statements. A relatively high percentage of content of statements (35.71%) was merely repeating the others' messages and about 24% of statements were related to students' own experience and showed that they had worked independently to find answers or solve problems (Table 9-14). However, around 19% of statements were comments on messages sent by others. More than 14.28% of statements were responses that agreed or disagreed with others' views. The majority of these statements (11.90%) were accompanied by appropriate explanations reflecting the senders' own points of view. Regarding interaction with the tutor, 7.14% of statements responded to the tutor's requirements or demands (Figure 9-3).

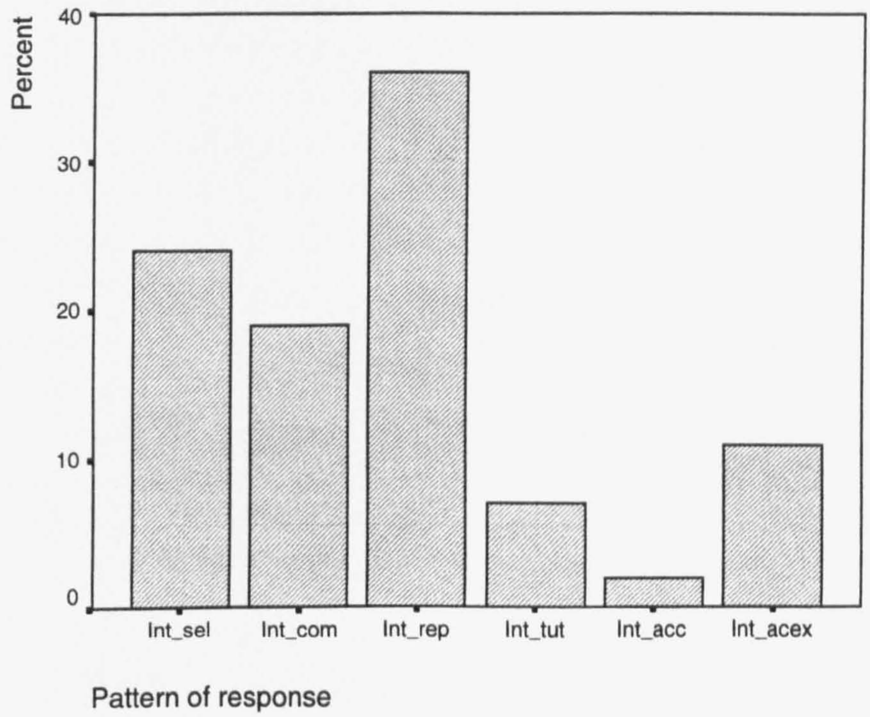
Table 9-14: Patterns and examples of students' interactive responses

Patterns	Percent	Examples of responses
Self-introduction (Int_sel)	23.81%	'My opinion is this equation [...]'. 'I plotted [...]'.
Statements that comment on another message (Int_com)	19.05%	'So do I [...]'. 'I found the same results as Mohamed Abd Elrahman [...]'. 'I think Walied found the correct answer [...]'. 'Of course Ahmed, for example [...]'. 'Mark, you can't use the Grapher [...]'.
Repeating information in another message (Int_rep)	35.71%	'The relationship between the height of a plant and its age' 'The relationship between the age and the height of a person is a function'.
Responding to the tutor's views or advice (Int_tut)	7.14%	'I used Grapher to graph the negative values. The difference is the graph will be plotted in the quof page [...]'. 'Hello Mr [...], I'll do that at home because there is no time today'.
Responding to accept or reject others' views and opinions without explanation (Int_acc)	2.38%	'[...] the relation between the two lines of the equations is changing a changes the slope of the equation as Mona said'. 'I think Walied's found the correct answer. My answer is the same as his'.
Responding to accept or reject others' views and opinions with more explanation (Int_acex)	11.90%	'Yes this is correct. When a changes, the slope of the line changes. When c changes the y-intercept changes'.

The above analysis shows that although the tutor emphasised the importance of thinking and adding personal thoughts one of the important features noticed in students' responses was repetition. A large proportion of students (35.71% of the content) quoted or adapted what others said in their messages, instead of using their own points of view or expressions. However, although this result has a negative side, it indicates that students, at least, read and interacted with what others said and communicated with them to some extent.

However, social interaction with other students by accepting, rejecting or commenting on their views was noticeable and more common than interaction with the tutor. Many students tried to emphasise or clarify classmates' solutions, although only a small percentage of students did so. At the same time, students presented themselves through self-introductions and opinions (e.g., 'my opinion is'..., 'I plotted the graph and I found' ..., etc.) in the majority of their messages, allowing them to support each other and build a sense of community. In other words, students attempted to create a sense of social presence by referring to each other by name and to some elements in the learning environment (such as the Grapher and examples section) rather than interacting with the tutor. In other words, students preferred student-student interaction rather than student-tutor interaction.

Figure 9-3: Pattern of students' responses in terms of interaction



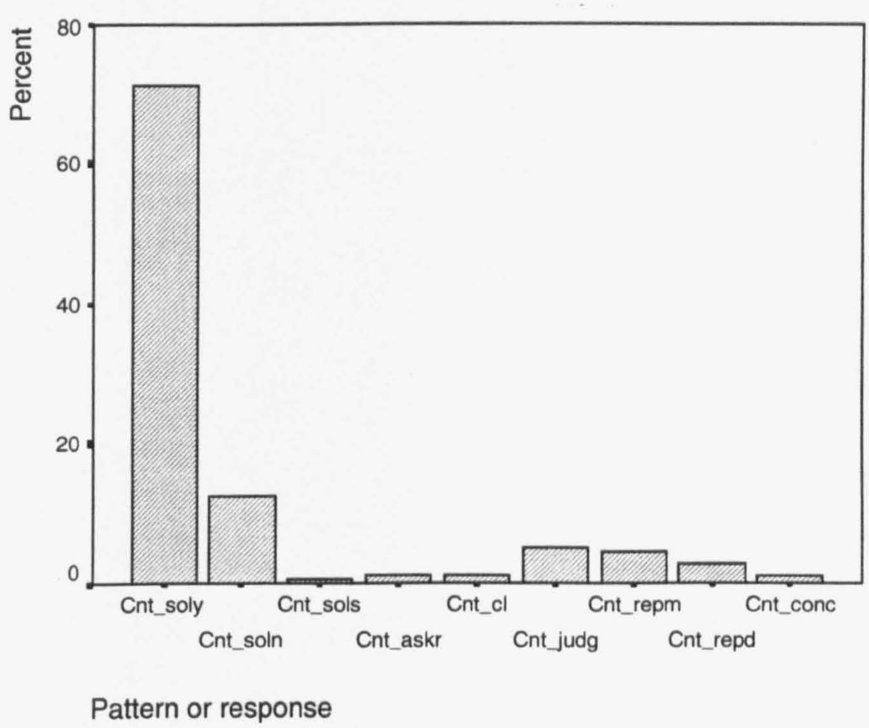
To reveal patterns of cognitive and content-related responses, statements which would tell how students thought and responded to discussion questions were analysed. The statements related to understanding, reasoning, cognitive skills and problem solution were coded and categorised according to the content-related indicators shown earlier. The number and frequency of each type of statement, and an indication of the total number of statements, are shown below (Table 9-15).

Table 9-15: Patterns and examples of students' cognitive and content-related responses

Patterns	Percent	Examples of responses
Solution without explanation (Cnt_soly)	71.35%	'The relationship between the depth and pressure is a function'. 'My results are $x=0, y=9, x=1, y=12, x=2, y=15, x=3, y=18$'.
Solution accompanied with explanation (Cnt_soln)	12.36%	'I used Grapher to graph these negative values. The difference is the graph will be plotted in the second quarter of the page'. 'The new pairing of the numbers is not a function because the record 35 has two values 1995,1996'. 'The graph does not represent a direct variation because it is not a line'.
Alternative solution (Cnt_sols)	0.56%	'The length of shadow and the time. The time and temperature'.
Question directly related to the discussion topic (Cnt_askr)	1.12%	'[...] did you use the Grapher to graph it? If yes, how?'.
Question for more clarification (Cnt_cl)	1.12%	'[...] Do you need the results?'. '[...] What other equations are?'.
Judging the relevance of solution (Cnt_judg)	5.06%	'6 notebooks are cheaper than 5. Because when 5 notebooks cost 4.5 then the book costs .9. When the 6 notebooks cost 5 pounds then the book costs .83. If we plot the table we will not get a straight line'. 'If it is positive then the gradient is positive. If it is negative then the gradient is negative'.
Repeating information contained in the course materials (Cnt_repm)	4.49%	'[...] the slope is positive if $a>0$ and it is negative if $a<0$ [...]'
Repeating information contained in the discussion topic (Cnt_repd)	2.81%	'1. What do you notice? I noticed that we got the same results. 2. Does the equation have the same solution in each case? Yes.' 'What do you notice about the graphs of the first group when a changes? The slope is changed'.
Conclusion (Cnt_conc)	1.12%	'If the value of the coefficient of x is positive then so is the slope and if it's negative then so is the slope'.

The results of the content analysis showed that cognitive and content related statements accounted for more than 80% of the overall number of statements posted by students. The majority of statements (71.35%) were short answers to the main discussion topic. However, only 12.36% of the statements were clarification statements accompanying solutions, to support or interpret participants' opinions. In addition, it was found that 2.81% of the statements came directly from the text of the discussion topic. However, only 5.06% of statements were judgements showing the relevance of solutions provided by the same participant or other participants. Students posted only 2.24% of the total content to know more about participation in discussion boards or for more explanation of the discussion problem. Only one statement gave an alternative or additional response to the discussion question (Figure 9-4).

Figure 9-4: Pattern of students' responses in terms of cognitive and content-related



The above results indicate although Wired Class provided general instructions/rules to students to participate in discussion boards and specific guidelines within each discussion topic (e.g., tell what the difference between the two graphs, why this difference, how did you find the answer, etc.) and the tutor emphasised the importance of active and constructive participation in discussions (e.g., 'I do not want you to copy others' messages, instead I would like you to think and share your own ideas' and 'I would like to see the entire class become involved in discussions and everyone has at least one participation in every discussion board') that the majority of students did not understand the actual purpose of on-line discussions, and responded to discussion questions as they would respond to conventional textbook exercises. Students did not go beyond stating the direct algebraic solution (71.35%) and did not establish a sense of argument in examining their own or others' responses. In addition, they did not clarify the evidence behind their answers in their messages, or provide alternative solutions to the problem, if applicable (Table 9-15). Even messages that contained questions comprised only 2% of the total content and half of them were asked only to obtain assistance or more clarification. The application of higher level cognitive skills (e.g., judging the relevance of a solution) was minimal.

For example, in the first discussion board the learning objective was understanding the definition of a function. Therefore, students were asked to suggest and examine examples of functions, as a special relationship in which each input (or x value) results in one and only one output (or y value). The purpose was to investigate students' understanding of the function concept, encouraging them to find a general expression for the function and pave the way to the next lesson. In addition, examining examples and non-examples could help students who have difficulty with the concept of a function, possibly because of its many interpretations, to understand the definition. Good examples of functions would be that each student at a school has a unique fingerprint, each house on a street is assigned a unique address and the distance a car travels in one hour is a function of the speed of the car.

Although Wired Class students provided good examples of function (Example 1: Table 9-15), even if many of them were repeated, and they showed understanding that a function is a correspondence that applies to each element of one set one and only one element, they neither explained the correspondence between the two sets of variables (whenever x increases y increases) nor looked at the function concept in different ways (e.g., as a relationship between sets of information, matching up one group of numbers with another group or mapping of some domain onto some range).

Also, when students were asked to explore and discuss the effect and significance of the coefficient 'a' on the graph of an equation $y = a x + b$ and describe what 'a' tells about the graph (Example 3: Table 9-16), although it was obvious that the students were able to understand and state the meaning of 'a' and 'b' in the equation $y = a x + b$ and that the coefficient 'a' measures the steepness of the line (the larger the value of a the steeper the graph and a positive increase in y for a positive increase in x), they could not conclude the important result that *[change in y] = [slope] [change in x]*.

In addition, it was obvious that students used the algebraic approach rather than the graphical approach to investigate this relationship, but they could not show their conclusions clearly. Possibly, one factor that led students toward the algebraic approach was the lack of visual presentation on the text-based discussion board. Lastly, since students' participations in discussion boards were textual, they could not flexibly choose or move between algebraic and graphical representations, even though graphical tools were available within the learning environment.

In addition, it was noticed that students did not refer to on-line course materials or exploit the Web resources provided within each lesson and discussion topic, to respond and enrich discussion content. In Module 1–Lesson 2, for example, the discussion board presented the following question:

> 'In this lesson you learnt what is the a co-ordinate graph, axes and plotting points. Now, plot the following points *(x, 0), (-x, 0), (0, x) and (0, -x), where x=1, 2, 3, 4,* in a co-ordinate graph. Tell us what is the difference in the location of the points: *(x, 0), (-x, 0), (0, y) and (0,-y)* ? Tell us your opinion now'.

Since this issue, and other discussion topics, had not been directly discussed in the text, therefore, students could not rely only on course materials to answer this question. Students' responses indicated that they either plotted these points themselves, using graphing tools, or drew on their own experience to conclude the relationship between the value of x and y and their locations on the co-ordinate graph. For example:

> 'I plotted these points and I found that these points *(1, 0), (-1, 0), (0, 1) and (0, -1)* are located in the same axis but in the opposite direction'.
>
> And
>
> 'The points are plotted in the opposite direction of the x axis and y axis'.

Table 9-16: Examples of discussions

Example	Discussion topic	Students' responses
Example 1 Module Lesson 1	[...] try to find an example of a function yourself. Tell us about your example, what the relationship is and how and why it represents a function.	'Grades in school exams depend on how [well] the student studies'. 'The relationship between depth and pressure is a function'. 'The relationship between the age and the height of a person is a function'.
Example 2 Module 2 Lesson 3	Graph the following two groups of equations on one pair of axes. *Group 1: ...* *Group 2: ...* Now, 1. What do you notice when *a* changes? 2. What do you notice when *c* changes? Click on discuss a problem and tell us about your results.	'In group 1 $a = 1,2,3,4,5$ in group 2 $c = 1,2,3,4,5$ the same values . The difference is the slope *c* is the *y-axis* intersection *a* changes the slope of the line *c* changes the y-intersection'.
Example 3 Module 2 Lesson 5	Graph each of these two equations: $2x + y = 1$ and $-2x + y = 1$ .... Now, what is the difference between the two graphs? What is the relationship between the sign of the *x* coefficient and the direction of the line? Try this for other pairs of equations. What conclusion can you draw from your experiment?	'If the coefficient is positive then the slope is positive. If the coefficient is negative then the slope is negative'. 'I have plotted the two equations and I find that the direction of the slope depends on the value of coefficient *x* (*2* and *-2*)'. 'The result is increasing *a* increases the slope. The slope of the equation $y=2x+1$ > the slope $-2x+1$'.

In addition, students' responses indicated that they did not exploit information and tools provided by the Web sites recommended by the tutor, which explained the co-ordinate graph and provided useful and interesting tools to help them to solve plotting problems. The analysis of students' messages in this lesson indicated that students did not cite or refer to conclusions, solutions or examples presented at these sites.

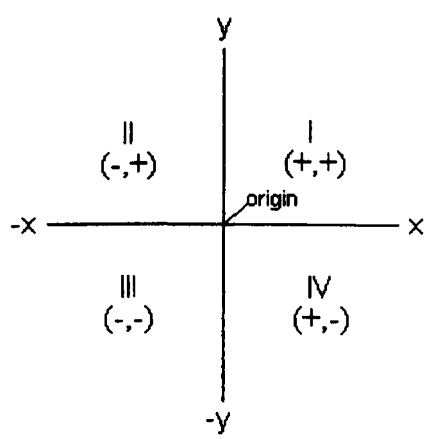
For example, although students were advised to visit the 'Link 4' Web site ('Excellent explanation of the axes, co-ordinate graph and graphing!'), which provided good information and a graphical conclusion about the co-ordinate system and ordered-pairs, none of the six out of eight students who participated in the discussion board and accessed Web resources referred to the information provided at this site, or provided a comprehensive conclusion of the relationship between the sign of *x*- and *y*-coordinate and their positions in the co-ordinate system, as shown below (Figure 9-5). Moreover, it was found that the other two students who participated successfully in this discussion did not access the 'Links' section before or during discussion.

Figure 9-5: Web resources in co-ordinate systems

Link 4: Co-ordinate systems and graphing

http://library.thinkquest.org/10030/6graph.htm

Each quadrant has a distinct pattern



1. In the first quadrant, both the *x* and *y*-coordinate are positive.
2. In the second quadrant, the *x*-coordinate is negative and the *y*-coordinate is positive.
3. In the third quadrant, both the *x* and *y*-coordinate are negative.
4. In the fourth quadrant, the *x*-coordinate is positive and the *y*-coordinate is negative.

The third issue considered in analysing students' messages was the relationship between the structure and objectives of discussion topics and the quantity and quality of students' responses. Since discussion topics varied from simple discussion questions to controversial problems, the requirements for discussion varied from a low level of intellectual behaviour to a high level of intellectual operations and skills. To investigate this relationship, first, the requirements for each discussion topic were analysed and coded into three levels according to Bloom's taxonomy:

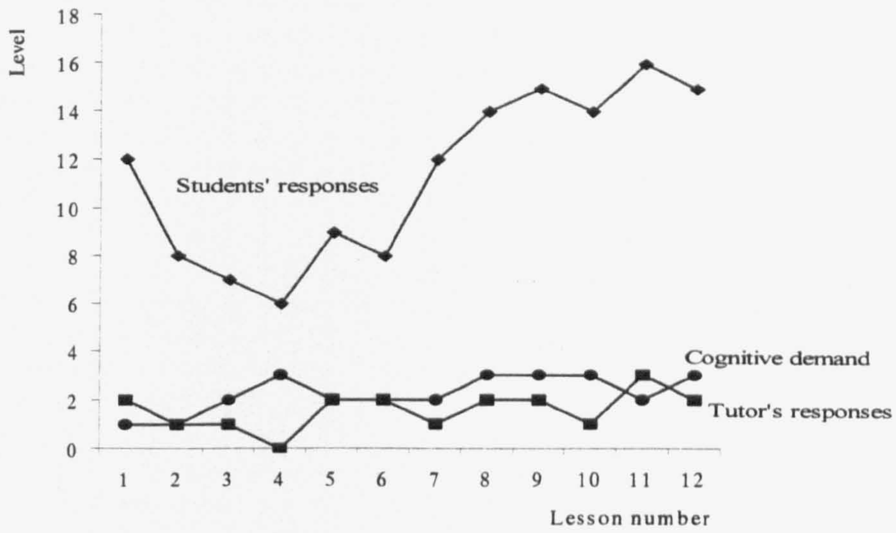
1. Low-level discussion topics, which require doing simple calculations or mathematical operations and directly depended on concepts and problems mentioned in the text.
2. Moderate-level discussion topics, which required translating knowledge into new context, solving problems using available knowledge and skills, formulating, comparing and interpreting results.
3. High-level discussion topics, which required analysing, creation and verifying evidence and results.

Consequently, each discussion topic was analysed using to the above coding system and the quantity and quality of students' messages for each discussion topic were coded (Table 9-17). Plotting the results showed that the development in requirements and cognitive demands of discussion topics from low-level demands, in earlier lessons, to moderate and high-level demands, in later lessons, might be associated with growth in students' level of involvement in peer-interaction (Figure 9-6).

Table 9-17: Requirements for discussion and level of participation

Lesson order	Requirements for discussion	Cognitive demand	Level of response
M1L1	Give examples that meet the requirements of the definition	Low	High (N = 12)
M1L2	Study external Web links, draw graphs and investigate relationships, similarity and differences.	Low	Moderate (N = 8)
M1L3	Compare and assessing values of theories, verify values, generalise from definitions and solve problem.	Moderate	Moderate (N = 7)
M1L4	Observe, list and recall information, compare, contrast, examine, test values and solve problem.	High	Moderate (N = 6)
M1L5	Tabulate, graph, interpret, observe pattern, explain and generalise.	Moderate	Moderate (N = 9)
M1L6	Tabulate, graph, use old ideas to create new ones and draw conclusion.	Moderate	Moderate (N = 8)
M2L1	Change using mathematical operations, formulate, compare and interpret facts.	Moderate	High (N = 12)
M2L2	Tabulate, plot and construct graph, interpret the new graph and examine, identify and describe changes.	High	High (N = 14)
M2L3	Construct graphs, compare changes, experiment, distinguish, assess and conclude.	High	High (N = 15)
M2L4	Apply, solve problem, examine, recognition of hidden meanings, predict, draw conclusion and make choices based on discussion argument.	High	High (N = 14)
M2L5	Construct graphs, compare graphs, describe differences and draw conclusion.	Moderate	High (N = 16)
M2L6	Evaluate the relevance of data, modify, assess presentation of equations, solve a problem and draw conclusion.	High	High (N = 15)

Figure 9-6: Students' responses related to cognitive demands and tutors' responses



However, correlation analysis between cognitive demands of discussion topics and students' level of responses showed no significant relationship (Table 9-18). In other words, the structure and objectives of discussion topics did not affect students' quantitative performance in on-line discussions. However, this performance varied significantly between earlier and later lessons and was affected by the tutor's presence and participation in discussions, as reported above, and confirmed using correlation analysis below (Table 9-18). At the same time, it was not surprising to find that there was a significant relationship between the cognitive demands of each lesson and its order in the course, since in the design, care was taken to choose and construct discussion topics of graduating difficulty, from simple topics making low cognitive demands, in earlier lessons, to complex topics making high cognitive demands, in later lessons.

Table 9-18: The inter-relationships among students' level of responses, lesson and discussion order, tutor's responses and cognitive demands of discussion topics

Variables	1	2	3	4
1. Lesson and discussion order				
2. Students' level of response	.774**			
3. Tutor's level of response	.429	.635*		
4. Cognitive demands of discussion topic	.686*	.340	-.114	
* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).				

In order to find out if the order of the lesson or discussion topic, and any other factors, could together predict the variance of the dependent variable, multiple regression analysis was conducted using students' level of response as the dependent variable. Independent variables included in the analysis were lesson order, tutor's level of response and cognitive demands of discussions.

Table 9-19: Summary of multiple stepwise regression analysis for variables predicting students' involvement in discussion boards

Model		Sum of Squares	df	Mean Square	F	Sig.
Model 1	Regression Residual	83.084 55.583	1 10	83.084 5.558	14.948	.003
Model 2	Regression Residual	98.666 40.001	2 9	49.333 4.445	11.100	.004
Model 3	Regression Residual	99.332 39.335	3 8	33.111 4.917	6.734	.014
R Square $_{Module\ 1}$ = .599, R Square $_{Module\ 2}$ = .712, R Square $_{Module\ 3}$ = .716						

The results showed that the R Square for model 1 (in which the predictor is the lesson number) is 0.599 (Table 9-19). The R Square of 0.599 means that about 60% of the variation of students' participation in discussion (the dependent variable) could be explained by the variability in lesson number. Adding the level of tutor response as the second independent variable added 0.113 to the R Square. However, adding the cognitive demands of discussions as the third independent variables (model 3) added only .004 to the R Square to become .716.

These results show that around 70% of the variation of students' participation in discussions could be significantly explained by the variability in lesson number and level of tutor response to discussions, with a significant F value at 11.1 ($p<.05$).

Table 9-20: Summary of multiple regression analysis of variables predicting students' level of involvement in on-line discussions

Variables Entered						
Model		B	Std. Error	Beta	*t*	Sig.
Model 1	Constant	6.379	1.451		4.396	.001
	Lesson number	.762	.197	.774	3.866	.003
Model 2	Constant	4.767	1.557		3.062	.014
	Lesson number	.605	.195	.615	3.101	.013
	Tutor responses	1.662	.888	.371	1.872	.094
Model 3	Constant	5.786	3.216		1.799	.110
	Lesson number	.713	.358	.724	1.994	.081
	Tutor responses	1.390	1.191	.310	1.166	.277
	Level of cognitive demand	-.572	1.555	-.121	-.368	.722
Variables Removed						
		Beta In	***t***	**Sig.**	**Partial correlation**	**Toler**
Model 1	Tutor responses	.371	1.872	.094	.529	.816
	Level of cognitive demand	-.361	-1.367	.205	-.415	.530
Model 2	Level of cognitive demand	-.121	-.368	.722	-.129	.325

Second, a content analysis of randomly-selected messages (50%) in low, moderate and high level discussion topics was carried out, in the light of the analytical framework for discussion messages to investigate the relationship between the requirements for discussion topics and types of students' responses. The analysis revealed that when discussion topics presented easy and direct questions requiring low level intellectual skills (e.g., suggest examples, study external Web links, draw graphs and investigate relationships, etc.), students responded in brief statements without showing the cause and effect of the relationship or explaining the reasons behind their arguments. In addition, they did not use statements that were social in nature or try to build a sense of community through discussions (e.g., responding to accept others' views and opinions without explanation), as shown below.

> 'The relationship between the age and the height of a person is a function' (M1L1).

'The only difference is the direction in which the point is located and whether x and y are positive or negative' (M1L2).

However, in moderate-level discussion topics, students sent more positive responses, solved mathematical problems correctly and in detail, and interpreted the results. For example, when students were asked to discuss together which of two tables provided a function and why (M1L3), what was the difference between the graphs of two equations (M2L5) or how an equation not in the slope-intercept format could be graphed (M1L6), they provided many alternative solutions and explained how and why the answer was correct. They also responded to accept or reject others' responses with more explanation, as shown in the examples below.

'The year is not a function of the record time because to each year there is no one record time that corresponds exactly' (M1L3).

'The result is, the slope is the same but the direction is different. When $a = 2$ the slope is on the right side of x and when $a = -2$ the slope is on the left side of increasing x' (M2L5).

'I used Grapher to graph these negative values. The difference is the graph will be plotted in the second quarter of the page' (M1L6).

In high-level discussions which addressed more controversial problems requiring relatively high-level thinking and intellectual skills (such as analysing, verifying evidence, assessing information and drawing conclusions) it was noticed that students posted more alternative points of view and detailed responses, with relatively more peer interaction.

'6 notebooks are cheaper than 5. Because when 5 notebooks cost 4.5 then the book costs .9. When the 6 notebooks cost 5 pounds then the book costs .83. If we plot the table we will not get a straight line' (M1L4).

'I think Walied found the correct answer. My answer is the same as his' (M2L3).

'$0=7$ is impossible. We can't assume that $y=0$ because it is given that $3y=5$. So it is not possible to intersect with the *x-axis*' (M2L4).

Table 9-21: Patterns' of students' responses

Discussion question	Examples
We have the linear equation $x=5$. As you notice, y disappears from this equation. This is a problem because we can't put the equation in the slope-intercept form $y = a\,x + b$. So, how can we graph this equation? Of course there is a simple solution. Think then go to the Discussion board to tell us your opinion and take a look at others' solutions (M2L6)	1. 'Mark, you can't use the grapher. I didn't use it but I plotted it. Use the table [to plot the points] when $x = 5, 5, 5, 5$ and $y = 0, 1, 2, 3$'. 2. 'In my opinion we can graph this slope-intercept form using the values $x=5, y=1, x=5, y=2, x=5$, y=3. We find it a line parallel to the *y*-axis'. 3. 'Of course there is a simple solution. I graphed this function like this $(0, 5), (1, 5), (2, 5), (3, 5)$ when x is constant'. 4. 'It is not a problem because $y = a\,x + b$ is the same equation when $y=0$'. 5. '[...] it is not a simple equation. Did you use the grapher to graph this equation? If yes how? I can't use it. But it is a line'.

For example, when students were asked to post their opinions regarding graphing an equation not in the slope-intercept format, they responded in a variety of ways (such as giving examples, providing evidence and referring to others' solutions) and their contributions were related to their own personal examples and methods they were familiar with (e.g., using graphical calculators or following examples in the texts), allowing other students to hear and comment on different explanations of the problem (Table 9-21). However, in low-level discussion topics, where simple question-answer was employed, students did not respond actively or engage in real thinking processes. They used only recalling and low-order cognitive skills (such as calculation skills and interpretation) to propose solutions, without real interaction with others or with the tutor.

9.1.3. Discussion of interactivity results

Usually, attention is given to the content and the delivery features of the technology rather than the human dialogue between the learner and others, including the tutor and peers (Garrison, 1989). The need to understand student-teacher and student-student interaction, however is emphasised in the literature. Moore (1986) stated that:

> '[The] effectiveness of distance education is determined by a complex interaction of variables which include learner variables, teacher variables, subject variables, and communication variables' (p. 11).

In addition, although most earlier Web-based research in asynchronous learning has emphasised and focused on the social aspects of communication, evaluating the cognitive aspects of students' responses is as important as understanding the interactive aspects of responses. The importance of this is:

1. It allows on-line tutors to draw conclusions about the educational value of discussions and evaluate learning outcomes according to the educational criteria (Mason, 1991).
2. It allows the learner to see others' ideas and cognitive decisions. This ability may impact the quality of learning and group decisions (Smith and Dillon, 1999).

The importance of analysing and understanding students' interaction throughout Wired Class on-line discussions was that distance education students are expected to carry out a great deal of learning on their own (Baynton, 1992). To investigate to what extent students shared, critically analysed and applied information, it is essential to know whether they constructed their knowledge successfully or not (Garrison, 1990). In addition, there is evidence in the literature that in classrooms with higher levels of interaction, students have higher levels of achievement and more positive attitudes toward learning (Ritchie and Newby, 1989).

Although participation in Wired Class discussion boards was an essential activity and the tutor emphasised the importance of regular participation by sending many messages asking students to participate by responding or commenting on others' messages, the results of quantitative analysis showed that the average number of messages sent by students was very low (one message per student per two weeks). However, this number varied from nothing to nine messages per student. According to students' logs and informal feedback to the tutor, many possible reasons were behind this varied and modest level of participation.

Although students' feedback showed that they had very high positive perception of using discussion boards, it was found that students believed that peers' messages were not useful or helpful in promoting their learning. Therefore, it was not surprising to find that students' perception of interaction via boards was not among the reasons that affected their participation in discussions, as found in the next chapter. This means that other instructional or organisational factors might affect involvement in discussions.

One possible explanation is that students in Wired Class thought that they could not post correct answers that would add meaningful value to discussion, or simply they had nothing to say. Another explanation is that students did not consider discussions to be as important as conventional tasks. This explanation is supported by the results from formative evaluation which, revealed that more than 85% of students completed the conventional tasks (such as exercises and 'send to the teachers' tasks) regularly and without more pushing from the tutor, even if they were not successfully achieved. In addition, analysis of students' logs showed that the majority of students accessed discussion boards only in the last few minutes of the lesson, which did not allow them to participate fully. This may have been because the discussion questions came at the end of each lesson. Therefore, students, particularly those who could not manage their time effectively, paid less attention and time to discussions. Although all students accessed the discussion boards and read their contents, according to their logs, a significant number of students (21.8%) 'lurked' and sent no messages or fewer than three messages for twelve discussion topics.

However, it was noticed that one of the significant factors that may have affected students' participation in on-line discussion was the structure and objectives of discussion topics. Since discussion questions varied between easy-to-answer open-ended questions and more debatable and controversial problems, it was found that in discussions that addressed more debatable questions, students were motivated enough to engage actively in critical thinking processes and pay more attention to interaction with peers. However, topics that required low cognitive demands did not help students to use higher order thinking, interact with others or learn from others' experience.

Moreover, it was found that the number of participants who got involved in the later discussions was greater than those who got involved in the earlier discussions. The correlation results showed that although there was no significant relationship between students' level of response and cognitive demands of discussion topics (Table 9-18) there was a significant difference in students' level of involvement between earlier and later discussions. Multiple regression analysis has shown that about 60% of the variation of students' participation in discussions could be explained by the variability in the lesson number. According to earlier research, students very rarely interact via discussion boards, due to lack of opportunity to develop peer relations and intimidation about using new technology (Flottemesch, 2000). Possibly, after four or five weeks of studying in Wired Class, students who could not participate in public discussions had begun to engage actively and become familiar with the new style of constructivist learning and technology.

Also, it was found that the more participation there was from the tutor, the more messages were posted by students. The non-appearance of the tutor might have been interpreted by students as non-involvement or absence, rather than giving them the chance to think and negotiate meaning. Although personal e-mail messages were sent from the tutor to students, asking them to be more active, e-mail messages did not give them the evidence or the impression of the presence of the tutor. This result indicates that, possibly, students need more encouragement and support to participate more positively, bring ideas, agree on whose ideas will be accepted and feel a sense of community.

This result was expected and is consistent with Harris (1999), who indicated that the role of the tutor in discussion is as important as the role of the 'chair of a conference'. He argued that the tutor's role is essential to open and close discussions, encourage students to participate and interact, keep discussions on track and assess learning. Also, Jonassen et al. (1995) argued that tutor-student interaction 'exemplifies the constructivist design model' of on-line education, but the instructor's contributions should be only 9-15% of the message volume, as achieved in Wired Class (Table 9-17). Trentin (2000) called the tutor's modest participation the 'initial approach'. This approach aimed at 'breaking the ice between the students and those responsible for leading and assisting them throughout the course' (Trentin, 2000, p. 19). According to Trentin, the outcome of using this approach is that the distance learners' sense of isolation is reduced and this helps in enriching and fostering discussion.

However, the result of this study did not agree with research results on learning via discussion by Powell (1986) and Dymock and Hobson (1998), who argued that students usually participate more in discussion when the teacher is away from the discussion group. This inconsistency in findings may be attributable to two reasons. First, these earlier studies were implemented at the university/higher education level, not in earlier education. Young students, particularly those who are isolated at a distance, may not be motivated enough to use discussion boards. Second, presence/absence of the teacher is not the only factor that affects student participation. The nature of the discussion topic and the possibility of more interesting issues being raised by students during discussion play an important role in fostering and encouraging the debate.

Therefore, on-line tutors should pay more attention and address more concern to strategies to foster participation and interaction and build the sense of community in Web-based learning environments. This can be achieved by directing comments or questions to students, suggesting materials, encouraging further exploration or opening up new avenues for development (Cox, 2000).

Stating another point of view, since discussion boards addressed more controversial issues and problems than those addressed by other tasks, students who had good experience and skills responded to discussion problems more frequently than those who lacked these abilities. This idea is supported by Stahl's (1999) argument that:

> 'Students more readily engage in discussion, responding spontaneously to existing notes without taking time to appropriate the ideas in new syntheses. True construction of knowledge involves distinct tasks – including brainstorming, articulating, reacting, organizing, analyzing and generalizing' (Stahl, 1999).

Consequently, it was not surprising to find that also the quality of social and cognitive-related interaction was low. This low quality of participation was visible in the 'surface processing' of information, which reflected in repeating information in the discussion topic or others' messages without self explanation, supporting/rejecting others' opinions without adding personal comments or providing clear evidence, offering solutions without providing clear interpretation, providing solutions directly depicted from the text not from external Web resources or self-experience and asking questions that were not directly related to the discussion topic.

In addition, superficial processing of information showed that much of students' learning came out as a result of interaction with the course content, rather than by negotiating and constructing meaning via peer-interaction or Web resources suggested by the tutor. Content analysis of students' messages showed that when students were challenged by discussion questions, they did not resort to Web links and this did not allow them to find information to clarify the discussion problem or respond to the discussion question. Consistent with this finding, since the learning process is influenced by student's interactivity and ability to manipulate information (Henri, 1991; Fisher, 2000), on-line learning can be effective when students have the skills and experience to participate in interactive activities and are able to carry out in-depth processing of discussion topics.

9.2. User-friendliness

Since the early development in computer-based multimedia applications in the early 1990s, the term 'user-friendly' has become an important concept in designing, evaluating and selecting between instructional programmes. Corry et al. (1997) indicated that 'computer systems designers and developers have begun to use the term *user friendly* to label products they believe are easy for the lay public to use' (p. 65). Smith and Dillon (1999) argued that evaluating the user-friendliness of a Web-based course should address many issues such as the:

1. appropriateness and consistency of user-interface design;
2. branching and support strategies;
3. ease of use; and
4. navigability of the site.

This section attempts to answer the research questions:

Q4.5. Is the Web site user-friendly in terms of user-interfaces, ease of use, programming and navigation?

9.2.1. Results related to user-interface

Najjar (1990, 1998) examined many studies in educational user-interface design and concluded that the majority of design principles are based on experts' opinions and guidelines rather than on learners' feedback. Therefore, it was quite important to take into account students' satisfaction with the design of user interface. Principles of design and organisation of page layout for printing or computer screens, graphics, colours, page layout and formatting are essential elements that should be considered in designing for the Web.

Regarding the design of the user interface, students were asked to reflect on the design and layout of the first and subsequent pages of Wired Class. Four items were presented in this section, as shown below. A large majority of students (81.25%) found that the design and implementation of page elements (e.g., forms, buttons, etc.) was attractive and constituted an appropriate portal to Wired Class pages and components. Moreover, most students (75%) considered that the employment of fonts and colours was helpful in presenting the content of pages. Around 70% of students expressed that graphics, icons and nodes were clear and meaningful (Table 9-22).

Table 9-22: Students' perceptions of user-interface (N=32)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The design of Wired Class pages is attractive.	14	12	3	2	1	81.25	4.13	1.0395
Pages are simple and offer appropriate choices.	21	5	4	1	1	81.25	4.38	1.0395
Fonts and colours help me to read the content.	11	13	4	3	1	75.00	3.94	1.0758
I can understand the meaning of graphics and symbols easily.	5	17	3	6	1	68.75	3.59	1.0734

Comments from students regarding design of user interface include:

1. 'The web site is wonderful. I really liked it'.

2. 'The logos are good '.

For more reliable feedback and deep analysis of the appropriateness of user interface design, experts were asked more specifically to evaluate the design of texts, colours, fonts, spaces, graphics and other elements of user interface. Many items were used as design guidelines to judge user-interface design, as follows (Table 9-23).

Table 9-23: Evaluators' responses to the design of user interface (N=41)

Statement	Response Distribution					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
Font sizes, style and colours have been used appropriately	17	12	6	6	0	70.80	3.9756	1.0837
White spaces, margins, paragraphs and indents help students to focus on the content	14	15	7	5	0	70.70	3.9268	1.0097
Text and graphics are well aligned	15	15	3	7	1	73.20	3.8780	1.1661
The icons clearly reflect the content they represent	32	7	2	0	0	95.10	4.7317	0.5488
Captions are concise and accurately describe the images and graphs	16	11	5	9	0	65.80	3.8293	1.1812
Page design is appropriate for screen appearance	8	10	8	13	2	43.90	3.2195	1.2352

With regard to the presentational features of user interface, the design of icons throughout Wired Class was the most favourably regarded element; students and experts indicated that the icons and symbols clearly reflected the content or links they represented. The second most favoured features were the alignment of text and graphics, and the presentational features. More than 70% of evaluators agreed that font sizes, styles, colours, white spaces, alignments and margins were used properly to present the content, allowing students to focus on the content and process their information.

However, evaluators were not entirely satisfied with the labelling style or captions of graphs. Only 65% indicated that the captions were concise and accurately described images and graphs, as one explained later. Moreover, evaluators did not agree that the design of pages was appropriate for screen appearance under different types of resolutions. Comments from evaluators regarding user interface design are shown below.

> 'It has a convenient design but the home page houses so many links. Tables and colors make information easy on the user's eyes'.

Since Wired Class hosts so many components, these components and tools were categorised into groups called rooms (teachers' room, communication centre, students' room, etc.). However, the number of these rooms (5) and links (23) was still high, particularly for new users. However, the good use of tables could reduce this kind of problem, as indicated above.

Using Macromedia Flash and other similar objects was one of the issues considered in evaluation of Wired Class. For example, an evaluator commented that:

> 'I particularly appreciated the way in which desired learning outcomes can be achieved through the use of straight HTML as opposed to the flash 3/4 eye candy seen on other sites'.

This evaluator thought that Flash objects do not allow learners to interact with the user interface of Flash, which currently does not support menus and active coloured hyperlinks. This problem is associated with the need to download and install additional software or plug-ins, which have their own non-standard user interface controls (e.g., buttons, menus, etc.). Many evaluators found that Flash objects are very irritating in many cases and considered HTML combined with Java and Java scripts to be more flexible and clear than Flash objects. Therefore, they recommended using Flash objects only when it is necessary.

> 'The key is to identify routes to learning outcomes in HTML and then import plugin-dependent assets at a later date if so desired by the audience'.

Another point of view was stated by an evaluator who argued that although text, fonts, colours and graphs played a good role in presenting the content in an interesting way, they were not sufficient and should be supplemented by a printed version in PDF (Portable Document Format) to ensure high quality outputs.

> 'True Multimedia includes using all the appropriate media, including print. Your teaching solution doesn't exclusively have to be on-line'.

And

'[...] the use of PDF files is essentially to have the paper version on the screen'.

Other useful related comments came out to comment on the design of user- interface, as follows:

1. Page design is simple and consistent and that is the most appreciated feature in your design.
2. Some logos, or icons, are not available on all pages. This issue should be considered for the consistency of design.
3. Use the ALT [or alternate attribute] to describe images and graphs to make it more accessible for blind students.
4. Give the choice to users to select their own text and background colour.
5. Keep pages shorter.
6. Avoid using Italics, underlining and capitals as much as possible.
7. Links and their description are short, concise and simple.

To investigate the agreement between students (see Appendix 1: Student Questionnaire, items 16-19) and experts (see Appendix 3: Expert Questionnaire, items 1.5-1.10) in perception of the design of user-interface, as presented above (Tables 9-22; 9-23) an independent-samples *t*-test was used to determine the potential statistical significance of the differences. First, Levene's test (Bryman and Cramer, 1997) indicated that the differences between the variances of the two groups were statistically significant since the value of Levene's test was 0.015 (Table 9-24). Consequently, the *t* value on non-equal variances was considered. This is non-significant with a two-tailed value of 0.639 at the 0.05 level of confidence. Therefore, it is concluded that there was no significant difference in perception of user interface between students and experts.

Table 9-24: The significant of differences between students' and experts' perception of user-interface

Variance	Levene's Test for Equality of Variances		*t*-test for Equality of Means				
	F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	6.172	.015	.504	71	.616	.0809	.1608
Equal variances not assumed			.472	46.251	.639	.0809	.1714

9.2.2. Discussion of user-interface results

The results above have shown that the design of user interfaces succeeded in meeting students' expectations and minimising the effort needed by students to deal with the environment and access course information. The overall design, as well as the elements of the graphical user interface, including backgrounds, fonts, colours, menus, buttons, graphics, icons and alignment proprieties, as mentioned in Chapter 5, were well designed, so that a large majority of students found the design appealing. This attraction was apparent in students' simple and spontaneous comments to the open-ended questions.

The importance of a well designed user interface is that it facilitates and improves the performance of learners in using the Web and helps them to focus their attention on studying and learning the information more closely (Hillman et al., 1994; Jones et al, 1995; Najjar, 1998). Effective use of colours, for example, can give the learner a good first impression of the site and encourage his/her acceptance (Najjar, 1990). Also, graphics and symbols are the most visible elements on the Web and if they are simple, well labelled, consistent and in an optimal resolution they can increase learner motivation and concentration (Pellone, 1995). Similarly, the clear, uncluttered and consistent layout of instructional screen makes the learners' job easier and helps them to focus on the content.

Although students' feedback was important, experts' evaluation was also essential, to gather richer feedback and deep analysis of user-interface features according to design criteria. Based on experts' responses to the rating scale and open-ended questions, the major significant issues emphasised by evaluators are discussed below. These issues are screen scrolling, captions and alternative captions of images and graphs, multimedia Flash objects and Portable Document Format (PDF) against HTML.

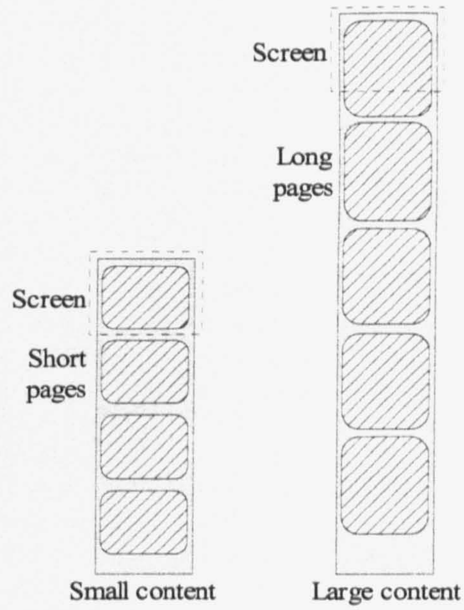
First, although experts highly rated most user-interface features, the problem of scrolling was highlighted by evaluators' negative rating and comments (Table 9-20). Experts were of the opinion that students do not like to scroll long pages, even if students scroll through pages without comment. This means that course pages should be shorter in length. This point of view may lead to an increase in the total number of pages. Therefore, the Web page designer is faced with a choice between two strategies: to create a large number of short pages or to create a few long pages. Of course, the selection of the appropriate strategy is based on the quantity of the content (Table 9-25).

Table 9-25: Page scrolling strategy

Strategy	Many pages	Few pages
Long pages	Very large content	Large content
Short pages	Small content	Very small content

A small amount of content can be presented in a few short pages. However, a larger content requires increased length of pages to keep an acceptable total number of pages for easy management and reasonable downloading time (Figure 9-7). At the same time, if the course is very small/very extensive, both the number and the length of pages should be minimised/maximised to cope with content volume and present it in a moderate way.

Figure 9-7: Scrolling problem and length of Web pages



Second, evaluators were not entirely satisfied (65.80%) with the design of labels or captions of images. One possible reason is that captions described both instructional graphs and other images very briefly, without detailed explanation of their content (e.g., maths graphs). Although students are familiar with this style of labelling in their traditional textbooks, this style is not appropriate for visually impaired students who use a screen reader to identify and manipulate images.

Therefore, on the Web it is not enough to provide well-designed and beautiful images or graphs to describe the content or provide important information. These images cannot be accessed by all students, unless text-based equivalents are provided. In conclusion, a more precise and meaningful labelling strategy considering disable students should be implemented to make the instructional user interfaces more appropriate for students with special needs.

Third, although Macromedia Flash objects have become a popular and widespread technique in designing Web interfaces, and many evaluators thought they should be incorporated, others were of the opinion that current Flash technology delays learners' ability to interact and decreases user control over the presentation. Of course there is no doubt that multimedia Flash objects have a role in instructional on-line materials, but current Flash technology tends to harm the graphical user interface of the Web (Nielsen, 2000).

Some browser buttons and functions (e.g. back, find in page and font size) do not work within Flash objects. For example, visually impaired students cannot enlarge font size or search for a specific word in the document. In addition, link colours do not work properly and the learners cannot easily see where he/she been and which links have been visited. Therefore, to maximise the benefit of Flash objects in education, designers should help learners to understand their graphical interface, enhance interactivity with the content and presentation and of course provide text equivalents of Flash content to overcome difficulties, as mentioned above.

Fourth, although the evaluators emphasised the importance of using PDF (Portable Document Format) as well as the beauty of HTML in presenting on-line text, on the one hand, and since PDF files always display documents exactly as created, regardless of fonts, software and operating systems, on the other, however, using PDF has its own limitations since it does not support interaction and control over the content as HTML does. Therefore, PDF is only useful where a large amount of information is to be distributed and printed rather than read on-line, as happened in Wired Class. In this case, students should interact with the content by responding to questions, filling-in forms and receiving the tutor's comments.

Lastly, it could be concluded that the 'user-friendly interface' is characterised by:

1. simple and consistent design;
2. appropriate screen appearance for different resolutions;
3. standard fonts and colours;
4. standard presentation rather than importing plug-ins interfaces; and
5. meaningful icons and small pictures to represent command and content.

9.2.3. Results related to ease of use

The purpose of this section is to investigate the extent to which new tools of on-line learning (e.g., e-mail and chat) and other components of the learning environment are easy to learn and use and to reveal technical problems that faced students in dealing with Wired Class. First, students were asked whether the time spent in learning how to use Wired Class was short or not. The results (Table 9-26) showed that the majority of students (84.38%)

strongly agreed that they needed only a short time to become familiar with Wired Class and learn how to use it.

Table 9-26: Students' responses to the ease of use

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The Web publisher is an easy way to publish my work on the Web.	7	13	5	7	0	62.50	3.63	1.0701
E-mail program is easy to use.	11	15	1	5	0	81.25	4.00	1.0160
Chat room is an easy way to communication with others in Wired Class.	7	10	4	11	0	53.13	3.41	1.1876
E-mail is easier than chat to communicate with others in Wired Class.	15	15	2	0	0	93.75	4.40	0.6148
If I have any problem in using Wired Class, the help pages guide me to solve it.	5	9	3	12	3	43.75	3.03	1.3072
Learning to use Wired Class takes a short time.	13	14	1	4	0	84.38	4.13	0.9755

In addition, students were asked whether the new components of Wired Class were easy to use or not, and whether the help system was helpful or not. Students pointed out that the Web-based e-mail and the Web publisher made it easy to conduct asynchronous interaction and publish work on the Web. However, only 43.75% of students believed that the help topics were helpful in solving the problems they had encountered in using Wired Class. Moreover, students showed less satisfaction with chat, as a real-time interaction tool, and the majority of them (93.75%) preferred e-mail to chat for peer-interaction and reported critical difficulties in using and communicating with others via chat rooms, as shown below.

The high satisfaction ratings were further supported by comments made by students. They added many positive comments that expressed their interest and satisfaction with the learning environment. For example,

1. 'Wired Class is easy to use'.
2. 'It is fine for me'.
3. 'No problems'.

4. 'Easy to use, different options, beautiful'.
5. 'Wired Class is good because I can talk with my friends online'.
6. 'I receive e-mail messages and it works fine'.
7. '[The Web] publisher makes it easy for me to edit and put my homework on the Web'.
8. 'Web publisher allows us to share ideas'.
9. '[Wired Class is] the easiest way to study. It works from any computer and contains email, chat, discussion and internet links'.
10. 'Page builder is really very good'.
11. '[Using Page Builder] it is nice to see others' home pages that they made'.

In addition, students pointed to some technical and organisational problems to get connected to the Internet and using and participating in chat sessions, as follows.

1. 'I could not participate in chat meetings because I need to type very quickly and I am not very good at spelling'.
2. 'Students couldn't enter chat'.
3. 'We were able to chat if only for a short time'.
4. 'I couldn't print the exercise to answer it at home. Something was wrong with the printer'.
5. 'My exercise page hasn't been printed. I'll photocopy this page from a friend'.
6. 'I wanted to enter but the server was not ok that time'.
7. 'Your [Internet connection] telephone line was busy'.
8. '[The connection is] slow'.

Second, since coding or programming or coding errors would affect the ease of use of the learning environment, experts were asked to review HTML/CGI forms, Java applets and Java Script tools to know whether they ran smoothly or not. The results revealed that they were very satisfied with programming and the smooth running of server-side scripts, as shown below (Table 9-27). One evaluator suggested that CGI scripts would be faster in downloading and more suitable than user-side (Java) in handling and manipulating learners' inputs.

1. 'Great use of Javascript and HTML'.
2. 'Good work for CGI programs behind processing forms and looking up records in a database'
3. 'I like the smooth running of chat and page builder where no Java is required'.

Table 9-27: Evaluators' responses to ease of use (N=41)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
No troubleshooting or coding errors are available	21	14	0	6	0	85.30	4.22	1.0371
The overall design of the system is suitable for students' level	8	13	1	13	6	51.22	3.10	1.4284
The on-line help system is efficient	8	12	7	7	7	48.78	3.17	1.3947

However, an evaluator thought that the Java scripts would not run appropriately and needed to be optimised to work under old versions of Web browsers.

> 'A few software bugs which caused it to hang occasionally. You need to prove your javascripts with IE 4.5 and Netscape 4.x (the expanded menu)'.

Since CGI scripts were used throughout Wired Class, one evaluator advised that using ASP is better for faster and flexible manipulation of data on the server side. Microsoft released ASP (Active Server Pages) to challenge other CGI compilers (e.g., C++ and Perl) under the Windows NT operating system.

> 'I think ASP is faster and more effective than CGI technology, both technically and in popularity. CGI will probably never be as fast as ASP'.

In addition, experts were asked whether the overall design of Wired Class was appropriate to the target learners and whether the on-line help system was efficient or not. Around half of evaluators agreed that the system was appropriate and easy for students to use. In addition, open-ended responses confirmed that the system is simple, well designed and easy for students to use, as shown below.

1. 'Your system looks simple and suitable for text-based asynchronous teaching'.
2. 'My overall impression is that it is a well designed site and easy to follow'.

However, less than 50% of evaluators (M=3.17) agreed that the help system was effective enough to solve on-line students' problems. The open-ended responses indicated that although the design of the help systems used graphics effectively, there was a need to provide a search facility throughout help topics and place a help icon in each page, as shown below.

1. 'There will probably be some changes, such as a new help browser'.
2. 'In addition to the main Help button [icon], there would be individual help buttons alongside each page'.

To investigate the reliability of students' responses and the agreement between students and experts in perceptions of ease of use, an independent-samples *t*-test was used to determine the potential statistical significance of the differences. Levene's test (Bryman and Cramer, 1997) indicated that the differences between the variances of the two groups were statistically non-significant, since the value of Levene's test was 0.255 (Table 9-28). Consequently, the *t* value based on equal variances was assumed. This is non-significant with a two-tailed value of -1.372 at 0.05 level of confidence. Therefore, it is concluded that there were no significant difference in perception of ease of use of Wired Class between students and experts.

Table 9-28: The significance of differences between students' and experts' perception of ease of use

Variance	**Levene's Test for Equality of Variances**		***t*-test for Equality of Means**				
	F	Sig.	*t*	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	0.255	0.615	-1.372	71	.174	-.3041	.2216
Equal variances not assumed			-1.365	65.393	.177	-.3041	.2228

9.2.4. Discussion of ease of use results

Overall, students' and experts' experience with Wired Class showed that Wired Class with its hypertext interfaces and simple structure was easy to learn and use. Students were quickly able to understand its options and commands and use them to access learning materials, search for information and interact with the tutor and other students. Particular components such as e-mail and Web Publisher were considered to be very attractive and easy to use to facilitate student-peer interaction. According to students' and experts' feedback, a Web learning environment like Wired Class is considered very easy to use for the following reasons:

1. No technical problems were found.
2. Students were able to learn how to use the learning environment in a very short time.
3. It provides various ways for students to access information and contact the tutor and classmates.
4. Communication tools, in particular, were easy to use in sending and receiving messages.
5. It provides easy to use tools to edit and publish Web pages without the need to learn HTML or principles of Web design.
6. It is appropriate to students' experience level and does not require prior experience in using the Internet or learning via the Web.

However, students and experts believed that some components were not easy to use. They argued that:

1. The system is text-based and requires good spelling, vocabulary, grammar and typing skills, particularly for non-native speakers. Therefore, asynchronous (delayed) rather than synchronous (real time) activities would be more appropriate and suitable for students. Discussion boards, e-mail and submission forms are good examples of asynchronous tools that give the learner the time to read, think, type and revises his/her inputs. However, chat might not be easy to use in formal learning sessions since it requires prior planning and arrangements using other medium, such as e-mail, good and appropriate Internet connection, logging-in to the chat room at a specific time, small number of participants and good typing and language skills.
2. It requires dealing with hardware such as printers and Internet connection. Therefore, onsite support should be provided to distance learners and the need to deal with additional software and hardware should be minimised.
3. The online help system needs to be on demand in each page, to facilitate searching for relevant information when students need it and guide them through the interface. Therefore, a more efficient and usable on-line help system should be provided throughout

the site. This system can guide students throughout the user interfaces as a human teacher does, with the possibility of adding sounds, animations and movies.

Although improving and exploiting the above advantages and overcoming the obstacles would provide students with a good experience in using and learning with Wired Class, an efficient and easy to use on-line learning environment requires the support provided by an integrated set of training, documentation and tools (Jones and Buchanan, 1996).

9.2.5. Results related to navigability

To evaluate the navigability of Wired Class, three statements were used to reveal information about students' experience in browsing through the Wired Class pages. Students were asked whether they could move smoothly from one lesson to another, whether they could go forward/back to a new page or page already visited and whether nodes were clear in meaning. The majority of students (more than 80%) indicated that navigation through modules, lessons and pages can be done smoothly without getting lost. Half the students believed that the nodes were clear in meaning and reflected their target links. In general, students were satisfied (3.81) with the navigation design of Wired Class (Table 9-29).

Table 9-29: Students' perception of navigation

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
I can find any page or lesson easily.	16	12	4	0	0	87.50	4.37	0.7071
From any page I can go to a new page or return to an old page easily.	10	16	0	6	0	81.25	3.94	1.0453
Usually, I know what a link means before I click it.	4	12	3	10	3	50.00	3.13	1.2636

Comments from students who approved the navigability throughout Wired Class indicated that it is well organised and they found it easy to navigate and follow its links, as follows:

1. '[Wired Class is] very easy to navigate'.
2. 'It is easy to go to any lesson and get back again'.

3. 'This is a great home page. I like the access to the different areas that I need to go'.

4. 'The [left-hand] menu displays the lesson in front of me quickly'.

5. 'The links are very organised'.

On the other hand, some students made negative comments regarding broken links or difficult-to-locate external Web sites and the problem of going back to the first page using the 'Back' button after logging into the site, as follows:

1. 'It got stuck at the lesson page and the browser refused to go back'.

2. 'If there is a back link in the URL instead of clicking the [Wired Class] home [icon] it will be better'.

More specifically, the evaluators evaluated the navigability of the site using twelve evaluation guidelines as shown below (Table 9-30). The results were very favourable and most evaluators thought that Wired Class was characterised by its efficient navigational system.

Comments from evaluators regarding the navigability of the site showed that the graphical expanded/contracted menu with which the content was structured was very successful in presenting and manipulating the content on-line. However, it was suggested that this menu should be dynamic rather than static, to allow students to construct their own menus and paths.

In terms of navigation tracking, evaluators (89.47%) indicated that the design of the Web pages would help students to go back to the home page from anywhere to access Wired Class components. However, only 36.48% of evaluators believed that the design would help students keep track of where they were in the site. In terms of simplicity and ease of use, the majority of evaluators agreed that Wired Class used clear navigational aids, a suitable indexing system, an adequate number of well-labelled links and icons designed in a consistent manner, and all these elements were served through simple Web pages and a well established hierarchy.

Table 9-30: Evaluators' perceptions of navigation system (N=19)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The site design helps students keep track of where they are	3	4	3	5	4	36.48	2.84	1.4245
The site uses clear navigational aids	10	2	4	1	2	63.16	3.89	1.4101
The indexing system provides quick access to information	8	7	2	0	2	78.95	4.00	1.2472
Students can easily locate the information in the lessons	2	5	9	2	1	36.84	3.26	0.9912
Links are well labelled and this helps the student to identify the meaning of a link easily	11	4	1	2	1	78.95	4.16	1.2589
The student can return easily to the home from any location on the site	13	4	0	0	2	89.47	4.37	1.2566
The navigation icons are consistent throughout the site	10	6	0	2	1	84.21	4.16	1.2140
Design of frames helps students to navigate throughout the modules and lessons easily	4	7	6	0	2	57.89	3.58	1.1698

Lastly, only 36.84% of evaluators agreed that students could easily locate the information in the different lessons using the suggested navigation system. The last negative result and others were clarified by experts' comments in the open-ended question as shown below.

> 'I am interested particularly in the interactive book (symbols, exercises with and without answers, exercise to and not to submit, test, examples). It's important to let the student navigate in the books in all kinds of ways. I wonder if you can let them choose different paths'.

Again, it was suggested that breaking the content into a tree of small nodes, as happens in the content menu, makes navigation through the site easier and is interesting.

> 'Your course as a tree of nodes and the student works his (her) way from node to node with minimal load time for each node looks very great'.

Additionally, other navigation aids such as the tool bar would facilitate learners' job of moving around the site from any location to another.

> 'I have spent quite a bit of time navigating around. The toolbar navigation does make getting around easy'.

On the other hand, although the frames-based design of Wired Class was recommended for easy navigation, as mentioned in Chapter 5, an expert claimed that an alternative non-framed version for those who are not interested in navigation using frames or those who have old browsers should be provided.

> '[...] a no frame version must be supplied for the entire site and access to it should be easily visible on the homepage'.

In addition, it was advised that an alternative HTML menu of the Java Script graphical expanded/contracted menu should be provided for those who may have difficulties in navigation using this type of menu.

> 'An alternative text-only menu must be supplied'

Other comments were made concerning the ease of navigation around Wired Class, need to consider a new indexing or numbering system, implementing a more reliable search engine to access course information and law-related issues, as follows.

1. 'Well arranged and a little easier to find things'.
2. 'Very good description of links'.
3. 'The hierarchy is simple and visually not overwhelming'.
4. 'The layout is very easy to navigate'.
5. 'Think about page numbering'.
6. 'Simpler and more accurate searching is required'.
7. 'Linking to other sites within frames is illegal!'.
8. 'You can't bookmark or search pages within framesets'.

9.2.6. Discussion of navigability results

Creating the navigation system was considered as a central aspect of the design and development of Wired Class. Simply, the aim was to help learners to understand the structure of the site and locate content, learning resources and tools relating to their needs easily and logically. Therefore, it was important to examine the navigation design from learners' and experts' perspectives.

First, judging by students' feedback, the starting page served successfully as a cross road or origin point to guide learners toward exploring, understanding and navigating through the site and its different contents. To do that, the starting page provided an overview of the whole site showing its major areas in categories (called rooms) with a brief functional description of each area and its links. The importance of a well-designed starting or home page was emphasised by earlier research in navigability.

It has been found that both young and well-trained users return to the home page frequently as the first step in locating information (Meyer et al., 1997). Therefore, links in the home page should be well categorised and detailed but using a moderate number of links to avoid confusion. These links should not take the learner too far from the starting page. At the same time, a 'home' link should be available in each page to take the learner back safely.

Second, however, as soon as the learner leaves the starting/home page following links to information, there is the possibility of getting lost in the site. To address this problem, many approaches and navigation guidelines were adopted. One main approach used was the 'indexed design' of links, rather than the sequencing or exploration design, to keep learners oriented, as shown in Chapter 3. Evaluation results indicated that although there is no clear evidence that students would be able to track their pathway in the site ('think about page numbering') pull-down, toolbars and expanded/extracted menus as well as the consistency of design would help students to define their locations and keep them visually oriented ('the hierarchy is simple and visually not overwhelming').

The expanded/extracted Java Script menus, in particular, were very reliable and attracted the interest of both students ('menu allowed the lesson to be in front of me quickly') and evaluators ('I am interested particularly in the interactive book; your course as a tree of nodes … looks very great'). In addition, other features such as using labels that clearly describe the function and destination of links and providing back links to the starting page or high-level site categories on every page minimised the chance of confusion or getting lost in the site.

Third, although frames seem to be a useful approach to reduce the downloading time and keep students visually oriented, the rating of them was relatively low. Evaluators who claimed that frames are not an appropriate approach highlighted many crucial legal and technical issues. The first issue was placing resources or documents from other Web sites illegally within the parent frames of the site to keep learners within the learning environment. Further investigation of this issue has confirmed this relatively new legal issue. It was found that although frames can make a learner's time on a Web page significantly more productive, showing others' remote pages through local frames is illegal and prohibited (Kuester and Nieves, 1998; Grossman and Rigamonti, 1998). Therefore, if it is needed to display remote learning resources, other techniques should be considered, such as opening a new justified browser window.

The second issue was that using frames has its own navigational limitations, such as:

1. the difficulty of bookmaking pages within the site;
2. the difficulty of reloading/refreshing pages; and
3. inability of in-site and Web search engines to search foremasts appropriately.

For example, although the search facility is a very popular and fast facility to help learners find information rather than moving around until they become lost, there is evidence in this study that information returned from searches was irrelevant or inappropriate ('simpler and more accurate searching is required'). One reason is that the Wired Class search engine had trouble picking up pages within framesets without pointing to relevant single HTML documents.

However, stating another point of view, since Wired Class was oriented to the completion of a series of interactive tasks (e.g., test forms, Java Applets, etc.) rather than reading separated pages, bookmaking would not be a navigational problem in this case. In addition, HTML tags and META tags (e.g., title, head, keyword and description) can be used to eliminate the problem of searching framesets.

Chapter 10: Organisational Issues

In his ACTIONS model, Bates (1995) argued that there are no significant differences between the organisational requirements for implementing different types of technologies (e.g., television, videoconferencing and computer). Often, there is a need for a team approach to design and develop learning, trained staff to run and maintain equipment and to facilitate access to technology and resources and clear copyrights (Bates, 1995). However, in Web-based learning, in particular, many organisational issues need to be considered. These include the security of the learning environment, tutors' and students' responsibilities, structure of the learning environment, student management and speed. In addition, factors related to students' perceptions of on-line learning, activities in the learning environment and academic achievement are investigated in this chapter. Therefore, this chapter attempts to answer the following research questions:

Q5.1. How secure is the site?

Q5.2. How are the responsibilities of the tutor and students established?

Q5.3. How is the learning environment structured?

Q5.4. How are students managed at a distance?

Q5.5. How long do students need to study the course materials?

Q5.6. What are the factors that affect students' perception and achievement in on-line learning?

10.1. Results related to organisational issues

First, since logging into the learning environment and students' records should be password protected, evaluators were asked to rate and comment on the level of security applied in Wired Class. Experts' responses indicated that the Wired Class Web site was not secure enough (Table 10-1) and that some limitations and issues should be considered to protect the learning environment and students' records from unauthorised access, as shown below.

Table 10-1: Evaluators' perceptions of security (N=41)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The Web site has a secure access	7	9	17	8	0	39.02	3.37	0.9939

Evaluators believed that Web security is a challenge that has no simple solution at the current time, but that, fortunately, the huge public interest in this issue may lead to very reasonable solutions in the near future.

> 'No one came up with a complete solution to security problem, but various workarounds are possible'.

Another evaluator highlighted a more interesting education-related security problem. He argued that establishing more sophisticated secure Web sites would prohibit and affect the flexibility, ease of use and costs of access from a distance. One reason is that the traditional assignment-based evaluation approach would be difficult to manage using sophisticated security solutions.

> '... If perfect security is desired, on-line assessment is a challenge, yet don't forget that perfect security is also difficult to achieve with traditional methods of assessment'.

However, stating another point of view, two evaluators argued that the security issue should be emphasised, even inside the learning environment itself, to keep students' privacy and confidentiality. Examples of this problem in Wired Class would be found in shared public discussion boards and students' personal Web pages that present their personal photos and e-mail addresses.

> 'However I would recommend moderating the shared spaces to avoid breaches of security and confidentiality'.

And

> '[…] but personal elements (pictures, e-mail address, etc.) require a password'.

In addition, an evaluator highlighted the need to save and secure students' data (e.g., personal records, assignments, examination results, e-mail messages, etc.) from being lost in the server, as well as saving them from unauthorised access.

> 'You have to ensure that your server is secure from unauthorized access, and that server is protected from data loss'.

Lastly, stating another point of view, it was suggested that in the case of access to the learning environment from a specific location (such as a computer lab or library at school) or machines (that have a permanent IP address), security problems can be avoided by restricting access to a specific domain or IP addresses.

> 'The perfect security is to constrain the access of certain pages to the IP addresses of a computer lab where your students have to show a password to use the computers'.

Second, since it is necessary for any on-line environment to establish its own policy and code of ethics for both tutors and students (Bates, 1995; Heydenrych, 2000), evaluators were asked to rate and comment on the guidelines for enrolment in the learning environment, submitting course-related tasks, using communication tools (e.g., e-mail, chat and discussion boards), copyright issues and accessing personal and shared spaces. The results revealed that the responsibilities of tutors and obligations of students were not stated clearly and need some improvement (Table 10-2). However, only one evaluator commented that more detailed description of tutors' and students' roles is needed and key issues (e.g., plagiarism) should be mentioned.

> 'You need to explain the behaviour and rules that are to be followed while online, how cheating applies to information found on the Web, activities, communications…'.

Table 10-2: Evaluators' perceptions of stated regulations (N=34)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
The responsibilities of the learner and the obligations of the tutor are well-stated	10	6	7	8	3	47.09	3.35	1.3681

Third, according to the ACTIONS model (Bates, 1995), a well structured program is one that implements the necessary components and technology to facilitate and support learning. These components or technology should be implemented successfully to achieve the objectives of learning. Only evaluators were asked to investigate Wired Class, to see whether its components (tutorial, interaction, management and support) were made available and used effectively to construct the learning environment for teaching students at a distance.

On the positive side, evaluators (61.76%) thought that Wired Class included the key components that should be available in on-line learning environments (e.g., registration tools, communication tools, etc.) (Table 10-3). For example, evaluators commented that:

> 'Your site is very impressive not only in terms of the scope but also in terms of the support that students are provided with. It is very well-thought of'.

And

> '[...] your system looks simple and suitable for text-based asynchronous teaching'.
>
> And

> 'I thought Wired Class was very well thought out and put together. You put up great tools for math, I love specially the presence of a teacher available to help the students'.

In addition, an evaluator found Page Builder an efficient tool to help students to build and upload their web pages quickly and easily.

> 'I am very impressed by the approach you have taken towards the publishing of user's own pages - simple and very effective'.

Although evaluators found that Wired Class offered suitable synchronous and asynchronous means to motivate and facilitate interaction, an evaluator argued that an on-line 'whiteboard' is needed to improve synchronous and visual interaction between the tutor and students:

> 'A real-time whiteboard is better, it allows you to perform functions such as typing and drawing while students watch'.

Table 10-3: Evaluators' responses to the site structure (N=34)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
Wired Class contains the key components of on-line learning (interactive tutorials, interaction tools, etc.)	10	11	9	4	0	61.76	3.79	1.0084
Synchronous and asynchronous interaction tools are suitable to conduct and facilitate student-tutor and student-student interaction	6	11	12	4	1	50.00	3.50	1.0225
The site provides appropriate support tools to enhance and manage instruction (e.g., the library, notebook, etc.)	3	3	7	13	8	17.65	2.41	1.2090
The management tools (e.g., tracking, control panel, students' grades, etc.) enable the tutor to facilitate the learning process	5	6	3	14	6	32.35	2.71	1.3602

On the negative side, evaluators (52%) believed that the management component (e.g., registration, tracking, control panel, students' grades, etc.) does not enable the tutor to operate the class efficiently, although they did not say why, or how this component could be improved. However, a positive comment in this regard came from one evaluator who argued that 'one of the greatest features is the marks editor', which enables the tutor and edit and update student's grades books easily and quickly. Lastly, evaluators disagreed or strongly disagreed (61.8%) Wired Class site provided appropriate support tools to enhance and manage instruction (e.g., the library, notebook, study guide, etc.). For example, an evaluator found that:

> 'The study guide does refer students to the course materials but not in any detail!'.

Fourth, in terms of management, evaluators were asked whether students are encouraged enough to be independent learners at a distance. The results indicated that students might not be able learn independently at a distance (Table 10-4). However, an evaluator argued that if the learning environment supports and implements constructivist principles, in which students depend on their own experience and interaction with others to construct their own meanings, the tutor's role would be superficial rather than essential.

> 'Why have a teacher at all if you want students to construct their own knowledge?'

Again, another evaluator emphasised the secondary role of the on-line tutor as a facilitator rather than a master.

> 'Learning in a distance environment is self-directed and the instructor is seen as a facilitator rather than the leader'.

Table 10-4: Evaluators' perceptions of student management (N=34)

Statement	Response Distributions					% Choosing SA or A	Mean	Std Deviation
	SA	A	N	D	SD			
Students are encouraged to study independently at a distance	4	6	16	5	3	29.41	3.09	1.0834
On-line exams are appropriate to assess students at a distance	5	6	3	14	6	32.35	2.71	1.3602
The site uses efficient ways to submit, process and grade students' work	11	13	4	3	3	70.59	3.76	1.2567

Also, evaluators found that although the learning environment provides an efficient approach to handle, process and assess students' work throughout the learning environment, the approach used to assess students at a distance using on-line exams was not efficient. Evaluators highlighted the problem of conducting on-line exams, as the most critical issue that should be considered in this regard. For example, an evaluator warned of cheating at a distance as a result of the absence of face-to-face monitoring.

> 'The evaluation system is not reliable because it is difficult to establish the identity of the student during the online test'.

Another one recommended the use of non-traditional assessment approaches besides the known assessment approach.

'Although I think online exams work well, performance tests shouldn't be the only means by which you assess the performance of your students'.

Lastly, an evaluator argued that the text-based approach might not be appropriate to conduct tests or exams online. He emphasised the need to use synchronous audio/video conferencing to enhance the reliability of on-line exams.

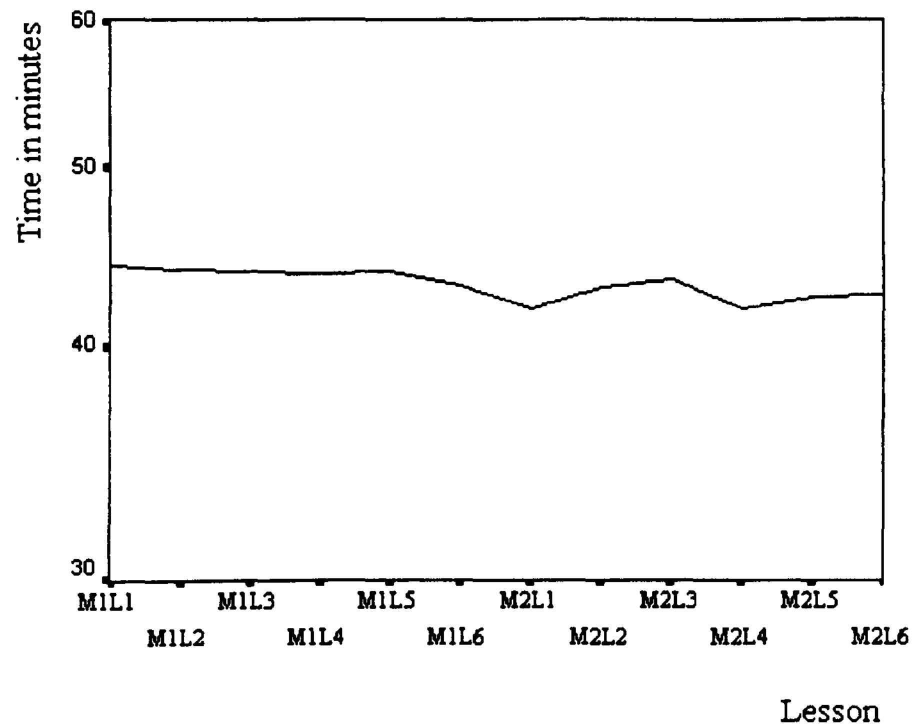
'You may need to incorporate audio and video into the exam'.

In terms of length of time spent in learning, Wired Class logs showed that the time spent varied between 42 minutes, in earlier lessons and 44.26 minutes, in later lessons, and from one student to another (Figure 10-1). The average time spent in learning one lesson, including interaction with lesson content, responding to self-tests, participation in discussion boards, browsing course-related Web resources and submitting tasks to the tutor, was 43.28 minutes. This means Wired Class students spent less time than those in the traditional classroom (50 minutes) and the average reduction in time spent in learning was 13.44% (Table 10-5).

Table 10-5: The average time spent by students in learning

	Number of lessons	Number of students	Mean time	Std. Deviation	Minimum time	Maximum time
Time spent in learning	12	32	43.28	.8064	42.00	44.26

Figure 10-1: Time spent in learning



10.2. Discussion of results related to organisational issues

First, with the dramatic growth in the popularity of the Internet and its related applications and services, the problem of protecting learning environments and its components has been highlighted. Valuable information can be lost or misused, allowing the virtual classroom to be corrupted. This means that, at least, students, who are authorised to access learning, may not be able to do that at any time or in any place (Longstaff et al., 1997).

Web-based learning environments, like other Web applications, are subject to the loss, damage or theft of data from the server, particularly when students are provided with on-line tests which involves various security considerations. 'This includes security for the test material, security for the student tracking information, security for the HTML source code, and security for ensuring that only registered students take the test' (Gibson et al., 1995).

In Wired Class, unfortunately, evaluators showed low satisfaction with the procedures taken to ensure the security of the learning environment, particularly those related to logging into the learning environment, accessing students' personal information and records and ensuring the security of on-line tests. However, evaluators' concerns about security problems arose not only because access control was not sophisticated enough, but because of the lack of public confidence in Internet security in general, as mentioned above ('no one came up with a complete solution to security problem'). Even sophisticated systems are very costly and not appropriate and easy to use in educational applications ('perfect security is also difficult to achieve with traditional methods of assessment').

Another kind of on-line learning security problem was highlighted when evaluators indicated the need for more control over the public areas (e.g., presentation board, chat rooms and discussion boards) and personal information (e.g., e-mail addresses and personal photos), even for authorised students themselves. The reason is that these areas and other available information may increase the risk of breaching the privacy and the confidentiality of students, particularly in the absence of the tutor or site facilitator.

Furnell et al. (1998) raised similar concerns and emphasised various security problems when they identified the generic security requirements that should be applied in the design of distance learning environments. These requirements are:

1. Security of payments;
2. Control of logging-in;
3. Security of course materials;
4. Security of communication;
5. Security of submitted work;
6. Security of exams and tests; and
7. Privacy of students' records and examinations grades.

These security issues should be considered at each stage of designing and delivering on-line learning (Furnell et al., 1998). At the same time, these security procedures (e.g., restricting access to specific IP addresses) should not affect the usability of the learning environment, including availability and ease of use. Therefore, designers should ensure that course related information and students' information and records are stored securely by paying more attention to security needs, as done in designing user interfaces and resources (Akeroyd and Currall, 2000).

Second, regarding the stated policy of the learning environment, although Wired Class has provided students with a brief guide explaining their roles and the safety procedures that should be followed while on-line, the results from the evaluators' questionnaire showed that more explanation of the tutor's and student's roles should be provided, particularly those concerning students' behaviour regarding copyright issues and communication rules. According to Bowman (2001), although the tutor's roles are too complicated to be stated clearly to students and parents, among these roles that should be known by students are:

1. Being available in a timely manner to assist students in diagnosing the problem and giving proper and specific feedback; and
2. Moderating interaction, mentoring students' activities and contributions and evaluating students' work (Bowman, 2001).

Among the student's responsibilities that should be stated clearly are:

1. Studying on-line tutorials independently and conducting further research as required;
2. Submitting relevant and meaningful answers to the tutor according to the course schedule; and
3. Contributing to discussions and other activities by commenting, questioning and reflecting on others' responses (Bowman, 2001).

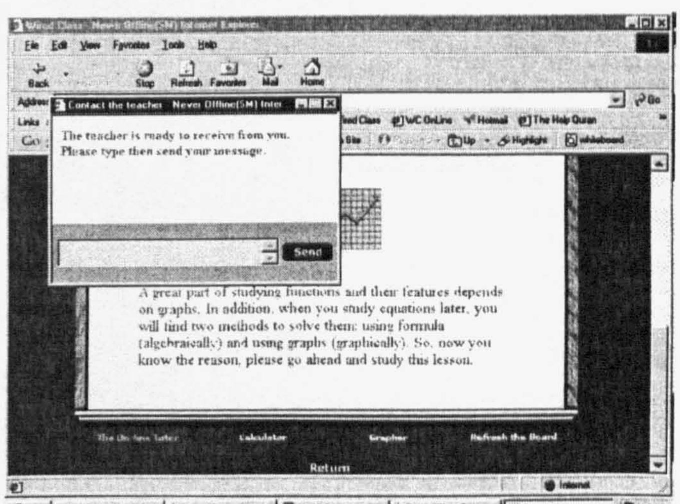
Third, the review of the WBI literature showed that there are many components that should be made available in on-line learning environments to simulate face-to-face education and support learners at a distance. The aim of this section is to investigate whether these components were implemented successfully or not and how it can be developed. These components are categorised into tutorial (e.g., syllabus and resources), interaction (e.g., e-mail, discussion boards and students' pages), management (e.g., registration and students' grades) and support (e.g., Page Builder and Presentation Board). In addition, new tools need to be developed and implemented (such as Page Builder) to bring the results of previous research to the reality and to help students in their learning.

In designing Wired Class, most of these components were adopted according to learners' needs and the objectives of learning. Overall, according to evaluators' views and comments, Wired Class contained all the components required to deliver instruction to students, facilitate asynchronous and synchronous interaction and manage students at a distance. An evaluator concluded that 'You have developed many useful tools'.

New tools, such as Page Builder, helped the majority of students (81.25%) to build their pages easily without the need to learn HTML; this was strongly favoured by evaluators (e.g., I am very impressed by the approach you have taken towards the publishing of users' own pages - simple and very effective). However, evaluators recommended the implementation of more efficient support tools and a real-time interactive board to improve student-tutor interaction using texts, drawing and graphs. In addition, the tutor's experience obtained during the two months implementation of Wired Class highlighted the need to provide effective visual, rather than only text-based tools to support students, particularly in a subject matter like mathematics.

Therefore, a new tool was suggested in this study called the 'on-line board'. Using the on-line board (or whiteboard), the tutor can communicate and post a demonstration to one student, or more, with text, high quality graphics and hyperlinks. If a student wishes to discuss a maths concept interactively, the tutor can discuss, explain the concept and guide the student through the content synchronously.

Figure 10-2: The on-line board



Such a board has an advantage over e-mail in that it enables the learner to conduct text-based real time interaction with the tutor and can be updated by the tutor at any time (Figure: 10-2). The tutor can prepare his/her presentations using any WYSIWYG HTML editor then upload HTML files and graphics using the on-line board's control panel. Presentations used in the on-line board can be saved by the tutor to be used with other students in the future.

Fourth, managing students at a distance as well as encouraging them to work independently are the most critical issues considered in the design and evaluation of distance education programmes (Chapter 2). In Wired Class, it was assumed that students would be encouraged to work independently through designing the following components:

1. Self-based learning materials and well-selected external Web resources;
2. Asynchronous peer-based discussion groups and presentation boards;
3. On-demand tutor support and on-line help topics;
4. Self-assessment tests and 'send to the tutor' questions;
5. On-line white board with synchronous interaction facility; and
6. Tutor's control panel and grading tools.

Evaluating these tools and approaches to know whether they were implemented successfully to support and manage Wired Class students at a distance revealed that although Wired Class offers a unique environment to monitor and track students' academic progress and handle and process their work effectively, a solely text-based approach was not adequate to deal with many critical issues such as examinations and learner support. Even the design of learning materials and learning aids (such as graphical calculators and animated graphs) was not sufficient to give students the feeling of control and independence at a distance.

Also, the results showed that the design of learning was affected by the human tutor's role, which discouraged students from being independent in constructing their own knowledge. However, although this point of view may be in-line with constructivist principles, as mentioned in Chapter 4, and the views of some distance educators, argue that distance students are expected to achieve a great deal of the learning on their own (Baynton, 1992), the on-line tutor's role is fundamental, not as a primary source of instructional support, but to monitor young students, check their attendance and submissions, address individual needs when they arise, encourage students to complete the course, select and develop problems for investigation and manage discussion groups (Bates, 1974; Davie, 1989; Flottemesch, 2000).

In their definition of control at a distance, Garrison and Baynton (1987) and Baynton (1992) agreed with this point of view when they argued that the learner will 'flounder' and may lose interest in learning if he/she does not have sufficient support provided by both the tutor and students. However, at the same time, they indicated that the concept of independence should be related to other factors that influence and direct the learning process. These factors are the learner's ability to participate in learning, which they called 'students' competency', flexibility in time and choice of course, attitude toward interaction and freedom of access resources.

However, since the term learner control is often used interchangeably with independence, Baynton (1992) concluded that 'the concept "control" provides a richer, more multidimensional description of the distance learning transaction than does the concept of "independence"' (p. 31). Tutor-student interaction, in particular is essential for the concept of control stated by Baynton and according to Peters (1998), without the interaction of learners with the tutor and peers, the learners would acquire knowledge in isolation.

Fifth, since evaluating and conducting exams for students at a distance is one of the ultimate aims of distance as well as traditional education managers, and since distance education, in particular, is characterised by the geographical isolation between the learner and the institution, the need to submit, assess and grade students' work is one of the main issues that have captured managers' interest. The results, as shown above, indicated that the experts were not at all happy with the text-based on-line approach followed to examine students at a distance.

The reason for their concern is that there was no practical way to ensure that the student did the exam in person and without cheating, as happens in face-to-face education. This problem was highlighted in the considerations of security requirements Furnell et al. (1998), cited above. The solution provided by the British Open University is for students to go to an approved proctor centre to do a traditional examination. However, a technical solution provided by an evaluator suggested that the examination could be conducted without the need to bring students into the campus or local centres if videoconferencing technology is implemented to monitor students and verify their identity. Stating a different point of view, an evaluator suggested that on-campus types of assessment like exams should not be the only way to evaluate Web-based distance education students, particularly with the implementation of modern instructional approaches likes constructivist and co-operative learning.

The above points of view reflect that there are three organisational-related problems with on-line exams. These problems (the difficulty of identifying students, the need to monitor and prevent cheating and security of tests) can be solved by either employing desktop videoconferencing technology to monitor distance students visually, a method which is already available and widely used, even if not by all students, or holding traditional on-campus exams, which would provide a more reliable situation and greater confidence in the education system.

Lastly, although students spent a significant time in downloading course materials, reading and browsing on-line course materials, responding to self-test on-line quizzes and submitting work to the tutor, accessing Web resources and participating in on-line discussions, it was interesting to find that there was a substantial reduction in time (13.5%) spent in learning over traditional classroom. This reduction in instructional time was found one of the most important advantages of using computers and technology in education (Niemiec and Walberg, 1987). In addition, Kulik and Kulik (1991, in Kulik, 1994) found that students spent less time in learning with computer-based instruction, with an average reduction of between 24% and 34%.

10.3. Factors influencing students' perception and achievement in Wired Class

Identifying demographic, instructional and social factors that would affect students' perception of the on-line learning environment and academic achievement is as important as identifying the weaknesses and advantages of the technical, instructional and management features of the learning environment (Bates, 1995; Jiang, 1998; Jiang and Meskill, 2000). This section is based on the assumption that there are casual relationships among various factors embedded in the learning environment. These factors are:

1. Gender;
2. Previous Internet experience;
3. Perception of interaction with peers;
4. Perception of interaction with the tutor;
5. Actual student-peers interaction;
6. Actual student-tutor interaction;

7. Perception of user-friendliness; and
8. Academic achievement.

10.3.1. The relationship between gender and perception of user-friendliness and interaction

The purpose of this section is to investigate to what extent student perception of user-friendliness of Wired Class (ease of use, navigability and interface design) was affected by gender. In the present study, only 6 out of 32 students were girls. The significance of differences in perception of user-friendliness of Wired Class (see Chapter 9: User-friendliness), between boys and girls was investigated using a *t*-test. The mean of the perception of boys was 4.13 and for girls 3.67, a difference of 0.46. (Table 10-6).

Table 10-6: The mean perception of boys and girls of user-friendliness

Group	N	Min	Max	Mean	Std. Deviation
Boys	26	2.62	4.92	4.13	0.6020
Girls	6	2.54	4.92	3.67	0.9376

A *t*-test of independent samples, with gender as the independent variable and student overall perception as the dependent variable, was used to determine the potential statistical significance of the differences. Using Levene's test (Bryman and Cramer, 1997), the differences between the variances of the two groups were non-significant (Table 10-7), and so a pooled variance estimate was employed for this purpose. Consequently, the *t* value based on equal variances was considered. This is non-significant with a two-tailed value of 1.496 at 0.05 level of confidence. Therefore, it is concluded that gender did not affect students' overall perception of user-friendliness.

Table 10-7: *t*-test for significance of differences between boys and girls in perception of user-friendliness

Variance	Levene's Test for Equality of Variances		*t*-test for Equality of Means				
	F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	2.782	0.106	1.496	30	.145	.4536	0.3033
Equal variances not assumed			1.133	5.986	.301	.4536	0.4006

Moreover, no significant differences were found between boys' and girls' perception of peer and tutor interaction. Both boys and girls reported relatively high levels of perceived interaction with peers ($M_{boys} = 4.02$ and $M_{girls} = 3.83$) and with the on-line tutor ($M_{boys} = 3.54$ and $M_{girls} = 3.50$). A *t*-test of independent samples, with gender as the independent variable and perceived interaction as the dependent variable, was used to investigate the significance of the differences.

Using Levene's test, the differences between the variances of the two groups were non- significant (Levene's test $_{peers}$ = 0.438 and Levene's test $_{tutor}$ = 0.004) (Table 10-8). Therefore, the *t* value based on equal variances was considered. This was non-significant with a two-tailed value of $t_{peers} = 0.522$ and $t_{tutor} = 0.062$ at 0.05 level of confidence. Therefore, it can be concluded that gender did not affect students' perceptions of perceived interaction, either with peers or with the tutor.

Table 10-8: *t*-test for significance of differences between boys and girls of perceived interaction

Variance		Levene's Test for Equality of Variances		*t*-test for Equality of Means				
		F	Sig.	*T*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
With peers	Equal variances	0.438	0.513	0.522	30	0.606	0.1859	0.3564
	Unequal variances			0.580	8.552	0.577	0.1859	0.3206
With the tutor	Equal variances	0.004	0.952	0.062	30	0.951	0.0384	0.6186
	Unequal variances			0.062	7.436	0.952	0.0384	06230

To investigate the actual participation of boys and girls in discussion groups, students' discussion logs are examined and categorised into two groups. Considering the different number of boys ($N_{boys} = 26$) and girls ($N_{girls} = 6$) enrolled in Wired Class, the number and percentage of participants in each group is calculated (Table 10-9). The results showed that the boys' mean percentage of participation in discussions is 33.65%. However, the mean percentage of girls was 37.50%, which was slightly higher than that of boys.

Table 10-9: Boys' and girls' levels of participation in discussion boards (based on Table 9-5)

Discussion topic		Total number of participants	Boys		Girls	
Module	Lesson		Number of participants	Percentage (N=26)	Number of participants	Percentage (N=6)
Module 1	Lesson 1	11	8	30.76%	3	50.00%
	Lesson 2	8	7	26.92%	1	16.67%
	Lesson 3	7	4	15.38%	3	50.00%
	Lesson 4	6	5	19.23%	1	16.67%
	Lesson 5	8	3	11.54%	5	83.33%
	Lesson 6	8	5	19.23%	3	50.00%
Module 2	Lesson 1	11	11	42.31%	0	00.00%
	Lesson 2	14	12	46.15%	2	33.33%
	Lesson 3	15	13	50.00%	2	33.33%
	Lesson 4	13	12	46.15%	1	16.67%
	Lesson 5	16	12	46.15%	4	66.67%
	Lesson 6	15	13	50.00%	2	33.33%
Total	12	132	105	Mean = 33.65%	27	Mean = 37.50%

To compare between boys' and girls' levels of participation (proportions), the non-parametric Mann-Whitne U test [*] was used (instead of the *t*-test) to compare medians rather than means (Bryman and Cramer, 1997). This test converts the scores on the continuos variable (level of participation) to ranks, across the two groups, which selected randomly and independent from each other, then evaluates whether the ranks for the two groups differ significantly or not (Pallant, 2001). The SPSS output produced by this test (Table 10-10) shows that there was no significant difference between mean percentages of boys and girls, as the Z statistic is not significant ($p>0.05$). In other words, since p value is large, the results do not give you any evidence to conclude that the overall medians of boys and girls differ.

[*] This test uses the ranks of the data rather than their raw values to calculate the statistic. Unlike the parametric *t*-test, this non-parametric test makes no assumptions about the distribution of the data.

Table 10-10: Mann-Whitney U test

Mann-Whitney/Wilcoxon	Men percentage in discussions
Mann-Whitney U	63.500
Wilcoxon W	141.000
Z	-.563
Asymp. Sig. (2-tailed)	.630 *
* Z is non-significant (p>0.05)	

10.3.2. The relationship between previous Internet experience and perception of user-friendliness

Previous research (Martinez and Sweger, 1996; Sturgill et al., 1999) has shown that students with better computer experience tend to report more positive perceptions of user-friendliness of on-line learning and may learn how to use the program better than those who had no or modest experience. To investigate these possible relationships, students' previous experience in using and learning via the Internet, as the independent variable, and satisfaction with the design of the learning environment, as the dependent variable, were correlated. Students' overall rating of technical and instructional design of Wired Class was measured in terms of their mean scores for friendliness of user-interface, navigability and ease of use means (Table 10-11).

Table 10-11: Students' overall perception of user-friendliness of Wired Class

Variable	N	Min	Max	Mean	Std. Deviation
Perception of user-friendliness	32	2.54	4.92	4.05	0.9829

Students' previous experiences were categorised into three groups:

1. Students who had a good background in using the Internet and its services (2): Those students had used the Internet before joining Wired Class and attended on-line courses as well;
2. Students who had a moderate background (1): Those students had used the Internet or one of its services (e.g., e-mail) but they had not joined any Web-based learning courses; and

3. Students who had no background (0): Those students had never used the Internet before (Table 10-12).

Table 10-12: Students' background in using the Internet

Background	Frequency	Percent
No background (0)	11	34.4
Moderate (1)	17	53.1
Good (2)	4	12.5
Total	32	100.0
Mean = 0.66, Std. Deviation = 0.48		

Since the data are ordinal (previous Internet experience) and interval (perception) in nature, the correlation coefficient (Pearson's *r*) was used to indicate the direction and the strength of the relationship between the level of involvement and achievement. Pearson's *r* for relationship between students' background in using the Internet and perception of Wired Class is 0.218, which is non-significant at the 0.05 level (Table 10-13).

Table 10-13: The relationship between previous Internet experience and perception of user-friendliness

Correlation	Perception	N	Sig. (2-tailed)
Previous Internet experience	$r = 0.218$	32	0.231
Correlation is non-significant at the 0.05 level (2-tailed).			

Since there is no significant relationship between the two variables, then it can be concluded that students' previous experience in using the Internet did not affect their perception of on-line learning.

10.3.3. The relationship between student's perception of the user-friendliness and academic achievement

To investigate the relationship between students' satisfaction with the design of the learning environment and achievement, students' overall rating of the friendliness of Wired Class and achievement scores were compared and related to each other. Since the data are interval in nature, the correlation coefficient (Pearson's *r*) was used to indicate the direction and the strength of the relationship between the level of perception, as the dependent variable, and achievement, as the independent variable. Pearson's r for the relationship between students' overall perception of Wired Class and their achievement (0.164) indicates that there is no significant relationship at the 0.05 level (Table 10-14). In other words, students who reported higher levels of perception of Wired Class course attained a similar level of achievement to those who reported lower levels of perception.

Table 10-14: The relationship between students' perception and achievement

Correlation	Achievement	N	Sig. (2-tailed)
Perception	$r = 0.164$	32	0.370
Correlation is non-significant at the 0.05 level (2-tailed).			

10.3.4. The interrelationship between students' perception of student-peers interaction, actual student-peer interaction and academic achievement

It was hypothesised that the students' perception of on-line interaction would affect their level of interaction with peers and the tutor. At the same time, according to constructivist principles, the successful construction of knowledge depends on the learner's interaction with the learning environment, including the tutor and students (Chapter 4). These two assumptions highlighted the need to investigate whether learners' level of interaction with peers and the tutor, as the dependent variable, via discussion boards and e-mail, respectively, was affected by the learner's perceptions of on-line interaction (as the independent variable). Similarly, it is investigated whether students who participated more positively in discussion boards and communicated more frequently with the tutor (independent variable) attained higher achievement (dependent variable) than those who did not interact or who interacted less frequently.

Since the data are interval in nature, first, the correlation coefficient (Pearson's r) was used to indicate the direction and the strength of the relationship between students' perception of on-line interaction (as the independent variable) and level of participation in discussion boards (as the dependent variable). Students' perception of interaction (Chapter 9) and the number of messages sent by each student were used to investigate this relationship. Pearson's *r* for the relationship between students' perception of interaction with peers and involvement in discussions (-0.026) indicates that there is no significant relationship at the 0.05 level (Table 10-15). In other words, students' level of participation in discussion boards was affected by other variables than perception of peer interaction alone, as shown below.

Table 10-15: The relationship between students' perception of peer interaction and achieved interaction

Correlation	**Participation in discussion**	**N**	**Sig. (2-tail)**
Perception of peer interaction	*r* = -0.026	32	0.888
Correlation is non-significant at the 0.05 level (2-tailed)			

To investigate whether students' final achievement scores as measured by the achievement test (as the dependent variable) were affected by the actual level of interaction with classmates via discussion boards (as the independent variable), the relationship between the number of messages sent by each student to discussion boards and his/her achievement score was examined. Since the data are interval in nature, the correlation coefficient (Pearson's *r*) was used to indicate the direction of the strength of the relationship. Pearson's *r* (0.477) for the relationship between students' level of participation in discussions and achievement scores indicates that there is a significant relationship at the 0.01 level (Table 10-16).

Table 10-16: The relationship between students' achieved interaction with peers and achievement

Correlation	**Achievement**	**N**	**Sig. (2-tailed)**
Participation in discussion	*r* = 0.477	32	0.006
Correlation is significant at the 0.01 level (2-tailed)			

In order find out if interaction with peers, and any other variables, could together predict the variance of the academic achievement (as the dependent variable) multivariate regression analysis using students' level of participation in discussions (as the independent variable) was conducted and stepwise regression was used for the selection of predictors. Several commonly used variables were included, as independent variables, to explore or predict factors that would affect students' achievement. Demographic information (gender and previous Internet experience) as well as students' perceptions of the design of the learning environment (technical and instructional) and interaction (with the tutor and peers) were collected and measured using the students' perception questionnaire. Information about the level of interaction with the tutor and peers was obtained from students' logs in Wired Class.

Table 10-17: Multiple stepwise regression analysis to predict students' achievement: Entered variables

Entered variable	B	Std. Error	Beta	*t*	Sig.
Achievement	10.224	.880		11.619	.000
Achieved interaction with peers	.558	.188	.477	2.972	.006

The results of the stepwise regression (Tables 10-17) showed that stepwise selection entered the independent variable 'achieved interaction with peers', measured by the number of messages sent to discussion boards, as the predictor of students' achievement (F = 8.831) (Tables 10-19) and all other variables were excluded as predictors (Table 10-18). However, although F is significant at the level of 0.05, the R Square is only 0.227. That means that nearly 0.23% of the variance in the dependent variable students' achievement can be explained by the variability in student interaction with peers via discussion boards.

Table 10-18: Multiple stepwise regression analysis to predict students' achievement: Excluded variables

Excluded Variables	Beta In	*t*	Sig.	Partial Correlation
Gender	.008	.045	.965	.008
Achieved interaction with the tutor	.072	.445	.659	.082
Perception of interaction with peers	.078	.479	.635	.089
Perception of interaction with the tutor	-.004	-.021	.983	-.004
Previous Internet experience	.021	.129	.898	.024
Perception of user-friendliness	.132	.813	.423	.149

Table 10-19: Achieved interaction with peers and academic achievement: Analysis of variance

	Squares	df	Mean Square	F	Sig.
Regression	39.167	1	39.167	8.831	.006
Residual	133.052	30	4.435		
R = 0.477 R Square = 0.227 (P < 0.5) Std. Error of the Estimate = 2.1060					

10.3.5. The interrelationship between students' perception of student-tutor interaction, actual student-tutor interaction and academic achievement

The correlation between students' relatively high perceptions of student-tutor interaction (Mean = 3.9) and actual achieved interaction with the tutor, based on the number of e-mail messages sent by students to the tutor (Table 10-20), was non-significant (r = -0.199) (Table 10-21).

Table 10-20: Number of messages sent by students to the tutor

Number of messages	Frequency	Percent
0	13	40.6
1	11	34.4
2	8	25.0
Total	32	100.0
Minimum = 0, Maximum = 2 Mean = 0.8438 Std. Deviation = 0.8076		

Similarly, no significant relationship (r = 0.084) was found between the frequency of interaction with the tutor via e-mail (as the independent variable) and academic achievement (as the dependent variable). This means that students who interacted with the tutor more frequently and obtained more academic help achieved similarly to those who interacted less frequently.

Table 10-21: Interrelations among perception of student-tutor interaction, achieved student-tutor interaction and academic achievement

Correlation	Achieved student-tutor interaction	N	Sig. (2-tailed)
Perception of student-tutor interaction	r = -.199	32	.275
Academic achievement	r = .084	32	.647
Correlation is non-significant at the 0.05 level (2-tailed)			

Lastly, it may be useful to investigate the interrelationship between all factors embedded in the learning environment. The correlation analysis (Table 10-22) shows that there are two new and unanticipated relationships between students' perception of friendliness of the learning environment (as defined in Chapter 9) and perception of peer interaction and between students' performance in formative evaluation test and actual participation in peer interaction. These two relationship lead to further investigations, as shown in the discussion below.

Table 10-22: Interrelationships among factors embedded in the learning environment

Factors	1	2	3	4	5	6	7	8
1. Gender								
2. previous Internet experience	-.332							
3. Perception of peer interaction	-.203	.146						
4. Perception of tutor interaction	-.160	-.057	.342					
5. Perception of user-friendliness	-.263	.151	.355*	.139				
6. Actual interaction with the tutor	.094	.237	.006	-.199	-.094			
7. Actual interaction with peers	.222	.115	-.026	.268	.004	.025		
8. Performance in formative evaluation	.211	.067	-.242	.184	-.208	.056	.453**	
9. Achievement	.257	.076	.066	.124	.043	.084	.477**	.519**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

10.4. Discussion of factors influencing students' perception of on-line learning, on-line activity and academic achievement

The importance of defining the factors that affect the success of learning via Wired Class through influencing students' perception, on-line activities and learning outcomes is that it will help educational organisations in exploiting these factors to design, manage and organise future on-line learning environments.

Two student demographic characteristics that have commonly been investigated in on-line learning environments are gender and previous computer and Internet experience. First, research (Oxford et al., 1993; Ory et al., 1997) has shown that boys and girls may not be equal in using and thinking about computing and other technologies like the Internet. The reason is that cultural factors may turn girls away and discourage them from using computers and the Internet (Hofstede, 1991). Therefore, boys' and girls' perception of using computers and the Internet may not be the same (Davis, 1999; Butler, 2000).

In Wired Class, despite the small number of girls who participated in the study, the results did not support the idea of gender-related differences in perception or interaction problems. In addition both boys and girls reported high levels of perception as well as relatively modest levels of interaction with the tutor and peers. This finding indicated that students' gender does not seem to be a significant factor in determining their perception or familiarity with on-line learning. However, interestingly enough, it was obvious that boys' mean scores in perceptions of user-friendliness and perceived interaction are always higher than girls' mean scores (Tables 10-6 to 10-10). Considering the limitation of sampling, the non-significant differences between boys and girls was probably due to the small sample size (N_{Girls}=6).

Considering the limitation of the empirical investigation of this study, one possible explanation of this result is the ease of use and user friendliness of the graphical interfaces of the Web, associated with the high popularity of the Internet as a means of communication and access to world-wide information. In other words, students' backgrounds may cease to be a significant factor in determining student success in on-line learning.

This result agrees with recent research (Gillard et al., 1996; Chin et al., 2000; Li and Kirkup, 2001) that examined the relationship between gender and success and perception of on-line learning. These researches found more similarities than differences in the majority of background variables (gender, age, academic workload, academic level and experience) that seem to be unrelated to the success or satisfaction of students with Web-based learning. Lastly, according to Freeman and Capper (1999), since the Internet, as a global environment, allows students to keep their identity anonymous, on the one hand, and as it is growing very rapidly worldwide, on the other, 'issues of gender and cultural expectations evident in an embodied encounter were minimised' (Freeman and Capper, 1999).

Second, since Wired Class was designed with the students' minimal Internet experience in mind, it was not surprising to find that there was no significant relationship between students' previous Internet experience and satisfaction and perception of ease of use of Wired Class, even with the diversity in students' previous experience. This means that if the design and structure of the learning environment are friendly and usable, as found in the previous chapter, students' previous Internet experience and skills are irrelevant and students can learn via the learning environment without their background influencing their success or perception. In other words, students' Internet experience may cease to be a significant factor in determining their perception of on-line learning. However, at the same time, this result does not mean there is no need to prepare students or enhance their experience and skills to use computers and the Internet.

Third, research has shown that there is a significant relationship between students' achievement and perception of using computers and the Internet, as a result of their increased motivation and perceived learning (Haertel et al., 1981; Fisher and Stolarchuk, 1998;

Charlton, 1999; Davis, 1999). In their meta-analysis, Haertel et al. (1981) found that students' achievement was enhanced when they felt they had greater cohesiveness and satisfaction with the computer-based course.

However, in Wired Class no significant relationship was found between these two variables. Possibly, this result is due to other variables that contribute in affecting students' learning and progress. The success or failure of students is dependent on many other course-related and cognitive factors rather than on perception of hardware or software. The extent to which students got involved in on-line instructional activities (such as peer discussions and on-line tests) might play a more significant role in determining whether or not technology has a positive impact on achievement, particularly when using the Web is necessary.

This conclusion is in line with the view of Newby and Fisher (1998) who argued that the influence of satisfaction with the on-line learning environment on formal summative examinations seems to be indirect and not measurable and other components (such as exercises) usually contribute least to the final grade. However, they believe that on-line environments could affect students' achievement indirectly by directly affecting their attitudes.

Nevertheless, in Wired Class, one of these factors that appeared to influence students' academic achievement is actual peer interaction via discussion boards. The relationship between students' level of contribution to discussion boards and grades in the final achievement test, confirmed by multiple stepwise regression analysis, indicated that 0.28% of the variance of the students' achievement can be explained by the variability in actual peer interaction via discussion boards.

However, although this significant relationship seems to be in line with one of the constructivists' principles, whereby learning is seen as a social activity and it is thought that students can learn successfully as they interact and talk with others, as shown in Chapter 4, the quantitative and qualitative analysis of results of interactivity, in the previous chapter, indicated that Wired Class students did not benefit much from peer interaction because of the low level of overall involvement, lack of student-student interaction and information exchange and superficial processing of information and problem-solving. Therefore, it is concluded that little educational effectiveness could be gained from asynchronous interaction via discussion boards.

This conclusion indicates that although there was a significant statistical relationship between students' involvement in peer discussions and academic achievement, this relationship does not mean that peer discussions, as the independent variable, enhanced students' achievement, as the dependent variable. However, it means that possibly, students' learning ability allowed them to participate in peer discussions. Post correlation analysis between students' performance in the mathematics course, using the results of twelve formative evaluation tests, and level of involvement in peer discussions confirmed that there was a significant relationship (r=.45) between students' mathematical performance, as the independent variable, and involvement in peer discussions, as the dependent variable.

Table 10-23: The relationship between students' performance in formative evaluation and participation in peer discussions

Correlation	Student-peer interaction	N	Sig. (2-tailed)
Performance in formative evaluation tests	r = .453	32	.009
Correlation is significant at the 0.01 level (2-tailed)			

Similarly, it was not surprising to find that actual participation in discussion boards had not been influenced by students' perception of peer interaction. The reason for this is that positive perception of peer interaction was not enough to motivate students to participate and argue to solve course-related problems. Students' academic experience and intellectual skills and types of discussion questions are other factors that would influence students' interest in peer interaction.

However, it is interesting to note in this regard that students who believed that the design of Wired Class is user-friendly, reported a higher perception of interaction with peers (Table 10-22). Pearson's r for the relationship (r=0.36) between students' satisfaction with the design of the learning environment and perception of interaction with peer indicated that there is significant relationship at the 0.05 level. In order to find out whether satisfaction with the design of the learning environment and other variables could together predict the variance of the perception of interaction with peers (as the dependent variable) multivariate regression analysis based on students' satisfaction with the design of the learning environment (as the independent variable) was conducted and stepwise regression was used for the selection of predictors.

Table 10-24: Multiple stepwise regression analysis to predict students' perception of peer interaction

Dependent Variable	B	Std. Error	Beta	*t*	Sig.
Perception of user-friendliness	1.787	1.091		1.638	.112
Perception of peer interaction	.563	.270	.255	2.083	.046

The results of the stepwise regression showed that stepwise selection entered the independent variable 'satisfaction with user-interface design and feedback' (Tables 10-25) as the predictor of students' perception of interaction with peers (F = 6.422) and all other variables were excluded as predictors. However, although F is significant at the level of 0.05, the R Square is 0.126 which means only about 0.13 of the variance of the dependent variable (perception of peer interaction) can be explained by the variability in student satisfaction with the design of the learning environment.

Table 10-25: Perception of design and peer interaction: Analysis of variance

	Squares	df	Mean Square	F	Sig.
Regression	1.827	1	1.827	4.338	.046
Residual	12.632	30	.421		
R = 0.355 R Square = 0.126 (p < 0.5) Std. Error of the Estimate = 0.6489					

In addition, an unpredicted relationship between students' perception of peer interaction and user-interface interaction of the learning environment was found. Students who had a highly positive perception of peer interaction had the same perception of ease of use and interaction with the elements of navigation design and user-interface and feedback, including hypertext links, navigation aids (e.g., frames, scrollbars, buttons, icons, menus, etc.), fonts, colours, graphics, symbols and help topics. Although there is no obvious reason behind this significant relationship, it is interesting to note that peer interaction and interaction with the elements of the learning environment (including the navigation system and user-interface elements) represent two out of three types of interaction with the learning environment (interaction with the content, interaction with peers and the tutor and interaction with the elements of display and feedback) (Moore, 1989; Hillman et al., 1994). According to Kanuka (2000) 'although conceptually we can deal with each kind of interaction independently, in reality all three are interrelated'. He explained that:

> 'educators tend think of each independently. However this independent view of interaction fails to acknowledge that when learners interact with other learners and their instructors they are interacting about the content; the content is a silent but active participant' (Kanuka, 2000).

Student-interface interaction, for example, is used in using the technology to communicate with the content as well as to negotiate meaning with the tutor and peers (Hillman et al., 1994).

Table 10-26: Interrelationships among perception of interaction with the content and other variables

Factors	1	2	3	4	5	6	7	8	9
1. Gender									
2. previous Internet experience	-.332								
3. Perception of peer interaction	-.203	.146							
4. Perception of tutor interaction	-.160	-.057	.342						
5. Perception of user-friendliness	-.263	.151	.355*	.139					
6. Perception of content interaction	.008	.221	.099	.253	-.108				
7. Actual interaction with the tutor	.094	.237	.006	-.199	-.094	-.123			
8. Actual interaction with peers	.222	.115	-.026	.268	.004	.221	.025		
9. Performance in formative evaluation	.211	.067	-.242	.184	-.208	.474**	.056	.453**	
10. Achievement	.257	.076	.066	.124	.043	.475**	.084	.477**	.519**
* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).									

This unpredicted relationship highlighted the need to re-consider the interrelationship between the third type of interaction (student-content interaction) and other variables of the learning environment. Student-content interaction was measured using questionnaire items that focused on organising the course content, usefulness of examples, appropriateness of exercises and clarity of formulae and graphs. The results of the new interrelationships are represented above (Table 10-26).

The results showed that students' perception of student-content interaction is significantly related to performance in formative evaluation tests and summative achievement summative scores. In other words, students who had positive perceptions of interaction with course content (hyperlinks, self-test, interactive forms, branching menus, forward and back links, etc.), including text, figures, formulae, gained higher grades than those who did not. A second multiple stepwise regression analysis was carried out using academic achievement as the dependent variable. The same variables included in the first multiple stepwise regression analysis were included in this analysis, together with perception of interaction with the content as the dependent variable (Table 10-27).

Table 10-27: Multiple stepwise regression analysis to predict students' achievement: Entered variables

Entered variable	B	Std. Error	Beta	*t*	Sig.
Academic achievement (constant)	-.0971	4.086		-.024	.981
Achieved interaction with peers	.457	.176	.391	2.591	.015
Perception of interaction with the content	2.503	.971	.389	2.577	.015

The stepwise method entered two variables, achieved interaction with peers and perception of interaction with the course content, as predictors of academic progress, with a significant F value at 8.56 ($p<.01$) (Table 10-28).

Table 10-28: Achieved interaction with peers, perception of interaction with the content and academic achievement: Analysis of variance

Model		Sum of Squares	df	Mean Square	F	Sig.
Model 1	Regression	39.167	1	39.167	8.831	.006
Model 1	Residual	133.052	30	4.435	8.831	.006
	Total	172.219	31			
	Regression	63.956	2	31.978		
	Residual	108.263	29	3.733		
	Total	172.219	31			

The results showed that the R Square for model 1 (predictor is the level of participation in discussion boards) is 0.227. Adding 'perception of interaction with the content' as the second independent variable (model 2) added only 0.144 to the R Square (0.371) (Table 10-29). The R Square of 0.371 means that about 0.37% of the variation of academic achievement (dependent variable) could be explained by the variability in students' actual interaction with peers and perception of interaction with the content. This finding seems to be meaningful and in line with research on designing interaction with on-line course materials.

Table 10-29: Summary of multiple stepwise regression analysis for variables predicting students' academic achievement

Model	R	R Square	Adjusted R Square	Std. Error
Model 1 - Achieved interaction with peers	.477	.227	.202	2.1060
Model 2 - Achieved interaction with peers - Satisfaction with interaction with the course content	.609	.371	.328	1.9321

The above results show that students who were satisfied with interaction with the structure and format of course content would gain higher grades than others. According to Moore (1989), learner-content interaction is important in obtaining intellectual information and constructing knowledge from the course material given. This type of interaction takes place in a variety of ways and many strategies can be developed to help students to obtain information from the material.

In Wired Class, the most important issue considered in designing the content was learner-content interaction. Students were able not only to read the content in short and visually attractive chunks but also to explore, browse and choose before reading throughout the lesson. Students were able to choose among chunks, jump a specific part, branch to a previous lesson or support materials, use interactive visuals (elements, graphics animations and tools), search the library catalogue, seek for more information in links provided with each lesson, assess their learning and get auto-feedback, submit their work to the tutor and receive human feedback and revise the material quickly.

Since, for learning to occur, students must interact and process the content of the course themselves (Bower and Hilgard, 1981), on the one hand, and since the design and development of the content is very important not only in facilitating learner-content interaction but also in directing and fostering other types of Web-based interactions, which are vital for the success of learning (Moore, 1989; Kanuka, 2000), on the other, it was not surprising to find that students' perception of student-content interaction seems to be a significant factor in predicting and explaining students' academic success in on-line learning.

Lastly, although learner-tutor interaction is one of the key features of Web-based distance education and interrelated to both learner-learner and learner-content interaction, it was found that it is not a significant factor in determining students' academic success. However, it is not appropriate to look at this result in isolation from the quantity and the quality of messages sent by students to the tutor. The average number of messages sent to the tutor (M = 0.84) showed that less than one message per student was sent in a period of 8 weeks and the content of the majority of these messages related to organisational or technical issues rather than seeking for academic or content-related support.

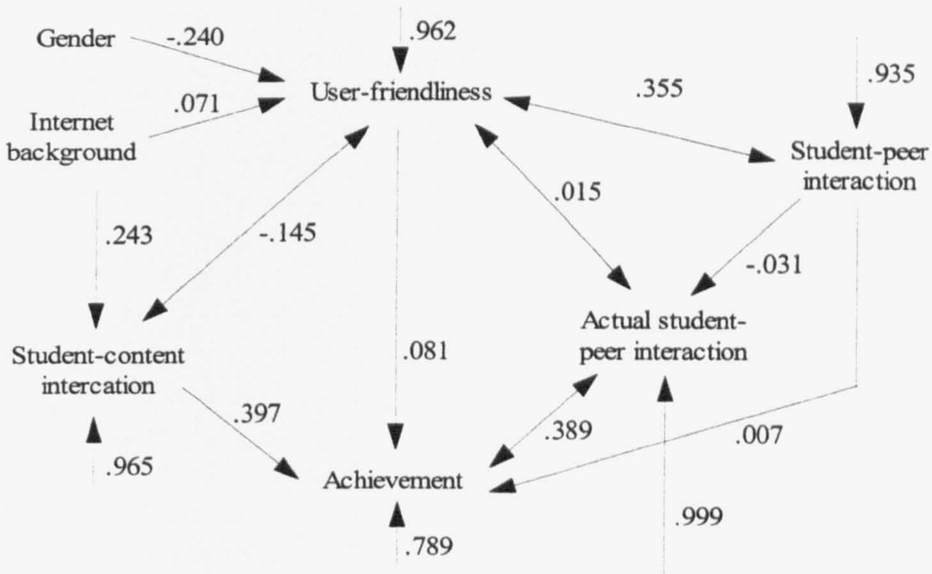
At the same time, regardless of feedback comments sent by the tutor following each task submitted by students, the majority of messages sent by the tutor aimed to break student-tutor isolation, motivate students and encourage them to do specific tasks, participate in on-line activities or to correct misunderstandings rather than to answer or solve course-related questions. Therefore, it was not surprising to find that there was a non-significant interrelationship among the number of messages sent between the tutor and students and grades in the final achievement test, since this attribute was not exploited effectively to enhance students' understanding of the course content.

Although a high level of student-tutor interaction is desirable, as widely cited in the distance education literature, it does not seem to be a significant factor in affecting students' achievement unless meaningful ways are implemented to structure and force student-tutor course-related interaction. Otherwise, other types of interactions, including student-peers and student-content interaction, could enhance learning more significantly than student-tutor interaction.

To summarise and provide further quantitative estimates of the magnitude and significance of hypothesised causal connections between the set of variables above, path analysis needs to be conducted (Bryman and Cramer, 1997). First, a path diagram makes explicit the likely causal connections between seven variables (gender, previous Internet experience, perception of student-peer interaction, actual student-peer interaction, perception of student-content interaction, perception of user-friendliness and achievement) employed in the above analysis and the path coefficients and error terms are computed using five structural equations treated as multiple-regression equations. A regression is done for each variable in the path model as a dependent on other variables assumed to be causes .

Since path coefficients are standardised, it is possible to compare their effect on the variables directly (Bryman and Cramer, 1997). Arrows show that there are assumed causal relations between two variables. A single-headed arrow (such as from student-content interaction to achievement) points from cause to effect. However, a double-headed arrow indicates that the two variables (user-friendliness and student-peer interaction, and actual peer interaction and achievement) variables are merely correlated but no direct cause-effect relationship is assumed. Arrows directed from outside the model refer to the amount of unexplained variance for each variable (Figure 10-3). The path diagram shows that students' gender and experience in using and learning via the Internet have very small effect on their perception of user-friendliness of the learning environment (-.24 and -.071). However, perception of interaction with the course content and actual interaction with peers have the strongest direct effects on student achievement (.397 and .389).

Figure 10-3: Path diagram for interaction and achievement with path coefficients



Chapter 11: Conclusion and Implications

Introduction

In the last few years, learners' and parents' interests in distance education have been enhanced dramatically as a result of changes in society and advances in audio-visual media and telecommunication technology. This has resulted in an increase in the access to the subject areas offered by distance education institutions. In response to this interest, distance education has become one of the formal means of education for those who are unable to attend traditional campus environments due to cultural, economic or geographical obstacles. The Web, in particular, with its interactive tools, user-friendly interface and rich information resources, has become the most promising medium for future distance education programmes (Yang and Moore, 1995). Besides higher education, schools and other educational organisations (e.g., training centres, national libraries, etc.) are also turning to the Web to meet students' needs and facilitate access to knowledge and formal educational opportunities.

The purpose of this study was to investigate the quality and the effectiveness of a Web-based learning environment for teaching secondary school students at a distance. The study focused on investigating learners' reactions and academic success at a distance while engaged in a real Web-based distance education programme. The evaluation methodology was implemented to show, analyse and describe the effectiveness of Wired Class based on Bates' ACTIONS model (1995).

11.1. FINDINGS OF THE STUDY

Since the ultimate purpose of the present study was to evaluate the quality and the effectiveness of Web-based learning, the need was highlighted to employ a Web-based learning environment to examine the strengths and weaknesses of on-line learning. The design and development phase was based on Wills' (1995, 2000) R2D2 instructional design model and constructivist principles. In the definition focus, many pre-requirements were investigated and defined, including learners' needs (academic background, experience in using the Internet, etc.), subject matter (nature of the content, learning objectives, teaching and learning approaches, etc.), front-analysis (needs of the programme, limitations of other alternatives, outcomes of developing a new programme, etc.) and technical requirements (software, hardware and Internet connection).

Based on the results of definition focus and front-end analysis of instructional platforms, constructing the learning environment required designing and developing tutorials and assessment elements, instructional support utilities, interaction tools, management and monitoring tools, help and support topics and a navigation system. The tutorial component was arranged in modules and lessons. Each lesson was arranged in a hierarchy of new concepts, examples, self-assessment, exercises, links to related Web sites and discussion areas. Management and administration tools were designed to help the on-line tutor to control/understand how the on-line class operated and to track students' progress. In addition, these helped students to register with the on-line class, access course grades and edit work. The interaction component was designed to facilitate student-tutor, student-student and student-content interaction.

Formative evaluation of the Wired Class was carried out at 'expert appraisal' level and 'student tryout' level simultaneously, to enhance the design and make improvements in the programme. To provide a complete virtual learning environment, it took more than eight months to develop the components of Wired Class, organise the course materials and evaluate its effectiveness. However, this learning environment still requires additional work to refine it, according to the summative evaluation results. To get a total picture of the findings, they are summarised and conclusions are drawn in terms of access, costs, teaching and learning function, interactivity, user-friendliness and organisational issues. Findings related to the speed of the system (speed of access, speed of interaction and time spent in study) are presented in the sections on access and organisational issues.

11.1.1. Access

According to the ACTIONS model, access is the first evaluation criterion used to decide whether the technology, learning resources and the tutor and peers are accessible by students at a distance or not. The comments in this section are based on students' ratings and feedback and experts' judgement.

In terms of compatibility, or standardisation, the results showed that the learning environment was compatible with most students' hardware and software and students were able to access and receive instruction without significant access problems. Compatibility was a result of taking into account the widely available Web clients and using platform-independent and standard HTML language (HTML 3.0), user-side standard programming languages (Java and Java Scripts), server-side scripts (CGI scripts), small size HTML pages and compressed graphics.

However, although course materials were designed in a way that minimised downloading time (e.g., minimising graphics in HTML files and using compressed multimedia format), students claimed that the low-speed Internet connection increased the time spent in downloading course materials, although they were satisfied with the speed of the tutor's responses. This result highlights the importance of improving the speed of communication and networking infrastructure using faster Internet connection types (e.g., faster dedicated-line networks, ISDN and wireless connections) and high-speed Web servers.

In addition, the feedback from students concerning the accessibility of Web resources showed that students did not use the Web as an archive of unclassified materials. Even links to external Web resources which were compiled, evaluated, commented on and categorised by the tutor were not found to be very useful by students, although such links are more appropriate for course-related information than having students search the Web for materials. Experts indicated that using public search engines might not be appropriate for young learners and search engines should be chosen with the specific subject matter in mind (e.g., school mathematics, English as a second language, etc.). Therefore, on-line tutors might need to develop strategies, such as using 'subject-specific directories' or 'topic hot lists', to maximise the benefit of Web resources and reduce geographic, organisational and time barriers of distance. Students also need to learn effective strategies to find, refine and evaluate the quality and the accuracy of course-related Web resources while learning.

In terms of access to the tutor and peers, a large majority of students felt that the tutor was close to them while studying and able to respond and answer their questions in a reasonable time, as well as providing them with useful feedback and support. However, students experienced difficulties in contacting each other via e-mail, as a result of the need to access and check the inbox regularly. Therefore, they preferred discussion boards to e-mail as a course-centred interaction approach, since they can access these discussion anytime, find others' participations, respond to tutor's comments, post their messages without the need to personal reply and read course-related topics.

Although e-mail is a remarkable asynchronous communication tool and available for students to use when they have the time and are able to participate, the use of e-mail as an instructional tool in on-line courses may need review. As a result of students' feedback, a new asynchronous interaction tool called, 'Quick Messenger', was designed and developed to facilitate student-student interaction while on-line. Using 'Quick Messenger', students do not need to check e-mail and can send and receive message instantly. The significance of facilitating student-tutor and student-peers interaction is that it may promote positive feelings towards the distance education programme and enhance the learning experience.

11.1.2. Costs

The main assumption that encourages distance educators to use a new technology like the Internet is that they can reach a wide population of learners with significant cost savings (Inglis et al. 1999). However, the analysis of the cost structure and cost relationships of the learning environment developed in this study showed that it is not possible to conclude that shifting to the Internet is always less costly than other approaches (e.g., print and CD-ROMs). The costs resulting from using the Internet to deliver instruction are affected by many design and implementation-related factors, such as the purpose of the distance education programme, the objectives of learning, the pedagogical approach, the quality of learning materials, the lifetime of the course and enrolments.

To realise the effect of these factors, three types of costs should be distinguished: capital infrastructure costs, course materials design and development costs, and delivery and support costs. Whereas it may be possible to construct a framework to estimate, understand and compare the development and delivery costs of on-line learning, it might be unrealistic to compare between the capital infrastructure costs of establishing a virtual classroom and those of the traditional classroom or other media, since each system has its own cost structure and lifetime. For example, whereas on-line learning requires a substantial investment in training staff and purchasing and installing network infrastructure, servers, connection and programs, print and audiocassette programmes may require less investment in infrastructure to be established. However, the costs of establishing on-line learning environment could be dramatically offset when compared to the overhead costs of traditional classroom infrastructure and labour.

Initially, two major factors were found to influence the development and support costs of on-line learning. These factors are the quality of on-line materials and the instructional design of the programme. Multimedia objects and interactive segments (e.g., input forms, interactive maps, etc.) are usually incorporated into the learning materials to enhance the quality of learning and improve students' performance. These quality materials need more planning and programming time than simple textual materials, and require sophisticated production tools and skilful Web developers to develop and maintain them.

The results of this study and previous research (e.g., Clark, 1983; Whittington, 1987; Clark, 1994 b; Spencer, 1999; Joy and Garcia, 2000) showed that it may be incorrect to believe that the use of interactive multimedia technology is able to enhance student learning. Spencer (1996) reviewed the effectiveness of media attributes in student performance and indicated that, overall, audio or visual media (e.g., radio, films and television), which require expensive equipment, much time to develop and maintain, and skilful producers, may not automatically improve student performance when compared with other static and low cost media (e.g., textbooks and filmstrips). The information provided by these media 'is often too much, in quantity or speed of delivery, and the student perceives only a fraction of it, and understands even less' (Spencer, 1999). On-line developers, in particular, should not assume that students will learn better from technology delivery systems. Rather, they should not focus on the instructional design strategies, regardless of the medium they choose (Joy and Garcia, 2000).

Therefore, unless the use of multimedia attributes (e.g., motion, sound, three dimensional images, simulation, etc.) to present specific concepts or skills (e.g., language) is essential to help students to understand processes, achieve course objectives or reduce study time, textual materials may be more cost-effective than multimedial and quality on-line materials, particularly for small population courses (Bates, 1995; Inglis, 1999).

However, in the case that a high quality and sophisticated presentation is needed, there is still doubt that on-line learning is more reliable and efficient than inexpensive and easy-to-deliver CD-ROMs. The significant recurrent costs of Web server maintenance, Internet connection, administering students online and technical support may eliminate any cost savings that can be made, from using the Internet. In CD-ROM delivery, the ratio of fixed costs to variable costs is quite high, since the costs of delivery are much less than the development costs. This high ratio allows the potential for economies of scale to be well exploited (Inglis et al., 1999). In the present study, it was found that this ratio was relatively insignificant due to the similarity of the fixed costs to variable costs and the high variable costs of tuition and support.

These high variable costs arose as a result of the instructional design of learning, which emphasises the tutor's and facilitator's roles in managing the learning environment (e.g., enrolment, tracking, grading, etc.), inviting and monitoring student activities (such as peer discussions), processing students' inputs (such as the 'send to the teacher' task), responding to students' questions and providing feedback. These activities might force the tutor to put much time into on-line interaction, asynchronously and synchronously, and make the development costs of even relatively simple on-line materials higher than print (Rumble, 2001).

Since offering distance students the opportunity for dialogue with the tutor is critical for social and academic support and reducing drop-put rates (Simpson, 2000), both synchronous and asynchronous student-tutor interaction approaches should be implemented with care. The synchronous approach requires fast and expensive connection and highly-paid staff to moderate discussions. However, the second asynchronous approach requires much time and also highly paid staff for planning students' activities and quality materials to support asynchronous learning. This raises many management questions, such as how many students can learn per course and how many hours are required (Rumble, 2001).

Therefore, the most significant way to increase the ratio of fixed development costs to variable costs seems to be cutting down the tutor's level of involvement and minimise student-tutor interaction. This can be achieved by using self-study and self-assessment materials and by encouraging students to support each other via on-line discussions. In this case, students may need to spend more time learning from the on-line materials and peers, allowing the students to reduce their demands from the tutor and the tutor to spend less time per student per course.

In addition, increasing enrolment should be emphasised, particularly when the fixed costs of establishing the learning environment are higher than the variable costs. By increasing the number of enrolments per course, the course lifetime and the number of courses in the learning environment, the fixed costs of course development can be distributed over a larger number of students, allowing the cost per student, or study hour, to fall significantly. Moreover, by increasing the number of international enrolments per course, the potential for economies of scale can be exploited to offset the on-line delivery costs when compared to the costs of copying and distribution of CD-ROMs or print to the world market (Inglis et al. 1999).

Nevertheless, the costs of receiving on-line instruction for home or using school facilities and local centres may hamper student access to on-line learning. Access or reception costs include the costs of purchasing computers and paying for Internet connection and phone access. These costs should be taken into account as an integral part of programme costs and cost analysis, particularly in countries with poor infrastructure or high telephone costs.

Overall, it can be concluded that it is unlikely that any cost saving can be made from shifting to the Internet to deliver instruction. Whereas the design and development costs of textual/highly interactive and quality on-line materials are less or similar to those of print/interactive CD-ROMs, the range of variable and recurrent costs of maintaining the on-line course materials, supporting, assessing and administering students on-line, running and connecting the Web server and access to the Internet by students can add more tuition and administration workload and contribute significantly to overall costs of on-line learning. In other words, instead of bringing the costs of tuition and delivery down using inexpensive technology, on-line learning systems add more costs to the additional institutional and access costs. However, if there is a necessity to exploit the two-way interactive nature of the Web, as well as speed, flexibility and global access to the Internet, these costs should be considered in the design of instruction and taken into account for budgeting and enrolment purposes, particularly when comparative cost-benefit analysis between Web-based learning and other approaches is being conducted.

11.1.3. Teaching and learning functions

According to the ACTIONS model (Bates, 1995), there are various quality criteria to be considered in the instructional features of on-line learning. These features are the quality of course materials (layout, graphics, presentations, etc.), the quality of course content (accuracy, comprehensiveness, etc.) and the quality of instructional design (teaching approach, activities, learning outcomes, etc.).

In terms of the quality of course content and materials, it was found that a flexible learning sequence and rich course information are important features that should be considered in designing on-line materials. The organisation of the course content into logically segmented and small chunks of content, in particular, was found to make it easy to follow and manage learning. However, although the course content was accurate, able to serve the objectives of learning and interesting to students, more real-life examples, exercises and debates will be required to encourage fuller student-content interaction and information exchange among students.

In addition, experts' feedback and student's logs (which shown that students rarely resorted to Web resources during learning sessions) indicated that students might need more convenient Web resources. These resources should be suitable for the subject matter, course objectives and students' level. However, exploiting Web resources within course materials may require more than linking appropriate and supplementary resources to the lessons. Resources should be analysed and integrated within course content from the earlier stages of course design, rather than at the later stages.

In terms of instructional design, Lockee et al. (1999) indicated that student achievement is the most desired indicator to the success of a distance education programme.

However, according to Smith and Dillon (1999), it is not sufficient to conclude that a distance education programme is as effective as the traditional classroom. The attributes of the on-line environment (e.g., interactivity, immediate feedback, accessibility, ease of use, navigation, active engagement, user-friendliness, etc.) should be described and their instructional roles should be defined to understand how the attributes of the medium were employed to support learning.

In Wired Class, a constructivist approach was adopted to construct an interactive and exploratory learning environment and encourage students to examine concepts and relationships that might enhance student performance more than a conventional classroom approach. Problem-solving activities, self-assessment questions, immediate feedback, interactive tools, interactive graphs and animations, links to external Web resources and peer discussions were provided to motivate students, correct misunderstanding, support and activate mental processing, reinforce correct learning and facilitate experiential learning (Brown, 1997; Smith and Dillon, 1999).

In addition, because of the hypertext environment of Wired Class, students could explore and choose their own paths throughout the course materials, according to their understanding, practise more critical thinking and interaction with the content, remain focused on task, have more control over the learning experience than traditional classroom students, and seek out information to solve problems and construct their own knowledge (Landow, 1992; Jonassen et al., 1996; Harper and Hedberg, 1997; Jonassen et al., 1997).

Using Java applets and Java Scripts, an interactive graphical calculator, for example, was used to help students to zoom in or out, alter scale, investigate new situations, translate among tabular, symbolic and graphical representations of relations, evaluate expressions and formulas, apply and construct solutions and solve problems as key aspects of a constructivist environment (McAlpine, 2000). According to David and Beverly (1992) Shama and Dreyfus (1994) and Charles (1996), these procedures would help students to construct their own connections between graphical and symbolic representations of equations and functions, relate graphs to their equations and read and interpret graphical information. In addition, Dunham and Dick (1994) found that these attributes can dramatically affect student understanding of the course content and improve their problem-solving skills.

In addition, interactive self-assessment was scattered in the text (called self-tests in Wired Class) to increase the involvement of students in the learning process and 'encourage students to reflect on their own needs, aptitudes and motivations' (Simpson, 2000, p. 34), make judgements and uncover deficiencies in their own learning (Polyson and et al., 1996).

In terms of peer interaction, although peer interaction may have a direct impact on students' achievement, research indicated that high levels of peer interaction may be an important resource for learning and contribute to student performance (Moore, 1989; Anderson and Garrison, 1995). 'Asynchronous communication technologies (e.g., bulletin boards) permit time for learners to reflect, which is an essential step in building meaning and knowledge' (Miller and Miller, 2000, p. 164). In Wired Class, student-student interaction was mainly conducted via discussion boards to help students to consolidate their knowledge and assess their understanding using realistic problems.

In Wired Class, students thought that they learned better from the on-line learning environment and its conditions and attributes helped them to improve their understanding of the subject matter. However, the results showed that there was no significant difference in mean achievement and criterion-referenced scores between on-line students and traditional classroom students. This finding is in line with what is frequently cited in the literature (the method rather than the medium can affect student learning: Clark, 1983; Jonassen, 1985; Lockee et al., 1999). Even so, in Wired Class, the engagement of students in constructive learning activities (e.g., problem-solving and peer interaction) and 'establishing the conditions that enable specific types of learners to perform specific information-processing tasks' (Jonassen, 1985, p. 30) did not lead to better learning outcomes than those obtained in the conventional classroom.

The reason is, these types of learning outcomes are dependent on student self-engagement in learning activities and the way students make use of resources and levels of involvement in discussions and student interest (McAlpine, 2000). For example, although the course materials employed hypertext throughout the content, provided links to relevant external Web resources, which were very necessary for many learning tasks (e.g., problem-solving and exercises) and facilitated peer discussions, students did not make sense of hypertext, comprehend Web resources or value student-peer interaction, as shown in the content analysis of peer discussions.

However, in distance education settings, even this may be a welcome finding since distance education courses are often designed to deliver instruction to those who cannot attend on-campus classes and distance educators need to ensure that distance students can receive at least the same quality of instruction as is offered by traditional classroom experience (Lockee et al., 1999).

11.1.4. Interactivity

Since students in more interactive classes might have higher levels of achievement and more positive attitudes toward learning, quantitative and qualitative analysis was used to study the quantity and the quality of peer interaction. This analysis revealed patterns of responses showing how well students responded to discussion topics and worked together to achieve learning objectives. Although chat offered the opportunity for real-time interaction, it was found to be very confusing because students could not manage their time to join real-time conversations, met access problems and failed to catch the flow of chat. However, discussion boards were found to be the most suitable approach to conduct formative and regular course-related interactions.

In terms of quantity of interaction, students spent less time in this type of activity when compared to other types of on-line learning activities (such as self-assessment). In addition, students believed that participation in discussions was not as important as achieving other conventional tasks and the average number of messages posted to discussion boards was less than anticipated. Therefore, students should be encouraged to participate more regularly in peer discussions and tutors may need to assign grade weight to the quantity and the quality of contributions and ask students to spend more time and effort in peer interaction.

In addition, the quantitative analysis revealed that the more participation from the tutor, the more messages were posted by students. Correlation analysis revealed that the number of students' responses per discussion topic had a significant relationship with the number of tutor's responses. The non-appearance of the tutor might have been interpreted by students as non-involvement, rather than giving them the chance to think and negotiate meaning themselves. To make instruction effective and promote active learning, discussions should be carried out within a tutor's scaffolding approach at management level (tracking, encouraging, grading, etc.) and cognitive level (explaining, facilitating, suggesting, etc.), particularly for those at lower academic levels.

In terms of the quality of interaction, the results revealed that the quality of social and cognitive-related interaction was low and consisted of the surface processing of information, reflected in the repeating of information in others' messages without self-explanation, supporting/rejecting others' opinions without adding personal comments or providing clear evidence, and providing solutions without providing a clear interpretation. Content analysis of students' messages showed that much of the students' learning was based on interaction with the course content, rather than interaction with various Web resources or negotiating and constructing meaning via peer-interaction.

The quality of interaction also depended on the types of topics discussed. In discussion topics that addressed more debatable questions, students were actively engaged in critical thinking processes and paid more attention to interacting with peers. However, topics that made low cognitive demands did not help students to use higher order thinking, interact with others or learn from others' experience. Textbook exercises or simple discussion questions might limit students' ability to think and interact and keep the discussion at a low cognitive level.

11.1.5. User-friendliness

To evaluate the user-friendliness of the learning environment, the appropriateness and consistency of user-interface design, ease of use and navigability were assessed. The results of the analysis showed that simple and consistent page design, appropriate screen appearance for different resolutions, standard fonts and colours, standard HTML presentation (not importing plug-in interfaces) and meaningful icons and small pictures are the most important features of design that facilitate using the learning environment and help students to focus their attention on studying course information.

It was suggested that labelling strategies or text-based equivalents of graphs, buttons and other elements of user-interface should be considered to make the user-interfaces more accessible by visually impaired students. Future design should also consider the length of Web pages. A small amount of content can be presented in a few short pages. However, larger content requires increased length of pages to keep to an acceptable total number of pages for easy management and reasonable downloading time. In addition, when using multimedia objects and documents formats (such as Flash and PDF), they should be implemented in a way that does not harm either the consistency of user-interface design or the students' ability to interact and control the presentation.

Investigating the extent to which the learning environment and new tools of on-line learning (such as e-mail and chat) were easy to use, and the problems that might face students, revealed that the clear and simple site structure, assistance tools (such as page builder and Web publisher), instructions associated with each tool, hypertext-based design and compatibility with students' software and hardware were the most important features that allowed students to learn quickly how to use the learning environment and helped them to access learning materials, search for course information and interact with the tutor and other students easily. However, scheduling for synchronous learning, the requirements of real-time and text-based interaction (such as language level) and on-line support are the most important issues that need to be considered in designing easy-to-use on-line learning.

In terms of navigation, students' feedback indicated that an efficient navigation design might help learners to understand the structure of the site, save on-line time and locate learning resources and tools needs easily and logically. The starting page, or home page, navigation hierarchy and framesets are essential features of any navigation system. The well-designed starting page may work as an origin or starting point, provide an overview of the site and categorise its major areas and functions. Also, 'indexed-design' and frames might keep students visually oriented and minimise the chance of confusion or getting lost in the site.

11.1.6. Organisational issues

In Web-based learning, there are many organisational issues, which need to be investigated. These include the security of the learning environment, tutors' and students' responsibilities, submitting and handling students' inputs and factors related to students' perceptions of on-line learning and academic achievement.

In terms of the security of Web-based learning environments, evaluation revealed that although perfect security is a challenge at the current time, developments in Web technology may lead to advanced solutions in the near future. The establishment of more sophisticated secure Web sites may affect the flexibility, ease of use and costs of access from a distance. However, security inside the learning environment itself (e.g., security of course materials, communication, submitted work, exams and tests) should be emphasised to protect students' confidentiality by giving them the chance to control access to course activities and personal information (such as interaction at public areas and personal photos).

In addition, the results and the on-line learning literature (e.g., Akeroyd and Currall) showed that there are many problems still related to on-line exams. Examples are the difficulty of identifying students, the need to monitor and prevent cheating and security of delivering test questions. These problems could be solved by either employing videoconferencing technology to monitor distance students visually, a method which is already available and widely used, or holding traditional on-campus exams, which provide a more reliable situation and greater confidence in the education system (Furnell et al., 1998).

Investigating the policy and code of ethics of the learning environment (guidelines for enrolment in the learning environment, submitting course-related tasks, using communication tools, copyright issues, accessing personal and shared spaces, etc.) for both the tutor and students revealed that detailed information about tutors' and students' roles is needed, particularly those concerning students' behaviour, including copyright issues, submitting work, participation in class activities (such as discussions) and communication policy (such as rules for using e-mail and chat rooms). In addition, information about the availability of the tutor and his/her instructional roles might be useful to students.

In terms of student management, the results showed that students' learning and independence, in an environment that forces students to construct learning on their own, might be breached by the tutor's roles (such as checking attendance, tracking student progress, examining performance, providing feedback, etc.). However, since the learner may lose interest in learning if he/she does not have sufficient support provided by the tutor, it was argued that, in constructivist environments, the tutor might need to have some, but not complete, control over the learning sequence.

In terms of site structure, although Wired Class contained a wide variety of components to deliver instruction, facilitate interaction and manage students at a distance, new support and interaction tools are needed to enhance the structure of on-line learning environments, simulate face-to-face education and support learners at a distance. An example of such a tool is the 'on-line board' suggested in this study. Using the on-line board, the tutor can post a demonstration to any number of students, in text, high quality graphics and Web links and communicate synchronously.

In terms of time spent in study, the results showed that although students spent a significant time in downloading and interaction with course content, they spent less time (13.5%) than traditional classroom students. This reduction in time might be one of the most important benefits of the programme, particularly as no significant differences in learning were found between on-line students and traditional classroom students.

Identifying the factors that might affect students' perception of the on-line learning, on-line activities and academic achievement was an important organisational issue considered in the evaluation of the learning environment. The importance of this investigation is that it may help distance educators to consider these factors in designing, managing and organising future on-line learning environments. In the present study, the interrelationships among gender, previous Internet experience, student-peers interaction, student-tutor interaction, perceptions of interaction with peers, perceptions of interaction with the tutor, satisfaction with the design of the learning environment and academic achievement were investigated.

As a result of the ease of use and growing popularity of the Web, students' gender and prior experience in using the Internet may cease to be significant factors influencing students' perception of on-line learning. The results showed that there were no significant gender-related differences in perception of on-line learning and peer interaction. In addition, there was no significant relationship between students' previous Internet experience and perception of learning via the Web.

Also, the analysis showed that student satisfaction with the on-line learning environment did not influence students' learning. However, the factor which was found to be related to students' academic achievement was actual peer interaction via discussion boards. A significant relationship was found between students' level of contribution to discussion boards and their final achievement scores. However, this relationship does not necessarily mean that peer discussions directly enhanced students' academic achievement. It was found that students who had higher learning abilities, as appeared in the class records, were able to contribute to peer discussions more than others who had lower abilities. In addition, the quantitative and qualitative analysis of students' contributions showed that little educational effectiveness could be gained from asynchronous peer interaction, as a result of the low level of overall involvement and superficial processing of information and problem-solving.

Furthermore, it was found that students' contributions to peer discussions had not been influenced by students' perception of peer interaction. The reason is that positive perception of peer interaction was not sufficient to allow students to contribute to solving course-related problems. Students' academic experience, intellectual skills and types of discussion questions are other factors that influenced students' interest in peer interaction.

However, there was a significant relationship between students' perception of peer interaction and perception of interaction with the program. It was found that peer interaction and user-interface interaction represent two out of three types of interaction with the learning environment (social interaction, student-content interaction and student-user interface interaction). This finding led to an investigation of the interrelationship between student-content interaction and other variables, which revealed that students who had higher perceptions of interaction with the structure and format of course content gained higher grades than others who had lower perceptions. This result emphasises the importance of student-content interaction and how interactive content structure can facilitate and enhance student learning.

Lastly, there was no significant relationship between the level of student-tutor interaction and achievement. One possible reason is that this type of interaction was attempted only to break student-tutor isolation, motivate students and encourage them to do specific tasks or to correct misunderstandings, rather than to fully support and guide the learning process.

11.2. IMPLICATIONS OF THE STUDY FOR TEACHING AND LEARNING ON THE WEB

The findings from this study highlight many implications for teaching and learning on the Web. These implications concern the appropriate teaching/learning approaches for on-line education, on-line interaction, tutor's roles in on-line learning, design of user-friendly learning environments and costs of Web-based distance education.

Although there is general agreement in the literature on the appropriateness of student-centred approaches and constructivist epistemology for designing Web-based instruction (Strommen and Lincoln, 1992; Bannan and William, 1997; Lefrere, 1997), on-line learning materials and activities can be designed with a balance between different learning and instructional design approaches (such as behavioural approach versus constructivist epistemology and instructor-centred approach versus student-centred approach). A combination of different learning approaches can invoke both lower-level and higher-level cognitive processes and meet different learning requirements (introducing new basic terms, activating prior knowledge, acquiring skills, building understanding, constructing conclusions, etc.) and styles of learners.

For example, the design of on-line materials might be based on the behavioural approach or instructor-centred approach, in which information, examples, exercises and feedback are provided, then supported by constructivist and student-centred approach, in which discovery activities, problem-solving, social interaction and interactive learning activities are facilitated to help learners to construct their own learning and improve comprehension. In addition, since students have different learning styles and consequently think, process information and learn in different ways (such as visual or auditory learners, collaborative or independent learners) and they learn better when their learning styles match teaching approaches (Billings, 1993; Carnwell, 2000; Sorensen, 2000), instructional design for the Web should address or attempt to meet these various student needs. Assessment of students' learning-styles could be used at initial stages in the instructional design process to define these learning styles and students' needs.

In terms of interaction, although a combination of asynchronous and synchronous peer interaction might be more appropriate than employing one interaction approach, students should be given the chance to choose an appropriate interaction approach. For example, while asynchronous interaction via discussion boards is more reflective and suitable for students who do not have good language, computer skills or availability to access, read and comment on messages, synchronous interaction via chat appears to be difficult for many students and students may encounter difficulties arranging for live chat sessions. However, although asynchronous discussions are usually group-based, permanent on the site and accessible by the public, many students may prefer one-to-one, synchronous and temporarily available conversations.

Moreover, while on-line tutors may fear that their contribution might affect student-student interaction negatively, the findings in this study revealed that students' active participation in discussions relied to some extent on the participation of the tutor and the tutor's silence might be interpreted as an unresponsive attitude. In addition, the on-line tutor should emphasise the importance of participation in discussions and co-operative activities in terms of frequency, quality and deadlines of responses, so that students will not consider it a waste of time and effort. Moreover, the tutor might assign a significant percentage of course grade weight to peer discussion and other social and cognitive peer interaction. Also, online instructors can enhance peer discussions by helping students to build a sense of community. The tutor can ask students to introduce themselves to the on-line class or discussion group using initial introductory messages and by building their own pages, which contain photos, personal information and details of interests.

However, in this regard, it should be considered that forcing students to engage in interaction and group-based activities may complicate their job and make the learning environment more difficult to use, particularly for novice distance students. Therefore, future learning environments may need to conduct and facilitate peer interaction in a way that encourages participation in an easy to use format (Northrup, 2001).

The results of this study also indicated that program user-friendliness is important in students' overall satisfaction with the on-line environment. Students enjoy simple user-interface (pages, colours, fonts, buttons, menus, margins, screen appearance, etc.), easy-to-use tools (e-mail, hypertext design, on-line support, Web-publishing, etc.), fast downloading pages and reliable navigation design (navigation tracking, indexing hierarchy, links, framesets, etc.) throughout the site and course content. However, they dislike reading long pages, using additional software and hardware to read page content, ambiguous icons and symbols, too many links in the same page, synchronous presentations and interaction that require quick replies and navigation problems due to using framesets. Therefore, the organisation of Web pages and design of screen appearance and navigation should be planned and designed with reference to users' demographics and skills in using the Web.

The results of the cost-analysis highlighted many cost saving issues to minimise the costs that developers and students may face in developing and accessing on-line learning. Schools, for example, should consider using extensible networking and Internet technology, in which LAN with shared modem or router are implemented, to serve groups of students with minimum hardware and access cost, or LAN with local server and high speed line to serve large groups of students with high bandwidth to maximise the benefit of access to multimedia and interactive applications available over the Web.

In addition, designers of on-line learning should develop policies that concentrate on cost savings in design, development and course management (such as student enrolment, number of modules, etc.). For example, since a significant portion of the total cost of the programme is module-independent costs, which are the costs of design and development of non-tutorial components (e.g., support and management tools, asynchronous and synchronous interaction protocols, etc.), using well-designed instructional solutions that integrate management, support and interaction components might be time and cost-effective and minimise the total cost of developing on-line learning environments by individual institutions and course providers. Also, adding more students to the same course, providing more courses within the same learning environment and extending the life cycle of the course could reduce the average cost of non-tutorial components. The cost-analysis showed that although the capital cost of establishing the learning environment was relatively high, savings can be made when running the course for five years with minor updates. Likewise, since the variable and recurrent costs of the programme are based on the costs of human tuition and support, strategies are needed to reduce tuition time. These strategies should pay more attention to student-centred activities, student-student interaction, simulations using advanced programs and intelligent auto-feedback systems.

Lastly, the results of this study and prior studies investigating students' achievement and satisfaction with on-line learning and cost-benefits of Web-based distance education may encourage educators and parents to support the concept of the virtual school or 'cyberschool'. Cyberschools may provide an opportunity for students who cannot attend full-time classes to study at home under the supervision of adults or parents. While many problems encountered by students in earlier distance education systems related to the difficulty of conducting social interaction with the tutor and peers, obtaining feedback and academic support and gaining access to appropriate learning materials and resources, cyberschools are able to facilitate social and cognitive interaction, expand access to tutor's and experts' support, enhance students' opportunities to access and interact with various and informative types of materials and support learning approaches that help students to explore, interact and construct their own learning. However, solutions for supervision and scheduling young students' time, assuring the quality of learning, cross-cultural problems and supporting various subjects may need more investigation.

11.3. SUGGESTIONS FOR FUTURE RESEARCH

The findings from this study point out directions for future research in developing, implementing and evaluation of Web-based distance education programmes.

11.3.1. Design and development of on-line learning

Research is needed to compare and investigate how different approaches for the design and development of user-friendly interfaces, easy to use and accessible learning tutorials, quality course content and learning based on sound theories can affect students' learning and satisfaction with the program and reduce the on-line time spent in study. For example, there is a need to study how tutorial layout, navigation aids, and interactive multimedia components can be designed and organised in a navigation hierarchy of hyperlinks (e.g., sequencing design, exploration design, indexed design, etc.) to facilitate the following and control of course information.

The importance of this type of research is that it can provide a generic framework to develop authoring systems that offer comprehensive approaches and tools to assist educators to establish their own standard tutorials in less time and with lower costs. Although current authoring systems (such as ToolBook Instructor) provide effective templates and tools for educators to develop course materials to be distributed off-line (using CD-ROMs), these systems and other on-line management platforms (such as Blackboard and WebCT) are limited and poor in their functions to develop on-line tutorials and cannot help developers to create on-line tutorials based on sound learning principles or pedagogy. The new authoring systems should be easy to learn and use by educators, who have not adequate technical and pedagogical skills to design their own tutorials from scratch. They should help developers by suggesting appropriate lesson content and materials to be added and flexible enough to take advantage of the new interactive capabilities and rich resources available on the Web.

11.3.2. On-line tutoring

More research is needed to investigate how the amount and type of instructor involvement can affect the amount and type of student learning and participation. In other words, there is a need to investigate the relationship between the presence of the on-line tutor at different levels and the quality of the distance education programme (including, learning outcomes, student satisfaction, cost saving, etc.). Examples of tutor presence approaches in on-line learning environments are the 'initial approach', 'act of distance tutoring' and 'reflection about the process underway' (Trentin, 2000). The purposes of these approaches varied between 'breaking the ice' (low-level) between the student and the tutor to offer permanent support via conferencing throughout the course (high-level).

In this case, a question like 'do instructors with high/minimal course presence generate high/low levels of student satisfaction and success?' can be introduced. At the same time, since it was found that the higher levels of tutor presence or involvement are more costly than lower levels, there is a need to find alternative approaches that can be used to substitute or, at least, complement the tutor's roles in on-line learning environments. In addition, there is a need to study how much should be invested in tutor interaction to guarantee a high, or at least acceptable level of quality of on-line learning.

11.3.3. Peer-interaction

Another important type of interaction, besides student-tutor interaction, is interaction among learners in on-line environments. This type of interaction is one of the few features that distinguish the third generation of distance education and on-line learning. Although interaction among students is one of the most frequently mentioned issues in the literature of on-line learning, many issues and questions need more investigation. For example, while many different interaction tools are available, little research has been done to identify the interaction strategies that most contribute to student academic success. In this regard, many questions need to be answered. These questions may concern the ways of improving student-peers interaction and enhancing the quality of on-line learning, the social and cognitive factors affecting this quality and what interaction tools are needed to achieve learning objectives. For example, in the present study, a new interaction tool called 'Quick Messenger' was developed to improve one-to-one asynchronous interaction. This tool has never been tested before, since it was suggested in the light of the results of the field-testing; future research may be needed to assess its strengths and weaknesses in facilitating peer interaction and reaching learning objectives, compared to other interaction approaches (e.g., e-mail and discussion boards).

11.3.4. Students' needs in on-line learning environments

Although the literature addresses many academic advantages and cost-benefits of implementing on-line learning and how successful learning can be achieved, there is little information about students' non-academic needs and how non-tutorial support can be provided for on-line students at a distance. This may include, advising and giving feedback on non-academic skills to promote study and developing leadership. Therefore, there is a need for future research to address this gap in the literature and explore the non-academic needs of on-line distance learners.

11.3.5. Conducting a large scale study

Although comparative studies are common in media research and have been widely criticised, they are relatively new to the field of distance education and 'can be used to improve the design of distance education, but only if we first understand the conceptual issues surrounding comparative studies' (Smith and Dillon, 1999, p.7). However, whereas experimental media research could be simple in design, use of randomly assigned control and treatment groups is difficult and it may be unfeasible to control and conduct this type of research in distance education settings, where the majority of participants are usually adults, physically separated from the researcher, at different ages and have various academic, social and cultural backgrounds.

Since this study involved only a small number of participants at three schools, and were from a homogeneous cultural and academic background, the period of study was limited and only one subject matter was provided, future research is needed to design and evaluate on-line learning environments with larger sample sizes, more culturally and academically diverse groups of participants, longer periods of study and various subject matters. Such research may help in identifying the strengths and weaknesses of the Web in delivery of different subject matters, comparing cross-cultural perceptions towards Web-based distance education, identifying the factors that are conducive for successful on-line learning and generalising findings related to the effectiveness of the Web in learning.

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LISTSERVS

WWWDEV: World Wide Web Courseware Developers' Listserv http://www.unb.ca/web/wwwdev/

DEOS-L: The Distance Education Online Symposium http://lists.psu.edu/archives/deos-l.html

WWWEDU: The World Wide Web in Education List http://www.ibiblio.org/edweb/wwwedu.html

LEARNING ENVIRONMENTS

Blackboard [Blackboard, http://www.blackboard.com]

First Class [SoftArc, http://www.education.softarc.com]

Top Class [WBT Systems, http://www.wbtsystems.com]

WebCT [University of British Columbia, http://homebrew1.cs.ubc.ca/webct]

APPENDICES

Appendix 1: Student Questionnaire [*]

Dear Wired Class student,

This questionnaire is being administered to gain information about your experience as a student enrolled in Wired Class, to help us improve its design. The tutor will not share the results with your school and your responses will be confidential and used only for research purposes.

In this questionnaire, you are being asked to provide information about yourself (part one), perceptions of Wired Class (part two) and comments on the things you like or dislike in Wired Class (part three). When you complete the questionnaire, please click the 'Submit' button and let your teacher know that you have finished.

[*] Formatted to be uploaded to the Web.

Part One

1. Name:
2. Gender: Male ( )   Female ( )
3. School:
4. Did you use the Internet before joining Wired Class (to send e-mail, search the Internet, chat with others, etc.)?   Yes ( )   No ( )
5. If yes, did you attend on-line courses before?   Yes ( )   No ( )

Part Two

Please click the response that expresses your opinion on the following statements

1. Wired Class works in my computer without any problem.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

2. Using the search engines, I can find what I am looking for on the Web.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

3. I can access 'Links' under lessons easily.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

4. I feel that the teacher is near to me whenever I am studying.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

5. Using e-mail, I can contact anyone in Wired Class easily.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

6. Discussion board is a good place to meet and talk to my classmates.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

7. I can access Wired Class quickly.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

8. I can submit my work and receive a reply quickly from the teacher.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

9. Dividing each lesson into parts (lesson, examples, self-test and exercises) helps me to study and understand its content.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

10. The graphs and mathematical formulae are clearly presented.
   O Strongly agree   O Agree   O Neutral   O Disagree   O Strongly disagree

11. I like the way in which the lessons are presented (links, self-tests, interactive graphs).
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

12. Wired Class helps me to learn and understand this subject.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

13. I can answer exercises easily after studying each lesson.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

14. Discussion boards help me to learn from my classmates' ideas.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

15. I like to participate in the discussion boards.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

16. The design of Wired Class pages is attractive.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

17. Pages are simple and offer appropriate choices.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

18. Fonts and colours help me to read the content.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

19. I can understand the meaning of graphics and symbols easily.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

20. The Web Publisher is an easy way to publish my work on the Web.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

21. E-mail program is easy to use.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

22. Chat room is an easy way to communicate with others in the class.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

23. E-mail is easier than chat to communicate with others in Wired Class.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

24. If I have any problem in using Wired Class, the help pages guide me to solve it.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

25. Learning to use Wired Class takes a short time.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

26. I can find any page or lesson easily.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

27. From any page I can go to a new page or return to an old page easily.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

28. Usually, I know what a link means before I click it.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

Part Three

Please answer the following questions to help us improve Wired Class

1. What is the thing you most like in Wired Class?

2. What is the thing you most dislike in Wired Class?

3. Do you have any comments you need to add regarding using or leraning with Wired Class?

Thank you for completing the questionnaire

Appendix 2: Achievement Test [*]

Part One

Please answer the following questions

Question 1:

Read the following statements carefully and tell whether is *true* or *false*

Statement	True	False
(a) If one variable in a direct variation is tripled, then so is the other.		
(b) If the graph of a function is a curved line, it is an inverse variation.		
(c) The graph of the linear function is a line that intersects the origin.		

Question 2:

Complete the table for the following function

$$y = 3x - 1$$

x	2	4	6	
y				*23*

Question 3:

Write down the gradient (a) and y-intercept (b) of each of the following linear equations

Equation	a	b
(1) $y = 3x + 9$		
(2) $y = 2x$		

[*] Formatted and administered via the Web to on-line students.

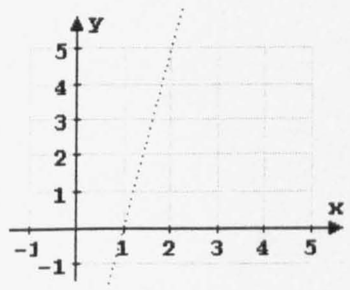
Question 4:

Select the figure which graph the function

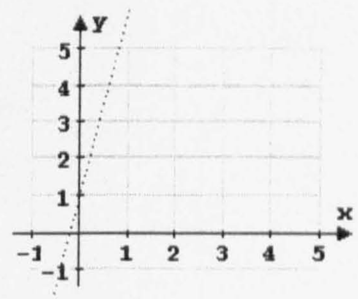
$$y = 5x + 1$$

then tell why.

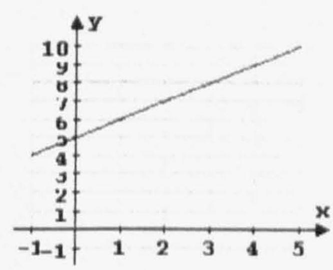
(a)



(b)



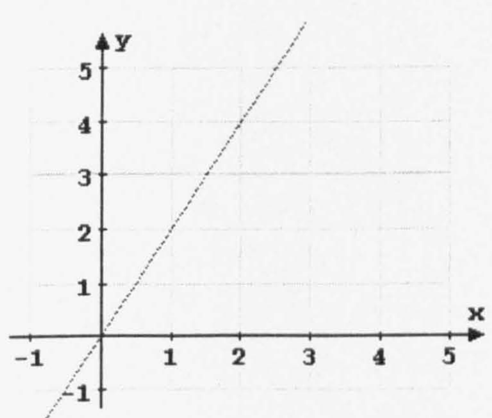
(c)



Question 5:

Write the formula of each of the following functions represented below then tell why.

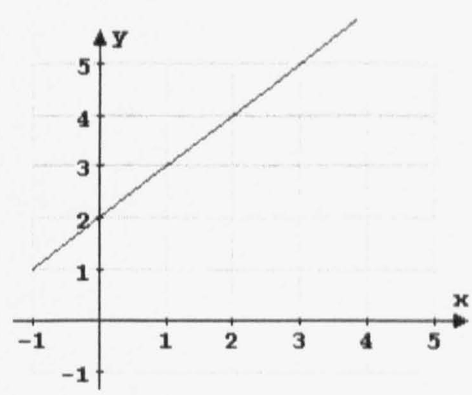
(a)



$y =$

Because

(b)



$y =$

Because

Part Two

Question 1:

Complete the following table of some of the solutions of the equation

$$2x + 3y = 12$$

x	-2	0		6	
y			$4/3$		-1

Question 2:

Does the point $(-1, 10)$ lie on the line of the equation $5x + 2y = 15$? Why? Is this point a solution to this equation?

Question 3:

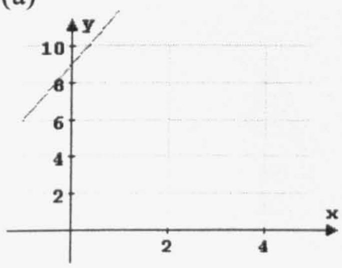
Write each of the following equations in the slope-intercept form ($ax+by=c$).

Equation	slope-intercept form
(1) $7x - 9y = 17$	
(2) $3x = y - 4$	
(3) $9x - y = 11$	

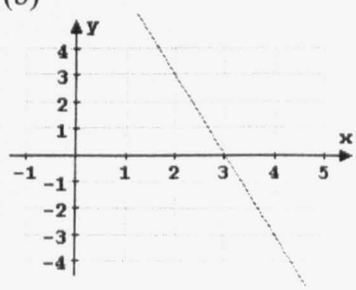
Question 4:

Select the graph which represents the equation $3x - y = 9$ without graphing it, then tell why.

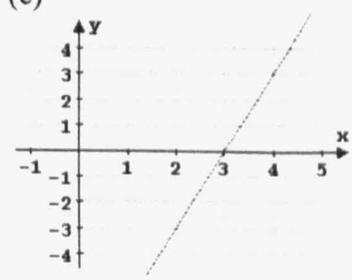
(a)



(b)



(c)



Appendix 3: Experts' Questionnaire

Dear Sir/Madam,

I am currently a doctoral candidate in the Institute for Learning at the University of Hull, UK. The purpose of my study is to evaluate the effectiveness of using the World Wide Web, as an interactive learning environment, to teach students at a distance. This questionnaire is a part of the summative evaluation process to find out to what extent a Web-based learning environment, developed by this study and called 'Wired Class', is able to achieve this purpose in terms of technical design, site structure, navigation system, quality of content, quality of resources and instructional design.

The researcher would appreciate it if you would help by reviewing Wired Class then filling-in the questionnaire. A five-point scale is provided (Strongly agree, Agree, Neutral, Disagree and Strongly disagree) for this purpose. In addition, open-ended questions are left for your suggestions if you think any change in the programme may be needed.

I greatly appreciate your co-operation and help.

Thank you.

Sincerely,

Alaa Sadik

Institute for Learning,

University of Hull,UK.

1. Technical design

In terms of standardisation

1. The site is based on standard HTML.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

2. The site is compatible with standard browsers.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

3. Size of graphics and the number of pages are suitable for the downloading time.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

4. Do you have any comments/ideas to make Wired Class more accessible?

In terms of user-interface design

5. Font sizes, style and colours have been used appropriately.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

6. White spaces, margins, paragraphs and indents help students to focus on the content.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

7. Text and graphics are well aligned.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

8. The icons clearly reflect the content they represent.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

9. Captions are concise and accurately describe the images and graphs.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

10. Page design is appropriate for screen appearance.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

11. Do you have any comments/ideas to enhance the design of user-interface of Wired Class?

In terms of ease of use

12. No troubleshooting or coding errors are available.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

13. The overall design of the system is suitable for students' level.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

14. The on-line help system is efficient.
O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

15. Do you have any comments/ideas to make Wired Class easy-to-use by students?

2. Navigation design

1. The site design helps students keep track of where they are.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

2. The site uses clear navigational aids.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

3. The indexing system provides quick access to information.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

4. Students can easily locate the information in the lessons.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

5. Links are well labelled and this helps the student to identify the meaning of a link easily.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

6. The student can return easily to the home page from any location on the site.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

7. The navigation icons are consistent throughout the site.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

8. Design of frames helps students to navigate throughout the modules and lessons easily.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

9. Do you have any comments/ideas to enhance the navigability of Wired Class?

3. Site structure and management

In terms of site structure

1. Wired Class contains the key components of on-line learning (interactive tutorials, interaction tools, etc.) .
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

2. Synchronous and asynchronous interaction tools are suitable to conduct and facilitate student-tutor and student-student interaction.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

3. The site provides appropriate support tools to enhance and manage instruction (e.g., the library, notebook, etc.).
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

4. The management tools (e.g., tracking, control panel, students' grades, etc.) enable the tutor to facilitate the learning process.
O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

5. Is there any components that need to be added to Wired Class?

In terms of management

6. On-line exams are appropriate to assess students at a distance.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

7. The site uses efficient ways to submit, process and grade students' work.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

8. Students are encouraged to study independently at a distance.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

9. The responsibilities of the learner and the obligations of the tutor are well-stated.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

10. The Web site has a secure access.
    O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

11. Do you have any comments/ideas to enhance the management of the learning environment?

4. Quality of course content

1. The objectives are clearly stated in each lesson.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

2. The content is sufficient, accurate and relevant to the objectives.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

3. The content is developed in accordance to the needs, knowledge and experience of the target learners.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

4. The content provides real-life examples and situations to facilitate the study of abstract content.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

5. Examples are relevant to the objectives and the content of lessons.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

6. Ample exercises are available for practising.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

7. Multimedia objects are used effectively throughout the duration of the course to support the learning process.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

8. Lessons are logically organised in segments (e.g.,examples and self-test).
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

9. Graphs, figures and formulae are clear and accurate.
   O Strongly agree O Agree O Neutral O Disagree O Strongly disagree

10. Do you have any comments/ideas to enhance the design of the course content and materils?

5. Quality of Web resources

In terms of access Web resources

1. Resources are easily located.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

2. Powerful as well as suitable research engines are available for learners.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

3. Do you have any comments/ideas to imporive student access to Web resources?

In terms of quality of Web resources

4. Resources are suitable for the learners' level.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

5. Resources are appropriate for the course activities.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

6. Resources are logically categorised.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

7. Objectives and content of resources are well described.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

8. Do you have any commnets/ideas to enhance the quality of Web resources added to Wired Class?

6. Teaching/learning approcah

1. The design of course content challenges the student to play an active role in assimilating knowledge.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

2. The design of learning provides many opportunities for interactivity by enabling students to work co-operatively.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

3. Discussion boards are well utilised to improve learning.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

4. Students are engaged in active problem-solving situations to construct their own knowledge.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

5. Students are encouraged to present and discuss their work and evaluate the works of peers.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

6. Student-centred activities are implemented throughout the course.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

7. Student's performance and progress are monitored throughout the learning process.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

8. Formative assessment is well utilised in the course.
   O Strongly agree *O Agree* *O Neutral* *O Disagree* *O Strongly disagree*

9. Do you have any comments/ideas to imporove student learning via Wired Class?

Messages to experts and listservs

Message 1

Dear Sir/Madam,

I am currently a doctoral candidate in the Institute for Learning at the University of Hull, UK. The purpose of my study is to evaluate the effectiveness of using the World Wide Web, as an interactive learning environment, to teach students at a distance. This questionnaire is a part of the summative evaluation process to find out to what extent a Web-based learning environment, developed by this study and called 'Wired Class', is able to achieve this purpose in terms of technical design, site structure, quality of course content, quality of resources and teaching/learning approach.

The researcher would appreciate it if you would help by reviewing Wired Class then filling-in the questionnaire. A five-point scale is provided (Strongly agree, Agree, Neutral, Disagree and Strongly disagree) for this purpose. In addition, open-ended questions are left for your suggestions if you think any change in the learning environment may be needed.

More information available at:

http://w134.loten.hull.ac.uk/wiredclass/evaluation/experts/cover.htm

I greatly appreciate your co-operation and help.

Message 2

Greetings All,

I am looking for your feedback about a Web-based learning environment for teaching students (15-17 years) at a distance called Wired Class. Wired Class is available at: www.wiredclass.net

Thank you in advance

Alaa Sadik, Ph.D. Student (1998-2001),

Institute for Learning, Univ. of Hull, UK.

Message 3

Greetings Developers and Deliverers of Web-Based Instruction,

I designed a Web-based learning environment for teaching students at a distance (14-17 years old) called Wired Class. This environment was updated recently with new features for students and tutors as well. Sign-up as student, for free, and discover the components of Wired Class. Wired Class is available at:

http://w134.loten.hull.ac.uk/wiredclass/

Contact me personally to get your tutor access key to browse the Teacher's Guide and try Tutor's Control Panel yourself.

Alaa Sadik

a.m.sadik@educ.hull.ac.uk

Ph.D. Student, Web-based distance education

Institute for Learning,

University of Hull, UK.

Appendix 4: Wired Class Evaluation Checklists

Checklist 1: Students' reactions to the navigation and user-interface design

Behaviour	Happening		Why?
	Yes	No	
1. The student is able to access module or lesson	✓		Because of 'modules page' and the dropped-down menu on the tools bar.
2. The students is able to return to an old visited page	✓		Because of using indexed hierarchy and frames throughout the site.
3. The student knows the meaning of links	✓		Students become very familiar with icons and spend a short time reading the brief captions and descriptions of links
4. The student gets lost in the site		✓	The starting page icon makes it easy to any student to go back to the main index
5. The student is able to run tools (e.g., calculator and grapher) from within any lesson	✓		Because of the availability of the tool bar in each lesson
Navigation and user-interface problems			
1. The 'refresh' or 'reload' concept is not clear in the minds of many students. Sometimes, it causes a problem with HTML forms if the 'submit' button is clicked more than once.			
2. Students do not close the 'book' icon on the left-hand navigation menu before opening a new one.			
3. Some external Web resources do not work or are difficult to reach from Egypt (the links were specified in a separate sheet).			

Checklist 2: Technical design of Wired Class

Feature	Availability		Why?
	Yes	No	
Learning to use Wired Class takes a short time.	✓		Most students spent about than 15 minutes exploring and learning how to use Wired Class. Only two students out of eight spent about 30 minutes until they could use it successfully.
The design is compatible with students' browsers and screens resolution	✓		The design is suitable for appearance in 640×480 and 600×800 screen resolution.
Some troubleshooting or coding errors are available	✓		Unexpected entries by students causes some coding errors, particularly with HTML forms.
The design of discussion board is suitable for students	✓		Students used the discussion board easily and understood what does forms and entries below mean.
The auto-feedback is efficient		✓	Because of the limitation of the scripts to anticipate students' entries.
The chat system is easy to use	✓		Because it is a text-based system and students are able to log-in and participate easily.
The Web-based e-mail is easy to use	✓		Students are able to access e-mail from within Wired Class, and access their accounts and send and receive messages.

Technical design problems

1. Students who did not read the help topics the first time they accessed Wired Class claimed that they did not know how to use many functions and find modules.
2. Placing too many links in the starting page, without putting them in a logical order, leads to students taking a long time to find the appropriate link they need.
3. Using Page Builder was not possible unless the student has a digital copy of his/her photo on hand.
4. The meaning of the 'home' icon as an indication to the starting page was not clear to many students.
5. Students did not understand the meaning of the 'log-in' and 'log-out' titles in the 'on-line students' page.
6. Offering more than one search engine in the search page is not useful and confuse students.
7. The time shown in the 'on-line students' page (GMT) was different from the local time (by two hours) and very confusing to students.
8. Many students did not have the key skills to use e-mail functions (e.g., forward and go to folder).
9. Students experienced difficulties in printing frames.