An Experiment to Review the Quality of Web-Based Multimedia Material

by

Khalil Al-haddad

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Supervisor: Dr P. A. Lawson

Director of Research: Dr C. J. Hinde

Computer Science Department

Dedication

To the spirit of my sister Nasima,

To my parents,

To my lovely wife, Kholoud, and my beautiful children Fatima, Mariam, Ebrahim and Raheel.

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Abstract

Currently, many educators are focusing on the development of Web-based material and the quality of such material needs to be evaluated. Expert review, as a formative evaluation method, is an important method to evaluate the material prior to release. Other studies have described the use of Subject-Matter Experts (SMEs) and also domain students, with enough knowledge in the subject area, as a way of enhancing the quality of the reviewed material. In addition to the SMEs and domain students a lecturer and graduate student, both in the subject discipline area, were used to review Web-based lectures on Advanced Computer Architectures. Both additional reviewers had sufficient knowledge of the discipline.

The research investigates three main hypotheses: 1) whether a review conducted by domain reviewers (SME and domain student) or discipline reviewers improves the quality of material, 2) whether using discipline reviewers improves the quality of the material more than domain reviewers and 3) whether there are differences in the quality of the material resulting from students' and lecturers' review.

Five versions of the material were developed and used as inputs to an experiment that was designed to test the hypotheses by using questionnaires and tests.

In summary, the findings of the research were that: SME reviewer and discipline reviewers were effective in producing higher quality than the unreviewed material. However, rather interestingly, the domain student was shown to be the least effective in enhancing the material. The investigation also found that there was no significant difference in the quality of the material resulting from students' and lecturers' review. Furthermore, it was found that the media used to present the material was more useful when the quality of that media was perceived to be high. Finally 90% of the subjects were willing to study Web-based lectures as part of the course.

Keywords. Distance Learning, Computer-Based Instruction, Web-Based Instruction, Multimedia, Formative Evaluation, and Expert Review.

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Chapter One

Introduction

1.0 Introduction

In the past, traditional teachers used chalk and blackboard to deliver their knowledge to learners or students. Teachers are always eager to find better ways of making the teaching process easier and more interesting. Over time, teachers began to use instruments like overhead projectors, computers, and videos in order to enhance their teaching methods. With recent developments more effort has been made to prepare teaching material by using today's computer technology, providing dynamics in the appearance of the material through animation, sound and video. Computer technology, today more than ever, is considered a merging of many technologies. The concept of combining text, graphics, sound, animation and video within a computer is commonly called Multimedia. Multimedia technology may help to enhance the students' understanding of the subject from a diverse range of perspectives. Educational organisations, especially those involved in distance learning, are following closely the advancement of such technology. Further development of computers combined with the development of the World Wide Web (WWW or just the Web) attracted interest from both the traditional educational organisations, such as schools and universities, and the non-traditional universities, such as the Open University. It has been argued (Bates, 1995) that the value of technology is in its capability to reach learners not well served by conventional education institutions, to match better the newly emerging educational needs of an information society and to improve the quality of learning. The Web with its graphical interface, ease of use, and hypertext ability made it of greater educational value than other technologies. Hypertext is a method that permits the storing and linking of text in logical ways such that the user can freely access it when and where required. This method made the creation of a Web-based material more attractive for traditional and non-traditional universities since it provides learners more control over the learning process. Also Hypertext facility allows learners to access a huge storage of knowledge and provides better control of multimedia applications. The combination of multimedia and hypertext is sometimes called Hypermedia.

Today, there is a need to discover or redesign methods of teaching and learning that match the use of technology to the demands of learners in the twenty-first century. Körnesfors (1994a; 1994b) suggested that the education of teachers must be adapted to modern technology. Student teachers are one of the categories that might benefit greatly from grasping the fascinating world of multimedia and hypermedia. The teachers of tomorrow need enough knowledge about the new methods and possibilities so that they can build their own material as well as adapt and arrange the vast wealth of freely available material into a form that is of use to the learner. In addition, they must be able to understand and adapt to the way their pupils use computers.

In much of the literature, it is recommended that any educational material should be evaluated before use. Formative evaluation is a component of many systematic approach models for developing educational material, whether it is Text-based or Computer-based. The purpose of formative evaluation is the testing and reviewing of the material before shipping. In contrast to summative evaluation that is conducted after the material has been finalised, formative evaluation is intended to be carried out when the material is still under development.

The process of formative evaluation involves collecting data from a variety of sources, and using a variety of data gathering methods and tools to review, test, and accordingly revise the developed material for the purpose of improving its effectiveness and appeal. Mainly, formative evaluation is conducted through four methods: Expert review, one-to-one evaluation, small group evaluation, and field-test evaluation. Two categories of participants as data sources are mainly used, experts and target learners.

In the literature various aspects of formative evaluation, in particular the sources that can provide feedback for this purpose, have been investigated empirically. For example, it has been found that draft material can be tested either with a sample representing the target learners, or from being reviewed by various types of experts. Either source can provide a considerable amount of input or data useful for revision. The collected data, once translated into revision, will make the materials more effective (Weston et al 1997; Dick & Carey, 1996; Byrum, 1992; Davidove & Reiser, 1991; Dupont & Stolovitch, 1983, Kandaswamy et al, 1976).

A large part of the empirical research in formative evaluation was conducted with a general focus on the learners as the source of feedback for revision. For example, many studies have compared the results of the 'one-to-one' methods against 'small group' evaluation methods (Kandaswamy, 1976; Banazak, 1974; Baghdadi, 1980; Byrum; 1992). Studies have also compared the impact of roles (e.g., active or passive) assumed by the experimenter in soliciting feedback from the learner (Geis, 1987; Medley-Mark & Weston, 1988). Furthermore, some studies used or suggested different groups of learners' abilities and different roles for the experimenter (Medley-Mark & Weston, 1988; Dick & Carey, 1996).

Several 'experts' were suggested in the literature but studies mainly used Subject Matter Experts (SMEs) and Instructional Designer Experts (IDEs) (Char & Hawkins, 1987; Davidove & Reiser, 1991; Saroyan, 92/93)

Some studies, in the literature, used lecturers and students as SMEs. However, these described the information collected without attempting to revise the material, or compare the quality of the revised materials (Weston, 1987). Using students, as SMEs, might be more cost effective than using lecturers. No previous study was conducted to compare the effectiveness of student SMEs against lecturer SMEs. It is the focus of this study to shed light on such an investigation. Furthermore, some studies concluded that IDEs perceived the material as means to learning that invoked effective strategies for revision, since they were less familiar with the subject and therefore reviewed the material as both learner and as expert in instructional design. No studies were found that compares the result of revising the material according to SME review and discipline-knowledge lecturer or discipline -knowledge student review. In addition, no study was found that conducted formative evaluation on Web-based material. The methodology used in the previous studies did not allow subjects to compare the revised material with the unrevised. For example, Davidove and Reiser (1991) concluded that future research should allow subjects to compare revised versions of the material. The methodology of this study uses that recommendation.

1.1 Research Questions

In this study four reviewers with different levels of expertise (knowledge) were used to review the material. The level of knowledge of the reviewers could be visualised on continuum of subject familiarity that increases from left to right. At the right of the continuum is the lecturer SME and at the left is the target learner. The middle area might include domain student, discipline lecturer, and discipline student.

The study investigates whether using such reviewers will produce quality of material that is better, or significantly better, than the unreviewed material. Two categories of reviewers were used, domain and discipline reviewers. Domain reviewers are two subject experts: a lecturer and a research student both of whom were fully conversant with the material. Two discipline reviewers were also used: a lecturer and a research student. These two reviewers were in the discipline of the material subject, Computer Science, but did not possess any detailed knowledge of the material.

The study attempted to answer the following questions:

- Is the quality of the reviewed materials better than unreviewed? In other words, is the quality of the material improved when reviewed by any of these reviewers?
- Do discipline reviewers produce higher quality material than domain reviewers?
- Do student reviewers produce the same quality as lecturer reviewers?

Previous studies, however, have not addressed these questions. Therefore, this study was conducted to fill these gaps in the literature, and to add to or confirm the result of previous studies. Specifically, it attempts to broaden the choice of reviewers and verify the use discipline reviewers.

In order to answer these questions, three main hypotheses were investigated through an experiment that was designed to verify them.

1.2 Research Hypotheses

The research was constructed to investigate three main research hypotheses that were divided into 20 sub-hypotheses: 8 sub-hypotheses were derived from the first, H1 through H8, another 8 were derived from the second, H9 through H16, and 4 were derived from the third, H17 through H20. The first two main hypotheses are put as an alternative to null hypotheses that implied no differences between reviewed material and unreviewed. The hypotheses are as follows:

1. **Any review by a domain or a discipline knowledge person will result in a higher quality material, in terms of students' satisfaction and learning, than the unreviewed material.**

    - H1a: Students are more satisfied with the material reviewed by a domain lecturer than unreviewed material;
    - H2a: Students are more satisfied with the material reviewed by a discipline lecturer than unreviewed material;
    - H3a: Students are more satisfied with the material reviewed by a domain student than unreviewed material;
    - H4a: Students are more satisfied with the material reviewed by a discipline student than unreviewed material;
    - H5a: Students studying the material reviewed by a domain lecturer score more in the test than students who studied the unreviewed material;
    - H6a: Students studying the material reviewed by a discipline lecturer score more in the test than students who studied the unreviewed material;
    - H7a: Students studying the material reviewed by a domain student score more in the test than students who studied the unreviewed material;
    - H8a: Students studying the material reviewed by a discipline student score more in the test than students who studied the unreviewed material.

2. **Discipline knowledge reviewers will provide a quality of material, in terms of students' satisfaction and learning, higher than domain knowledge reviewers.**

    - H9a: Students are more satisfied with the material reviewed by a discipline lecturer than the material reviewed by a domain lecturer;
    - H10a: Students are more satisfied with the material reviewed by a discipline lecturer than the material reviewed by a domain student;
    - H11a: Students are more satisfied with the material reviewed by a discipline student than the material reviewed by a domain lecturer;
    - H12a: Students are more satisfied with the material reviewed by a discipline student than the material reviewed by a domain student;
    - H13a: Students studying the material reviewed by a discipline lecturer score in the test more than students who studied the material reviewed by a domain lecturer;

- H14a: Students studying the material reviewed by a discipline lecturer score in the test more than students who studied the material reviewed by a domain student;
- H15a: Students studying the material reviewed by a discipline student score in the test more than students who studied the material reviewed by a domain lecturer;
- H16a: Students studying the material reviewed by a discipline student score in the test more than students who studied the material reviewed by a domain student;

3. **Lecturers and students, as reviewers, produce the same quality of material in terms of student's satisfaction and learning.**

- H17: Students are equally satisfied with the material reviewed by a domain lecturer and the material reviewed by a domain student;
- H18: Students are equally satisfied with the material reviewed by a discipline lecturer and the material reviewed by discipline student;
- H19: Students studying the material reviewed by a domain lecturer score the same in the test as students who studied the material reviewed by a domain student;
- H20: Students studying the material reviewed by a discipline lecturer score the same in the test as students who studied the material reviewed by a discipline student.

1.3 Research Structure

The study was conducted in five phases: reviewing the literature (although this continued throughout the entire period of the study), developing the material, designing the experiment, analysing of the experiment, and writing the thesis. As shown in **Figure 1.1,** the literature review is covered in two chapters, 2 and 3. The development of the material is covered in chapter 4, experiment design is explained in chapter 5 and the analysis and the conclusions are covered in chapters 6 and 7 respectively.

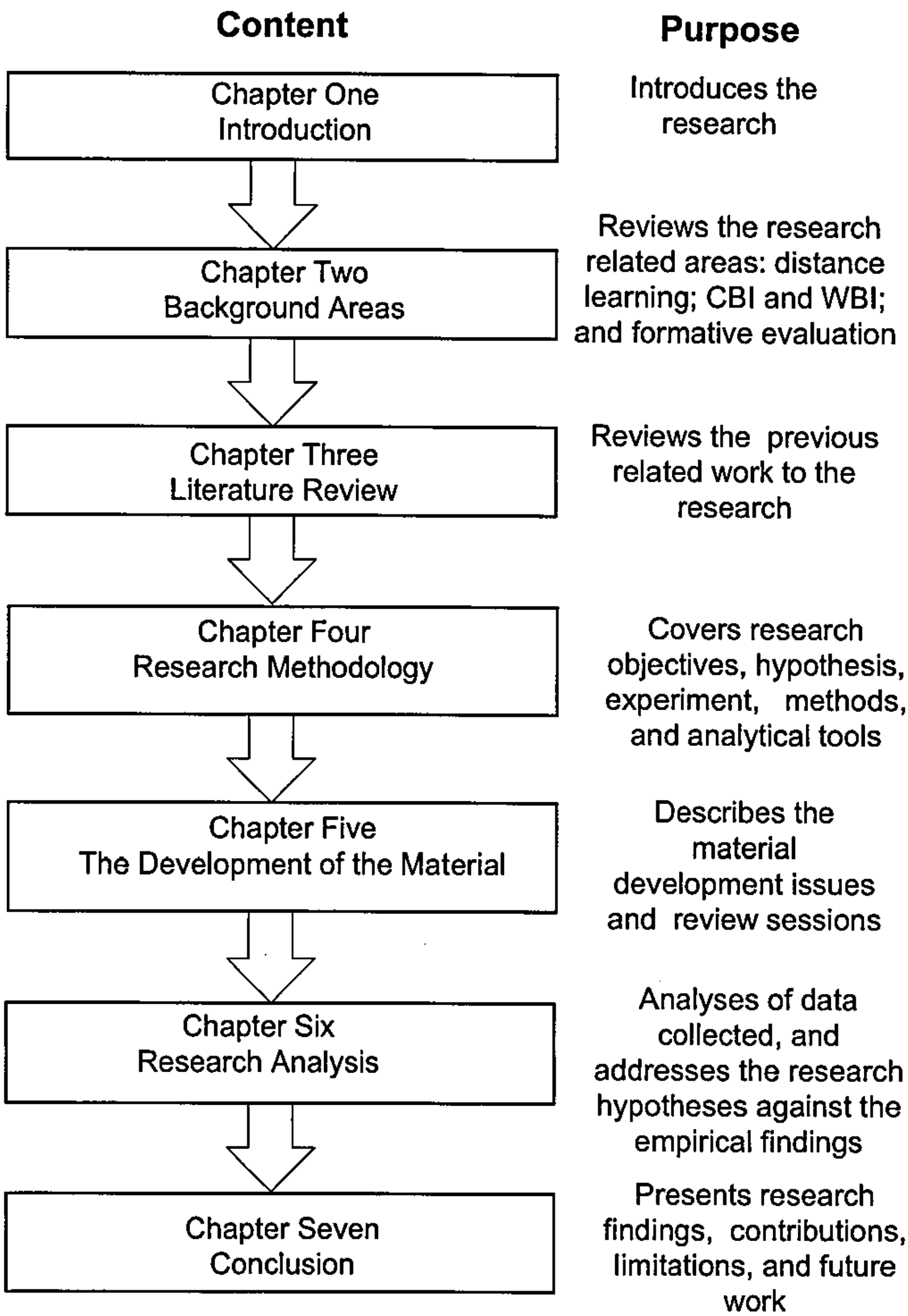

Figure 1.1: Research Framework

Following the introduction, chapter two presents background areas covering distance learning, Computer-Based Instruction (CBI) and Web-Based Instruction (WBI), and formative evaluation. The chapter presents distance learning definitions, technologies, and organisations. Also, the chapter covers the British Open University as an example of a world leader in distance learning. A review of Computer-Based Instruction (CBI) and Web-Based Instruction (WBI) is included in this chapter covering types and developments of CBI and WBI. The last section explains formative evaluation definitions and types. The literature and previous work related to the research is discussed in chapter three. Chapter four deals with the research methodology, the objectives of the study, the research hypothesis, the design of the experiment, the research methods (questionnaire, test), and the various analytical tools. Chapter five clarifies the issues surrounding the development of the material such as the design of the material and the cost of authoring the material. Also, it describes the review sessions such as the data collection tools and the results of each review session. Chapter six contains the statistical analysis of the data, collected through the questionnaires and tests, and addresses the research hypotheses against the empirical findings. The final chapter, chapter seven, presents the research findings, the research contributions, its limitations, and, at the end of the chapter, suggests areas of possible future research.

1.4 Significance of the study

The significance of this research is its contribution in filling the gaps in the literature of the following:

- Formative evaluation on Web-based material;
- New types of reviewers that could be cost effective to review the developed material;
- Experiment design that allows subjects to evaluate and compare more than one of the reviewed materials;
- Comparison between the review results of lecturer SME against student SME;
- Cost analysis of the development of Web-based and multimedia material;

The research also questions whether students are willing to study materials in non-traditional form, specifically Web-based material. In addition the research investigates how students perceived the quality and the usefulness of the media used in the material such as sound, video, animation, and presentations.

1.5 Conclusion

It is hoped that the research will contribute in broadening the review process in the development of Web-based material. It may provide answers to questions such as, does the review process for Web-based material result in a better quality of material? Is the use of domain students as effective as domain lecturers? Can the review process be broadened to include discipline reviewers?

The research highlights other issues regarding the use of multimedia and the acceptability to students of learning through Web-based material.

Chapter Two

Background Areas

2.0 Introduction

This chapter covers the three background areas related to the study: distance learning, Computer-Based Instruction (CBI), Web-Based Instruction (WBI), and formative evaluation.

Since the study includes developing and evaluating Web-based material, explained more in chapter 4, that is intended to be taught as distance learning material, a review of distance and open learning is presented as a section in this chapter. The section presents distance learning definitions, technologies, organisations, and an example of such organisation, specifically, the British Open University.

The second background area introduced is the computer-based material covered through a review of Computer-Based Instructions and, more recently, Web-Based Instruction (WBI). The evaluation of such material could be conducted through a process called formative evaluation, which is presented as the third background area of the study.

2.1 Open and Distance Learning

Traditional classroom teaching was the only model to deliver education for a long time. The model assumes that a teacher and a group of learners meet at the same time and in the same place. The education process then occurs when learners are introduced to a level of factual knowledge and conceptual understanding that is judged by pre-set standards that is appropriate for their level of knowledge (Schecgter, 1983). The model served the majority of learners. However, a large minority of learners were ignored since the model puts time, place, and in the past, wealth constraints on these learners. Learners, for some reasons such as, living in rural areas, working full-time, having family obligations, suffering from some disability, or not of school age are prevented from benefiting from such a model. It becomes imminent, for educators and governments, to find a way to serve this large minority of learners, to break the traditional model of teaching and explore new methods. Open and distance learning arose as an alternative to the traditional model to serve such learners.

Although the purpose of both methods, open learning and distance learning, was to deliver education in non-traditional way, they were defined differently. Distance learning definitions emphasise that learners are separated physically from the learning centre, whilst open learning definitions focus and concentrate on developing a flexible learning centre (Bukhari, 1994). Also, there were no agreed definitions, in the literature, for both terms.
Lewis and Spencer (1992), however, defined open learning as the provision of flexible courses to meet individual requirements, so attempting to remove barriers that prevent attendance at traditional courses. In addition, Dixon (1992) defined it as learning opportunities that aim to give access to knowledge and skills otherwise unavailable, and give learner the optimum degree of control over their learning. In total, both definitions highlight open learning principles. These principles are as follows:

- Permitting more people to learn by economising teacher time;
- Using a variety of media appealing to different learners;
- Permitting learners to study when and where they choose;
- Permitting learners to work at their own pace;
- Positioning learning activities in the learners' home, community or workplace;
- Making learners responsible for their own progress.

Although the principles of open learning could be found in distance learning but, they are defined differently. Dewal (1989) explained that, the difference between the two terms is that: distance learning refers mainly to the mode of delivery whereas open learning refers to structural changes in traditional teaching so as to make learning open with respect to place, time, content of learning and mode of learning.

Distance learning, however, simply means that learners and teacher are at a distance from one another with little opportunity for face-to-face contact. Rowntree (1992) defined distance learning as learning at a distance from one's teacher, usually with the help of pre-recorded, packaged learning materials, but with learners still being guided by the teachers. Additionally, Perry and Rumble (1993) defined distance learning as when the learner and the teacher are not face-to-face, so that in order for two-way communication to take place between them, a medium such as print, radio or telephone must be used.

Different media were used to provide two-way communication and interactivity between teachers and distance learners. Whenever a new technology becomes available that can provide better interactivity it was used as the two-way communication medium.

2.1.1 Distance Learning Technologies

Distance learning was started maybe more than two hundred years ago (Holmberg, 1989). Since that time the technologies used to deliver distance learning have changed, as new technologies become available. There were three generations of distance learning. Each generation was categorised by the technology used to deliver the learning process (Nipper, 1989). The first generation was categorised by correspondence. The communication was mediated through correspondence that lacks any direct interaction between teacher and learners and the material was only text instruction. The second generation was categorised by the use of a more integrated multimedia material, that was specifically designed for studying at a distance, and by the use of a two way communication system, mainly the telephone, mediated through a third person (e.g. tutor). For example, the Open University of UK introduced audio support for distance learning delivery in the form of audio-cassettes and telephone tutorials in the early 70's (Bukhari, 1994). The third generation is based on two-way communication media which allows direct interaction between the teacher, who originates the instruction, and the remote learner.

The technologies used in distance learning could be divided, in general, into four categories: telephone, computers, audiographic, and video technology (Franklin et al, 1995).

- Telephone Technology

The use of the telephone marked the beginning of an era of interactive distance instruction utilising an electronic medium. Telephone was the most cost-effective distance learning technology because of the following reasons:

- Telephone is available almost everywhere in the world;
- Telephone equipment costs less than other distance learning equipment and it is very user friendly.

The telephone frequently used to serve as an audio component of other distance learning systems. In distance learning system, the audio component can be as simple as a telephone and as a complex as a system of microphones, cabling, audio mixer, and echo-cancelling equipment. Audio is considered the most critical component to ensure effective interactive communication. Telephone is used with the following distance learning systems:

- Audioconferencing: Audioconferencing is a system that is used to let multiple sites or locations be connected simultaneously and conduct meetings so that every one can hear and talk.
- Callback: Callback is a system that is used with one-way video systems (explained later) to allow learners at remote sites to call into the originating location in order to interact with the instructors and other learners.
- Voice mail: Voice mail is a system that allows participant to communicate privately and asynchronously and to distribute one voice message to many people.
- Backup: telephone can be used to help troubleshoot problems and arrange an audio alternative for instruction.

Additionally, fax machines that use telephone lines are used to send documents. Fax now comes with the modem card installed in the computer. Instructors can use this facility to send material directly from their computer to fax machines or to a computer at remote site.

- Computer Technology

In the 60's, the use of computer technology involved large and expensive computers, e.g. mainframes. The costs of such a system were enormous and when compared with other media it did not look very favourable. The widespread use of computers as a distance learning medium did not occur until 1970's when, the first low cost microcomputers appeared (Schechter, 1983). Microcomputers, or Personal Computers (PCs), became an essential part of distance learning systems. A PC with some software and applications installed provides the user with the power to communicate, search and retrieve information resources from a global network, such as the Internet, and access collaborative learning environments.

Computer technologies and applications used in distance learning include the following:

- Coursework preparations and word processing;
- Electronic mail: E-mail allows learners and instructor to communicate regardless of time and distance using electrical messages typed through a computer. These messages can travel over both local network (LAN) or global networks (e.g. WAN, Internet);
- Computer-conferencing: Computer-conferencing is a computer based interactive communication environment that allows the participants to have a real time chat via the keyboard;
- Groupware: Groupware is a term used to describe some applications that allow an electronic workspace for collaborative work and sharing of ideas. Groupware can store, sort, and organise participants' inputs and support group processes, such as idea generation, evaluation, and consensus building;
- Computer-based Instruction (CBI): CBI is a self-paced instruction that learners access from desktop computers. The instructional materials could be mounted on CD/ROM, laser disk, installed on local computer, or accessed from computer network. Further description and discussion of CBI is presented later in this chapter;
- Web-Based Instruction (WBI): A learner in WBI accesses and downloads the course material such as lectures, readings, assignments from electronic bulletin boards. E-mail is used to provide a private

communication between learner and instructors. Further description and discussion of WBI is presented later in this chapter;

A major enhancement of distance learning was the result of the development in computer technologies. Currently, the computer is an amalgam of several technologies such as telephone, fax, and the World Wide Web. The advent of the Web provides a new and interesting environment for distance learning that offers new possibilities. The World Wide Web environment can offer a global, interactive, dynamic, cross-platform, distributed, graphical hypertext information system that runs over the Internet (Lemay, 1996). The Web itself can be considered as a merging of the following environments:

- Hypertext/Hyperlink environment: Hypertext/Hyperlink is a mechanism in the Web system that allows the user to read and navigate through text and visual information in a non-linear way. The user can click on the (hyper) text to move to another point in the same page, a different page in the same location, or a different page at a different location;
- Graphical User Interface (GUI) environment: On the Web, information could be displayed as both text and graphics using full colours;
- Multimedia environment: Information could be presented additionally using sound and video;
- Cross-platform environment: Cross-platform means that the Web could be accessed regardless of the user platform. The Web was designed to be machine independent;
- Distributed environment: information on the Web is distributed globally across thousands of locations or Web sites. Each Web site provides its own storage space for the information that it publishes;
- Dynamic environment: Web information could be updated easily allowing Web user to access current information.

These Web features could be used to create a Web-Based classroom that can perform learning-related tasks delivered at a distance. A Web-based classroom is not simply a mechanism for distributing information to learners, it also performs tasks related to communication, learner assessment, and class management (McCormack & Jones, 1998).

The Web, also, provides many valuable Internet tools such as e-mail, Usenet News, file transfer, and a variety of other computer applications such as databases that can be used with a Web-based environment. In addition, for the learners, the Web provides a simple and user friendly interface whilst for instructors the web pages are, generally, easy to program and publish.

The growth in use of the World Wide Web created a traffic problem on the Internet that put some constraints on distance learners. Some studies were conducted to study the traffic pattern and find solutions (Sedayao, 1994). But the recent and various developments in Information Technology (IT) and the 'so called' information superhighway will improve distance learning. Information highways are high-speed data networks used to transport information and link people who wish to be connected with others. The metaphor 'highway' is used to represent highway's characteristics such as speed, volume, power and efficiency, although some authors did not quite agree with the use of such a metaphor (e.g. Burge, 1995). Hawkridge (1995) described the emerging of the information superhighways as the Big Bang theory of distance learning. The euphoria came from the envisaged enhancement and the replacement of the old one-way systems of print, radio and television to a complete two-way communication systems that provide graphics, audio, and video interaction between teacher and learners. These highways will also enable learners to seek a huge knowledge store.

Developed countries, such as the USA and UK, are running to install this wideband communication infrastructure. In 1994 government officials of the USA proposed a creation of a Global Information Infrastructure (GII). It is expected that this network would offer telephone and interactive digital video to almost every American citizen, classroom, library, hospital and clinic by year 2000 (Hawkridge, 1995). It will be a global network so that every user, world-wide, would be able to reach huge sources of information. In the United Kingdom, universities are joined to accomplish a superhighway network that is used for educational and research purposes. The UK's SuperJANET (Joint Academic NETwork) was initiated to offer advanced distance learning, remote library access, instant document delivery, electronic journal, and interactive browsing. All kinds of multimedia services can be used on the

SuperJANET system which is predicted to reach all major sites in UK higher education institutions by the year 2000 (Bukhari, 1994).

- Audiographic Technology

The audiographic technology requires the use of a telephone line and a computer. In this environment, participants in a collaborative work use the telephone for voice interaction and the computer for sharing graphical material. In other words, participants can interact with visual presentations and audioconference at the same time. However, this technology is gradually being undertaken by the ability to conduct audio or videoconferencing over the Web, albeit at a, sometimes, lower bandwidth.

- Video Technology

The video environment can provide a synchronous interaction where instructor and learners can see and hear each other simultaneously. This technology provides a good environment for collaborative problem solving, demonstration, and skill practice. The video signals could be broadcast as one-way or two-way. The video signals in the one-way broadcast, are transmitted in one direction, simply from instructor to learners. This means that learners will be able to see the instructor but not vice-versa. Usually, video signals are transmitted by satellite and received by the remote site. Audio signals are transmitted and received by telephone lines, which allows learners to interact with instructor. In the two-way video broadcast the video and audio signals are transmitted and received in both directions, from instructor to learners and from learners to instructor, so that instructor can see and hear learners and vice-versa. There are two techniques used to deliver the video signals, full-motion and compressed video signals. The full-motion technique requires sites to be networked with high speed communication cables, such as fibre optics, that provide picture quality close to that of commercial TV. Without such a network, video information has to be compressed, reducing the size of it in order to be delivered through slower networks. The compression technique starts after translating video and audio signals into digital signals by removing redundant objects from the digitised signals. These compressed signals can be sent over switched digital telephone lines. Such systems are excellent for face-to-face contact or illustrations and diagrams, however, they tend to break down when detailing rapid movement or complex animations.

- Choosing the Technology

Recent technological developments provide an opportunity for revolutionary change through distance learning but which technology should be used? Choosing the right technology is not an easy task. The choice of the technology, according to Bates (1995), is influenced by three factors: learning requirements, costs and availability of the technology. He suggested raising the following points before choosing the technology:

- Access: how accessible is a particular technology for learners?
- Cost: what is the cost structure of each technology?
- Teaching functions: what are the best teaching applications for this technology?
- User friendliness: how easy is it to use?
- Organisational issues: what changes in organisation need to be made?
- Novelty: how new is this technology?
- Speed: how quickly can the teaching or training material be mounted with this technology?

The latest or most sophisticated technology is not always better than the older ones. Distance learning providers, or organisations, should conduct a comparative analysis when choosing the appropriate technology.

2.1.2 Distance Learning Organisations

There are three types of organisations, according to Holmberg (1986), that provide distance learning:

(a) Universities that exclusively enrol distant learners and use distance study methods for all or most of their teaching (e.g. British Open University);
(b) Extension departments of conventional universities providing distance study facilities (e.g. University of New England in Australia);

(c) Specialised bodies outside the university providing courses and tuitions for university degrees, the role of the university being that of an examination board. (e.g. British National Extension College (NEC)).

In addition, elementary and secondary schools are using distance learning applications to improve instruction and educational resources.

The programmes offered by these autonomous universities or dual-mode universities include:

- Undergraduate and graduate courses;
- Continuing education;
- Staff development and in-service training;
- Certification programmes;

Bates (1995) explained that political, economical and technological issues generally effect distance learning organisations. Examples of the political issues that may push distance learning forward are:

- Government promises to solve education problems;
- Giving assurances to minority and equity groups to make them able to access learning opportunities;
- Believing that economic development is linked with continuing life-long learning in workplace;

Economic issues, also, may have an impact on distance learning. Examples of such issues are:

- Reducing education or training budgets;
- The increasing demand for a better-educated workforce;
- The impracticality of traditional teaching for the employees;
- Employers often are willing to pay the full cost of high-quality education and training if delivered in flexible way;
- Governments support open and distance learning for workforce developments.

Technological issues, however, also effect distance learning organisations. Examples of technological issues are:

- The development of multimedia and its educational potential;
- The decrease of the cost of the technology makes it available to the general public;
- The merge of telecommunications, television and computing;
- The developments of public learning networks such as the Internet.

As a result of these political, economic, and technological issues a new type of distance learning organisation is emerging, e.g. virtual schools. A virtual school is a term used to describe a school without a physical framework such as a school building with classrooms, offices, reading rooms and libraries. A virtual school is intended to function as regular school. It is described as an information system, which functions as a school but without physical existence. Therefore, a virtual school should have the fewest possible limitations on communication between people. Communications should be possible without limitations in time and space. Paulsen (1989) worked on a virtual school project and concluded that it is possible to construct a virtual school around a computer conferencing system using the technology of today. Also, the British Open University held the first virtual summer school in 1994. Students did not have to stay on campus for the summer school. Instead they are linked to the tutor and to each other via e-mail, video-conferencing, and a collaborative work system.

More information about the British Open University, as an example of the world leaders in distance learning, is presented in the next section.

- The British Open University

The Open University (OU) is Britain's largest single teaching institution, with more than 200,000 people studying its courses[1]. Since its establishment by Royal Charter in 1969, it has offered a higher education for more than 2 million people. Miles Hedges (1999), a director at the Open University, stated that the OU is aiming to be "open as to people and open as to ideas." He further commented that the OU is one of the world leaders in providing higher education on a distance learning basis[2]

The purpose of the OU was to build a system that would:

1. Include everyone regardless of educational history;

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[1] From OU fact sheet (1998) found in http://www.open.ac.uk/factsheets/fcats98.pdf

[2] From OU news found in Http:// www.open.ac.uk/news/frontpage.html

2. Be sufficiently inexpensive to avoid excluding anyone;
3. Operate on a schedule that would be compatible with students who were employed full time;
4. Design courses that would avoid massive drop out, provide standard university level courses, and lead to a formal degree (Schechter, 1983).

The success of the Open University can be gauged by the continuing expansion of course offerings and the number of students that graduate each year. Currently with more than 200,000 students registered, OU has more students than any other British university. Undergraduate courses are open to all regardless of educational qualifications. Furthermore, the OU made higher education accessible to people with disabilities. In 1998, about 5,500 of OU's students were disabled.

More than 80% of OU's students continue during their studies as employees. The courses are designed for students studying in their homes or workplaces, in their own time, anywhere in the UK, Ireland, and Continental Western Europe and often further afield.

Almost all the available technologies suitable for distance learning were used in the OU. Courses utilise a range of teaching media – specially produced textbooks, TV and radio programmes, audio and videotapes, computer software and home experiment kits. In addition, personal contact and support comes through locally based tutors, a network of 305 regional study centres in the UK and a further 42 outside the UK, plus annual residential schools. More than 100 OU courses are now using IT to enhance learning in various ways: 'virtual' tutorials and discussion groups, electronic submission (and marking) of assignments, multimedia teaching materials and computer mediated conferencing. OU researchers are developing new applications of IT to learning: the 'virtual field trip' for level one Science students, and an Internet stadium capable of hosting mass events with up to 100,000 participants. In the past, the OU put a lot of effort in broadcast educational programmes through national TV Broadcast Companies. Jane Drabble (1999), Director of Education for the BBC, stated that "The OU's contribution to BBC Education has been an essential part of our service for nearly thirty years". Further effort led to expansion when, at the end of 1998, the OU signed a new agreement that will develop OU's digital and online services and take the partnership between the BBC and the OU into the new millennium. Ann Floyd (1999), Pro-Vice Chancellor of the Open University, stated that "this new agreement will allow the OU to provide the best possible service to distance learners."

The OU programme offers undergraduate and postgraduate degrees in the following subject areas[3]:

- Arts and Humanities;
- Business and Management;
- Computing and Information Technology;
- Development Studies;
- Education;
- Environment;
- Health and Social Welfare;
- Law [4];
- Mathematics and Statistics;
- Modern Languages [5];
- Psychology;
- Sciences;
- Social Sciences;
- Technology and Engineering.

The OU currently employs approximately 3,750 full-time staffs, of whom only about 900 are academics. The OU provides all kinds of support, especially technical support, for its staff and students. For example, the Academic Computing Service (ACS) was initiated to support university staff and students in their use of computer and communication technologies for the purpose of teaching and learning. One of the ACS roles is to design and produce educational software for OU courses. The produced material falls into several categories of educational software such as Computer-Assisted Learning, Simulations, and Computer Tools. Further explanation of such educational software is presented in the next sections.

[3] 1998 report found at http://www3.open.ac.uk/courses/frame/under.html; http://www3.open.ac.uk/courses/frame/post.html

[4] Undergraduate degree only

[5] Undergraduate degree only

2.2 Educational Applications of Computers

In the literature, the term courseware was used to differentiate educational or instructional computer programs from software or application programs. Courseware refers to a type of instructional material that constitutes applications programs administered by computer delivery systems (O'Neil, 1981; Criswell, 1989). More often common names found in the literature are Computer-Based Instruction (CBI), used in USA, and Computer-Assisted Learning (CAL), used in UK. Other names were also used such as:

- CAI - Computer-Assisted Instruction;
- CBE - Computer-Based Education;
- IAC - Instructional Application of Computers;
- CBT - Computer-Based Training;
- CMI - Computer-Mediated Instruction;

and a lot of other variations.

Recently, with the advancement of information technology (IT) and the World Wide Web, courseware could be delivered through the World Wide Web. In the literature, the term Web-Based Instruction (WBI) was used to describe such methods. In the following sections, CBI and WBI are discussed.

2.2.1 Computer-Based Instruction (CBI)

Computer-Based Instruction refers to any use of a computer to present instructional material, provide for active participation of the learner, and respond to learner action (Criswell, 1989). CBI, as a field, is based on a number of disciplines, but its primary origins lies in computer science and psychology. From computer science came the computers and the programs that allow them to work. From psychology came the knowledge of learning theory, instructional strategies, and motivation (Alessi & Trollip, 1991). The goal of CBI is to teach, whether the program is used as tool, tutor, or tutee (Taylor, 1991). CBI is considered as a tool when teachers and learners used it to aid learning and facilitate academic work. As tutor, the computer delivers instruction in CBI. Also as tutee, the learners instruct the computer and in doing so may learn as well.

Two types of software are involved in CBI, delivery and authoring system software. Delivery system software interfaces the learner with the computer, and authoring system software interfaces the course writer with the computer. To produce CBI materials instructional methods and techniques should be chosen based upon several criteria: learner characteristics, content, instructor style and knowledge, equipment availability, and cost.

2.2.1.1 Developing CBI

O'Neil (1981) explained that it has been necessary to develop and refine an Instructional System Development (ISD) process for CBI development to include the following steps:

- Analysis of the tasks that must be taught, and the existing courses;
- Design of the overall structure of lessons and objectives that will be taught, along with tests to assess mastery of the objectives. Skinner (1989) suggested that the design should consider four components in order to produce successful instruction:
    a) Clear instructional objectives;
    b) Teaching substeps as a way to attain mastery of larger units;
    c) Allowing learners to progress at their own rate;
    d) Carefully programmed, or sequenced, instruction.
- Development of the materials that will achieve the design objectives, including validation of the materials;
- Implementation into real-world settings;
- Control of implemented instruction system, to include field evaluation and subsequent revisions.

In addition to human factors issues, such as computer screens, Criswell (1989) explained that what makes CBI effective are the following:

- The use of clear instructional objectives;
- Careful overall and detailed sequencing;
- Frequent opportunities for learner practice;

- Careful screen lay out to ease the interaction between learner and computer;
- Holding attention and maintaining motivation.

In the literature, CBI was used in two distinct ways to support learning (Chambers & Sprecher, 1983):

- Adjunct CBI: represents the use of CBI to enrich, illustrate, or reinforce the learning of materials that are also covered in the regular classroom;
- Primary CBI: represents the use of CBI to replace regular classroom instruction.

More recent, Alessi and Trollip (1991) presented a model of 10 steps to develop computer-based material. Provided that lesson design should not exceed one hour, their model included the following steps:

1. Determining needs and goals: the goal of the developed material or lesson should specify what the students should know or be able to do after completing the lesson. Also, it is important to determine students' entry knowledge, characteristics and instructional needs.
2. Collecting resources: the developer should collect resources that provide information about the subject matter, instructional development, and the instructional delivery system. Useful resources include textbooks, reference books, original source material, manuals and other peoples' experience from using software.
3. Learning the subject of the material: the developer should learn and master the subject of the material.
4. Generating ideas: collect ideas regarding the development of the material through brainstorming sessions to generate creative ideas about instructional content and methodology.
5. Designing the instruction: this step is suggested to filter the ideas from previous step and to focus more on: task and concept analysis of the material, preliminary description of the material, and evaluation and revision of the design. The purpose of this step is to make a draft plan for a

lesson and present graphical or textual description of the content, methodology and sequence.

6. Flowcharting the material: the purpose of flowcharting the material is to lay out the complete plan of how the lesson progress. The flowchart should depict not only the lesson sequence from beginning to end, but all possible decisions throughout.
7. Storyboarding the displays on paper: storyboarding is the process of preparing textual and pictorial displays. Storyboard depicts the lesson content and presentation. The step includes drafting the actual instructional messages students will see, such as information presentations, questions, feedback, directions, prompts, pictures and animation.
8. Programming the material: this is the process of translating the result of the above steps into computer program.
9. Producing supporting materials: this involves producing supporting materials such as student manuals, instructor manuals and technical manuals.
10. Evaluating and revising the material: the material should be revised according to a quality review procedure that includes evaluating the quality of the material in terms of language and grammar, screen layout, subject matter, and other pedagogy issues.

Since the Alessi and Trollip model was available in the start of this study, it was used as a guide for the development of Web-based material presented in chapter 4.

2.2.1.2 Types of CBI

CBI was divided into five types (Alessi & Trollip, 1991):

- Tutorials: Tutorial programs are the simulation of traditional, i.e. human tutor. The computer is used in high-level dialogue where the learner can interact with the computer to get help and answer questions. Tutorials can be used at all educational levels. There are two types of tutorials: linear and branching tutorial. Linear tutorial presents the material in sequence for all learners. Branching tutorials permit interaction with only those parts of the tutorial that the learner has not mastered.

- Drills: Drill and practice is a common CBI form in which a type of repetitive approach emphasises rote memory. Drills engage learners in practising poor outcomes to reach fluency and retention. Drills are used at all educational levels.

- Simulations: Simulations provide a model in which the learner plays a role and interacts with the computer. Simulations have been used most often in higher education to model scientific processes. They are applicable to any field, however, and can be of significant help in illustrating concepts, in helping learners to develop problem-solving techniques, or allowing learners to explore complex interactions (Chambers & Sprecher, 1983). Training simulations in CBI are scenarios of real-life situations. Participants act in the situations by entering answers, directions, or decisions into the computer, and try to solve problems. Simulations are usually suited for advanced learners who have obtained mastery on a set of concepts and are now ready to apply the knowledge (Criswell, 1989). In an educational context, a simulation is a powerful technique that teaches about some aspect of the world by imitating or replicating it.

- Games: Instructional games are a type of training simulation (Chambers & Sprecher, 1983). Like simulation, they require the learner to act in problem situations. Games, however, usually involve fantastic or fanciful situations, whereas many training simulations involve real-life problem situations. An interesting game presents a challenge to the player, and the learner tries to make progress toward a goal by building points or beating previous scores. Computer colour graphics and animation also encourage interest. Games permit discovery learning and the actual results of a player's own actions teach and strengthen performance (Criswell, 1989).

- Tests: Computer-based tests are used in two major ways. First as an aid to construct the test, and second to administer the tests. Computerised tests could be used for a variety of purposes such as:

  a) To determine what a student knows and does not know;

b) To rank ordering students in terms of performance;

c) To assign grades and many other things;

d) To save time by frequent usage and frequent improvement.

Simulations typically have three major advantages over conventional tutorials, drills, and tests: enhance motivation; transfer learning better and they are considered more efficient (Alessi and Trollip, 1991).

CBI types can be modelled to represent traditional classroom teaching activities. Alessi and Trollip (1991) presented an expository model of effective instruction that includes these teaching activities in four phases:

1. Presenting information to the learners;
2. Guiding the learners' first interaction with the material;
3. Practising the material to enhance fluency and retention;
4. Assessing learners to determine if they have learned the material and what they should do next.

Tutorials, as Alessi and Trollip (1991) explain, are programs that generally engage in the first two phases of instruction. They take the role of the instructor by presenting information and guiding the learner in initial acquisition. Drills and games typically engage in the third phase, requiring learner to practice for fluency and retention. Tests almost always represent the last phase, assessing the level of learning. Simulation may be used to present information and guide the learner, to guide and drill, to do all three, or to test the learners' knowledge.

2.2.1.3 CBI Effectiveness

In the literature some authors discussed the effectiveness of CBI by presenting its advantages. For example, O'Neil (1981) summarised the advantages of CBI, shown in **Table 2.1**, in training and creating an educational environment in terms of cost reduction and improvement of effectiveness. Others discussed research studies that have been performed attempting to prove that using computers in teaching is better than using books, teachers, films, or other traditional methods (Chambers & Sprecher, 1983; Kulik & Kulik, 1986; Alessi & Trollip, 1991; Russell, 1999). The findings of such studies were either in favour with teaching through computers or that no significance difference was shown between the two methods.

Predominantly reducing cost	Predominantly increasing effectiveness
Reduce training time	Provide consistent high-quality instruction available on large scale
Reduce reliance on trained instructors	Provide high-quality training at remote sites
Reduce need for using expensive or possibly dangerous operational equipment	Provide hands-on, performance-oriented instruction
Provide rapid update of instructional material	Permit individualisation of instruction

Table 2.1: Advantages of CBI in the training environment (source O' Neil, 1981)

2.2.2 Web-Based Instruction (WBI)

The concept of having electronic documents interlinked and distributed all over the world was evoked by computer scientists as early as 1945 (Romiszowski, 1997). The idea was more publicly recognised in the late 80's when the Internet with its protocols and programs were used by non-profit enterprises such as public universities. Another step was taken towards improving the idea when, in 1991, the first version of the World Wide Web was put up on the Internet, by Tim Berners-Lee in Geneva's European Particle Physics Laboratory, after a decade of preliminary work (Crossman, 1997). A student team, at the National Centre for Supercomputer Application (NCSA) carried out further improvement. They released the first version of Mosaic browser, the graphical user interface to the World Wide Web.

The Web is a delivery technology that allows information to be distributed worldwide using generic language protocols that can be obtained by running programs that work on all computer platforms.

Educators, as users of the Web, realised that the characteristics of the Web are valuable tools for all learning modes: traditional and distance education. However, developing Web-based material into that of educational quality requires extensive effort and often needs a team of content experts, graphic artists, and WWW professionals (Willis & Dickinson, 1997).

Features of the Web gave the learning environment new ways of presenting and delivering information. Educators predicted that novel learning strategies that will be embedded in cognitive, social and cultural context will emerge in the future (Relan & Gillani, 1997). Currently, educators utilise the Web as a tool for assisting learning and providing new methods of delivering information for traditional and distance education. For example, instructors can use the Web to offer the learners a variety of hyper information resources (e.g. video, audio, lecture notes, expert reports, e-library) as well as new methods for learners social interaction and dialogue (e.g. voice and text chat tools, virtual whiteboards, debate forums, archive of transcript of users interaction).

The decrease in the cost and the increase of power of the computer technologies made the Web accessible to many educators all over the world. Accessing the WWW was a dream come true for many people, especially educators, who find the Web as tool that might be a solution for some problems in education as a whole. Some educators think that using such technology to deliver education might not be an option but a necessity to help students. For example, Jennings and Dirksen (1997) commented that "in many cases, being able to utilise the technologies available to us has become a necessity rather than a matter of choice... We must change the way we deliver education...Web-based instruction provides one alternative for helping students to be better prepared for the demands of today's society."

In the literature, the term Web-Based Instruction (WBI) is used broadly when the education, or instruction, is delivered mostly to remote learners through the WWW (Khan, 1997). But, more descriptive definitions of the WBI were found. For example Khan (1997) defines WBI as "a hypermedia-based instructional program which utilises the attribute and resources of the World Wide Web to create a meaningful learning environment where learning is fostered and supported." Relan and Gillani (1997) defined WBI with educational theory stating that WBI is "the application of a repertoire of cognitively oriented instructional strategies implemented within a constructivist and collaborative learning environment, utilising the attribute and the resources of the World Wide Web".

Currently, there are many WBI courses available for learners. Bannan and Milheim (1997) studied the existing courses at the time they wrote the article. They explained that existing courses range from classroom-based instruction, that may use the Web to post course information, through classroom-directed learning supplemented with specific Web-based activities, to courses delivered totally through Web-based resources as a full delivery mechanism for course interaction. They further commented that the design of these courses, based on learning theories, might be objectivist or constructivist. Objectivist and constructivist offer different viewpoints on how knowledge is represented, how meaning is created, and therefore how learning occurs. Objectivist design of WBI may involve posting of content organised by the instructor and delivered to the student. Constructivist design, however, may include multiple opportunities for the student to synthesise, organise, and restructure information.

Features of WBI, compared to traditional instruction, are summarised by Relan and Gillani (1997) as follows:

- WBI extents the boundaries of learning so that it can occur in the classroom, from home and in the workplace;
- WBI maybe employed to promote experiential learning, or learning on site, so that the process of learning is integrated with the real world;
- WBI offers co-operative learning that extends beyond one classroom to potentially every classroom that is connected to the Internet;
- WBI can offer more updated information than the textbook and the teacher;
- WBI offers more control of learning through the WWW hypertext characteristics;
- The WWW allows the instructors and learners to communicate privately or collectively in a synchronous or asynchronous manner that increasingly promotes the concept of distance education;
- WWW offers individualisation and student choice. Learners have the choice on content, time, resources, feedback and a variety of media for expressing their thoughts.

2.2.2.1 Developing WBI

The reputation of implementing WBI is growing and getting better as more technologies and ideas about learning assistance are emerging. Bonk and Reynolds (1997) explained that "While most WBI ideas about learning assistance appear to be speculative and untested, a myriad of innovative and exciting pedagogical strategies are emerging for WBI as we head into the next millennium".

In the literature, authors presented different views of designing WBI. As a design strategy, Ritchie and Hoffman (1997) suggested incorporating instructional design principles with WWW in order to use WWW pages as instruction. They explained seven common elements, shown in **Table 2.2**, of instructional design principles that could be applied on WWW.

Principles	WWW Methods
Motivating the Learner	- Carefully, use graphics, colours, animation, and sound as stimuli to motivate the learner. - Get learner attention through inquiry arousal, in which learners face a problem, contradictory information, or mystery to be solved. - Use links to related sites such as organisation, job positions that include related topics. - Increase learner's confidence in being able to complete their learning task by linking to examples of completed projects or providing easy practice activities.
Identifying the Objectives of the Instructions	- Provide Learners, early in the lesson, of what they will be responsible for knowing or doing at the end of the instruction. - Remind the learners with outcome and expectation while accessing the instructional material.
Reminding Learners of Past Knowledge	- Link the new information with some related information already stored in long-term memory. - Use links to remind learners with previously gained knowledge. - Understand the learners through collecting information about the expected learners such as their characteristics, differences, prior knowledge, attitude etc.
Requiring Active Involvement	- Require learners to compare, classify, induce, deduce, analyse errors, construct support, make abstraction, or analyse perspectives that they encounter in the course of their Web activities.
Providing Guidance and Feedback	- Use of relevant text descriptors for the links. - Provide feedback through the use of Common Gateway Interface (CGI) scripts that compare learners answer with a pre-set answer in a database or text file.
Testing	- Use CGI scripts to grade objective tests. - Use e-mail, especially, for open-ended tests.
Providing Enrichment and Remediation	- Use alternative methods of information presentation. - Provide additional practices and links and alternate tests. - Provide useful and related links to relevant topics.

Table 2.2: Instructional Design Principles of WBI (Source Ritchie & Hoffman, 1997)

Relan and Gillani (1997) explained that the instructional strategies could be designed to reveal the WWW potential as:

- Resource for the identification, evaluation, and integration of a variety of information;
- Medium of collaboration, conversation, discussions, exchange, and communication of ideas;
- International platform for expression and contribution of artistic and cognitive understandings and meaning;
- Medium for participating in simulated experiences and apprenticeships.

Some authors, such as Welsh (1997), recommended that any instructional design model for WBI should be:

- Systematic;
- Adaptable to different educational disciplines and to different pedagogical orientation;
- Technology independent;
- Useful in instructional context other than WBI.

Other authors, such as Jones and Farquhar (1997), presented guidelines for the interface design and HTML style of WBI. They suggested to:

- Employ structural cues such as advance organisers, maps, and overview. Also, the consistency placement and style of section titles can play important cue to the structure of information;
- Use standard colour of selectable areas indicating selection was made;
- Offer multiple versions of the material. As an alternative to the full option version, a version with less or smaller graphics may be more appreciated by learners with slow connection;
- Offer help link to update or upgrade the browser helper application;
- Keep Web pages short while offering an option that can combine several pages into a single document for printing;
- Use links to other pages not to other points in the same page;
- Place links at the end of text;
- Label links carefully;
- Place important information at the top of the page.

Some literature (Dillon & Zhu, 1997; Comber, 1995) discussed the Human-Computer Interface (HCI) issues in the design of WBI. Dillon and Zhu explained that although HCI measures in themselves do not guarantee learning will occur from using the system, they ensure that users of the system are capable of interacting with the application in an efficient, effective and satisfying manner.

Developing WBI may involve the use of authoring software. As a guideline to evaluate an authoring system for WBI course, Hansen and Frick (1997) suggested questioning the following about the software and the development team:

- The level of expertise of the developers with the software;
- The ease of learning the software;
- The availability of good documentation, on-line help and support for the software;
- The cost of the software;
- The ability of the software to create all aspects of the planned course;
- The ability of the software to convert components from other multimedia programs or incorporate existing materials from other programs into the new on-line course;
- The ability of the software to provide step-by-step creation methods, templates, clip art graphics, automatic generation of CGI scripts, and basic instruction for creating standard components.

Since the content of a WBI course is potentially infinite, where links to sites not created by the designer can be provided, it is considered an open system when compared to educational software which are considered closed systems (Jones & Farquhar, 1997). In the open system, such as WBI, the designer gives up a certain amount of control to the user which can make designing for it more difficult. Such a system may create a loss of control over the standard concerns of display and interactive design. Also, the user is not limited to any particular path. Therefore Jones and Farquhar suggested that there should be some consideration toward user preferences of perception and behaviour.

To verify user perception of WBI material, Nichlos (1997) explained that WBI material could be evaluated by conducting a one-to-one evaluation method, presented later in this chapter, using the Web tools, such as e-mail and conferencing applications, to communicate between the user and the evaluator.

2.2.2.2 Future of WBI

As telecommunications technology continues to evolve, WBI instruction can virtually replicate all the key learning activities that occur in traditional classroom-based and distance education environments. Although there are limitations in the degree that WBI can replicate traditional instruction, WBI can be considered as an enhancement over both the traditional classroom-based and the distance education environment. However, WBI is not a cure to the problems that effect traditional education, but maybe an alternative that is more or less useful depending on the educational context (Welsh, 1997).

The Web as a learning tool can be utilised in all learning modes. It can be used in the traditional classroom, as a resource of inquiry and information, flexible learning, and distance education. Virtual classrooms, and the two-way communication, shown in **Table 2.3**, are the new learning modes provided through the Web.

		Place	
		Same	**Different**
Time	**Asynchronous**	- Flexible Modes - Computer-Based Learning	- Virtual Classroom - Classic correspondence learning
	Synchronous	- Classroom-Based Instruction (Traditional Instruction)	- Distance Education with real-time one- and two-way communication

Table 2.3: New learning modes through the Web (Source Hedberg et al 1997, modified by the author)

The creation of a virtual community of learners collaborating in active learning will add to the distance learning environment the support needed to move it towards becoming an environment for learning (Hill, 1997; McLellan. & McLellan,, 1997).

As Web features continue to be enhanced, the future of the Web can be seen from two levels, micro, and macro. At the micro level the distinction between the Web and other educational delivery vehicles, such as CD-ROM, becomes blurred. Even the use of a variety of media, such as video, sound and animation, can now be integrated within the Web. Some authors, such as Hedberg et al (1997), believed that the ability to access unbounded or dynamic information is what primarily distinguishes Web-based instruction (WBI) from instruction using interactive multimedia materials on bounded delivery vehicles such as CD-ROMs. A more obvious advantage of the Web is the cost of CD-ROM production. CD-ROM production is generally higher due to labour and software requirements. Also, the Web product can be altered instantaneously and can be used remotely and universally from any location. As a disadvantage, Web users generally experience material of a lower quality but improvements are predicted for a higher quality material and better interaction in the next decade.

Harasim (1997) adds that the ability of the Web to reach remote learners makes it a viable option for all types of learners (children, parents, graduate students, etc.) across all grade levels. The Web environment can provide an active leaning environment that gives the learner the opportunity to engage and think.

At the macro level, the Web technology has a clear potential for creating a learning-centred environment, and bridging gaps between distance learning and traditional learning environments. As the educational use of Web-based technologies become widespread, the distinctions between distance education and classroom education may become less apparent.

Although the future of the Web appears very encouraging, the effectiveness of the educational material delivered through it needs evaluation. Formative evaluation, covered in the next section, was conducted whenever a new technology was used by evaluating the quality of material delivered via the new technology.

2.3 Formative Evaluation

Self-managed learning material, implemented by using various media, is becoming an important part of the educational environment at all levels, from infant school to university. In the literature, much has been written about the techniques and the phases of developing such material. An important phase or procedure in the development process, recognised to be critical in producing material of high quality and educational effectiveness, has been given less attention in the literature

(Nathenson & Henderson, 1980; Geis, 1987, Saroyan; 1992/1993). This phase sometimes described as formative evaluation conducted by expert and learners to review and try out the draft version of the material. An interesting analogy made by Geis (1987) that explains the importance and the purpose of this phase was with the job of models. Their job is to try new clothes and complain about their faults. The models are demonstrating one type of formative evaluation: the use of potential consumers to provide information about a product while still in-house where improvements can be made before distribution.

Scriven (1967) coined 'Formative Evaluation' to distinguish between the evaluation during the developmental stages of a product, such as CBI, and the evaluation after the completion of it. The latter is called 'Summative Evaluation' which is generally implemented after the development process is completed to measure the effectiveness of the product compared to other products and to find out whether the product met it goals.

In the literature, names such as tryout, developmental testing, pilot test, formative assessment, dry run, alpha/beta testing, quality control and learner verification and revision were used to describe the concept of formative evaluation (Tessmer, 1993). Presented in **Table 2.4**, is a summary of some terminology used in the literature, provided by Nathenson and Henderson (1980), and the type of learning material used with the term.

Term	Type of learning material	Goal	Data collected from	Data collected by
Developmental Testing	Programmed texts	To develop a workable programme	- Single students - Groups of 2 or 3 These students are not necessarily typical of target population	- Developer
Formative Evaluation	All (Programmed text, audio visual, CAI)	- Appropriateness of objectives - Effectiveness of the material of partial and/or complete drafts	- Experts of various kinds - Single students - Groups of students These students are not necessarily typical of target population	- Developer - Evaluator - Developer and evaluator together
Formative Research	Audio visual	- Appropriateness of objectives - Effectiveness of the material of partial and/or complete drafts - Attempt to formulate generalisable hypotheses	- Experts of various kinds - Single students - Groups of students These students are not necessarily typical of target population	- Evaluator
Learner Verification and Revision (LVR)	All	- Improve the material during the development and after production	- Single students - Groups of students. These students are usually typical of target population	- Developer - Evaluator - Developer and evaluator together.

Table 2.4: Summary of Terminology used in the literature (Source Nathenson and Henderson, 1980)

A newer term 'Constructive Evaluation' was suggested by Saroyan and Geis (1988) to include all the sources of data, such as learners, experts and users, that can contribute to the improvement of educational material at various stages of its development.

Tessmer (1993) explained the term formative evaluation as follows:

"Formative is used in a developmental sense, as children are in their 'formative' or developing years and are susceptible to growth and change. The evaluation target is instruction in its formative stages, instruction that is developing and not yet finished or 'grown up' and is thus amenable to revision."

"Evaluation is a data gathering process to determine the worth or value of the instruction, of its strengths and weaknesses. The identified strengths and weaknesses are used to revise the instruction to improve its effectiveness and appeal. Thus, 'formative evaluation' is a judgement of the strengths and weaknesses of instruction in its developing stages, for purposes of revising the instruction to improve its effectiveness and appeal".

There are many definitions found in the literature for formative evaluation. Some of these definitions are presented in **Table 2.5**.

Author	Definition
Dick & Carey (1996)	The collection of data and information during the development of instruction which can be used to improve the effectiveness of the instruction.
Tessmer (1993)	Formative evaluation is the process of testing or trying out instructions for the purposes of revising it.
Thiagarajan (1991)	Formative evaluation is the process of determining the worth of a package in order to improve its cost effectiveness.
Flagg (1990)	Evaluation means: The systematic collection of information for the purpose of informing decisions to design and improve the product. Formative means: the information collected during the formation of the product so revision might be cost-effective.
Geis (1987)	Explained formative evaluation as a way of obtaining feedback that can be used for the improvement of the product being developed.
(Weston, 1987; Grobman, 1971; Kline, 1984; Truett, 1984).	Formative evaluation, from many publisher and curriculum developers, means allowing reviewers, or experts, of various kinds to go over the premature material and suggest revision.

Table 2.5: Some formative evaluation definitions found in the literature

All of these studies, shown in **Table 2.5**, suggest that formative evaluation follow the early development of the instructional materials before they are ready for final production and distribution. This was not the case before the 60's, where formative evaluation was understood as the determination of the effectiveness of an innovation as compared with existing products. The evaluation was summative in its nature, where the material evaluated in its final form, and was not recognised as a part of the development cycle of the instructional material (Dick & Carey, 1996). The following figure, **Figure 2.1,** illustrates what Markle (1989) explained as the difference between formative and summative evaluation. Summative evaluation proves the material but formative evaluation improves it.

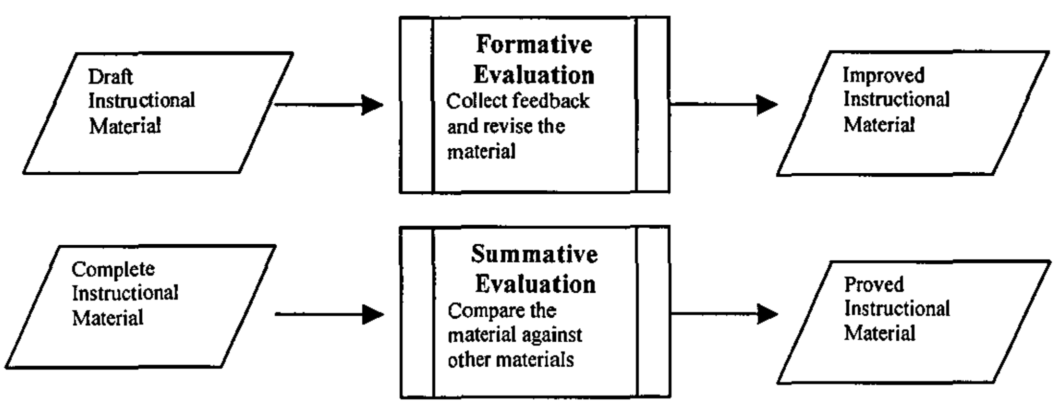

Figure 2.1: Formative evaluation versus summative evaluation

In general, as explained, the formative evaluation procedure involves using data from various sources to revise the instructional materials for the purpose of making them more effective before they appear in their final form. Typical modifications in this procedure may include:

- the deletion of unsuccessful portions,
- the addition of content for clarification,
- substitution of one thing for another,
- reorganisation of content (Saroyan and Geis, 1988; Bracewell, Bereiter & Scardemalia, 1979; Cowen, 1980, Sommers 1980; Nathenson and Henderson, 1980)

In the light of these modifications, studies have shown significant improvement in the instructional material. The importance of formative evaluation could be better understood when one considers the fact that 90% -95% of student's time, in elementary and junior high school, is spent with some form of instructional text (Saroyan, 1992/1993; Maxwell, 1985; Tulley, 1985). Only 1%-2% of all instructional materials conduct formative evaluation during their development (Saroyan and Geis, 1988). There are several strategies or types, existing in the literature, for collecting formative evaluation data.

2.3.1 Types of Formative Evaluation

There are two main approaches to formative evaluation in the literature that complement each other. One is called expert review, where experts review the material and provide comments and recommendations regarding several aspects of the material, and the other, called developmental testing, where naive learners are used to simulate the target learners to provide feedback and measure the effectiveness of the material (Geis, 1987). Under the developmental testing approach there are three types of evaluations that complement each other:

- One-to-one Evaluation: where representative learners work through the material individually and provide comments about the clarity of the material and other issues;

- Small-group Evaluation: where a small group of target learners, 8 to 20, work through the material, in order to assess their performance and to collect their comments;
- Field-test Evaluation: where the material is tested on a group of learners, 20 to 30, in a more realistic environment to assess their performance and attitude toward the material.

In ideal situations the two approaches, expert review and developmental testing, should be conducted. **Figure 2.2**, illustrates the stages of formative evaluation where the evaluator conducts expert's review and one-to-one evaluation first, then revises the material and then conducts small group evaluation. Finally, a field test stage is performed where the material is evaluated in the real environment. Expert review and one-to-one evaluations could be conducted in sequence or simultaneously and revision could be made according to both evaluations. These stages of evaluation are becoming known as the Classical or Traditional Formative Evaluation Methods (Tessmer, 1994). Each of these methods is explained next.

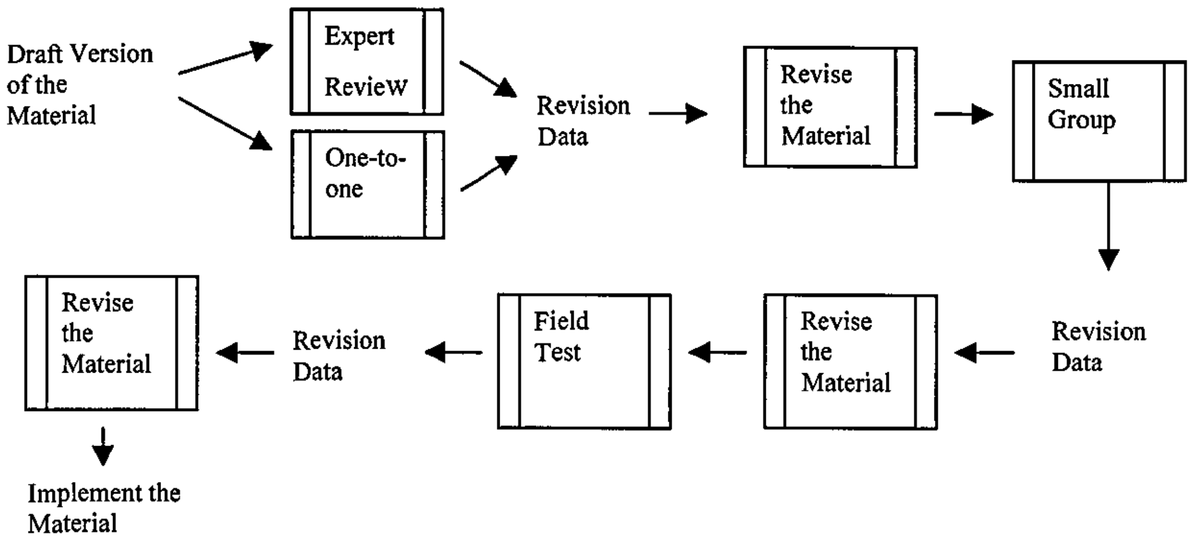

Figure 2.2: General sequence of formative evaluation types (Source Tessmer, 1994, modified by the author)

2.3.1.1 Expert Review

The purpose of this type of evaluation is to review the draft material, provide feedback and discover the material strengths and weaknesses in various aspects such as content and technical quality. Formative evaluators call upon experts to examine the developing material from their point view. Even if the evaluator or the designer of the material has good knowledge about the content area of the material being developed or they are working with a content specialist, it is recommended to have the material reviewed by another expert. The evaluator or the designer has seen so much of the material that they can appear blind to some aspects of the material. Markle (1983) made it clear that there is no substitute for certain kinds of expert review. The literature confirms the use of experts to review the material because it has been shown that experts improved the material (e.g. Davidove & Reiser, 1991). Different experts could be used in the review. Subject Matter Expert (SME) is one type of expert that is frequently used in the literature. SMEs are expected to comment more about the accuracy and currency of the content. **Table 2.6** presents a list of experts and their role in the review as discussed in the literature (Weston, 1987; Stolovitch, 1982, Thiagarajan, 1978; Geis, 1987, Flagg 1990).

Expert Type	Suggested Role
Subject Matter Expert (SME)	Content accuracy, material updates, comprehensiveness.
Pedagogical Expert (PE), Teacher and Instructors	Appropriateness of level of language, objectives and content for target population, suitability for use within a specific instructional setting, teaching strategies, ease of use, relation to the rest of the instructor's job, likelihood of adoption.
Instructional Design Expert (IDE)	Clarity of objectives, sequence and relationship of ideas within the content.
Presentation Expert	Technical quality, media, graphics.
Curriculum Expert (CE)	Compatibility of materials with program and other instructional materials in use.
Former students (Subject Sophisticates)	Content accuracy, insights about the new version.
Production Expert (Media Experts)	Media format, estimate the audio/visual quality of the final product, time and cost estimates.
Editors	Review all types of written or spoken material, improve the clarity and organisation of the instruction.

Table 2.6: A list of experts and their role in the review process as discussed in the literature

In most cases, information provided by experts is different from information provided by target learners. The expert's role and the amount of contributions they provide, in the evaluation, may vary depending on their area of expertise and the time at which they interact with the material. For example, the role of an SME may change from giving opinions about the selection of topics to be covered, in the design phase of the material, to commenting on content accuracy, comprehensiveness, semantic and syntactic ambiguities, in a more advance evaluation phase (Saroyan & Geis, 1988). The disadvantages of expert review are: the review can be costly and it does not provide performance data about the material since experts are non-learners.

- Expert Review Procedure

Two important issues, provided by Tessmer (1993), are required to prepare for expert review:

- The information needed to be learnt from the review. Possible types of information are summarised in **Table 2.7.**
- The type of expert which can provide the needed information.

Information Type	Information Example
Content Information	Completeness, accuracy, importance, currency.
Teaching Information	Appeal to learner, match to learner level, appropriate objectives, fit to curriculum, appeal to teachers.
Implementation Information	Ease of use, potential problems in use, user appeal, fit to learning environment.
Technical Information	Audio and visual quality, potential production problems, media appropriateness.
Design Information	Need for instruction, clarity of objectives, quality of instructional strategies, match of instruction to needs, tests.

Table 2.7: Possible types of information learnt from expert review

Although each expert can provide a limited type of information, a consideration has to be taken in using so many experts. Thiagarajan, (1978), warns that using too many experts might spoil the evaluation. Ideally, no more than three experts in content, design, and instruction and production need to be used to review the material. Practically, one or two experts in one or two of the most critical areas of the material, such as SME's with a teacher/trainer expert are chosen to review the material. Ideally, experts would indicate:

- Which part in the material appears to need modification?
- What are the causes of the problems?
- What might be done to solve the problems? (Geis, 1987)

The outcome of expert review should be recorded in organised manner to make the revision easier to implement. A data recording sheet and audiocassette could be used to collect and record the data from the review. After analysing the data and prioritising the changes recommended by the expert, revision should be made.

- Guidelines for Expert Review

Although the literature supports that revising the material according to expert review data provides a higher quality material, there has been little definition of, or research on, the process of reviewing (Geis, 1987). Some of the existing guidelines, Geis explains, are specifically directed toward matters of instructional design such as a guideline to remind the authors about the heuristics that guide the developments of the material. Checklists, for example, are self-review guides, which allow the authors to confirm each step in the design process. Another point made by Geis and that is there is even less research *to guide us in deciding whether to use experts, how to choose them, and how to guide their task or structure their output.* There are no agreed guidelines for carrying out developmental testing or expert review. Saroyan and Geis (1988) reviewed and consolidated 48 sets of recommendations and checklists, recognised by their authors as practical heuristics for the evaluation and revision of instructional material, in an attempt to make these guidelines more feasible, accepted and effective.

- Subject Matter Expert (SME) Communication Problem

Usually, expert review with SMEs is limited by the information provided about the course content based on SMEs' knowledge and experience (Faust, 1980; Indermill, 1986; Saroyan and Geis, 1988). But this knowledge has been considered as an advantage on one hand and a disadvantage on the other (Saroyan and Geis, 1988). SMEs sometimes are unable to communicate their expertise during an evaluation. The 'SME Mountain' is an explanation provided by Tessmer (1993) to explain this problem. He described the knowledge in the subject as a mountain and the expert is on the top of it. The expert started as a novice, at the bottom of the mountain, long time ago and then extended his knowledge to become a subject sophisticate[6] and, finally, become an expert at the top of the 'SME Mountain' (See **Figure 2.3**). The problem is that experts automate much of what has been learned so that they can act automatically and hence more efficiently. This might cause experts to face some difficulties in explaining how something is learned, because they might not remember how they solved the problems they encountered and the strategies they used in the learning process. The middle stage, which is subject sophisticates, may be better reviewers than experts to evaluate the quality of instruction or completeness of a procedure. However, if what is required is general content currency, completeness or accuracy, experts could be better reviewers.

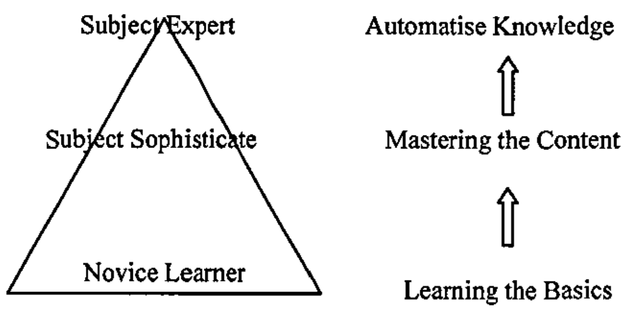

Figure 2.3: Subject Matter Expert's Mountain

2.3.1.2 One-to-one Evaluation

There are little doubts that the learner's contribution in the development process is valuable. Their role in verifying what the author or the developer assumed about the intended user of the material is the most important contribution in the development of the instructional material (Geis, 1987; Nichols, 1997). However, the learner's role complements the expert's role since they can not provide data regarding the accuracy of the content, the pedagogical implication, or the effectiveness of the presentation of the material (MacDonald-Ross, 1978).

[6] Subject Sophisticate: is a student who has successfully completed instruction or material similar to the developed material. In this study the term domain student is used instead of subject sophisticate.

As the name implies, one-to-one evaluation involves one learner, who works through the material, and one evaluator, who observes and probes the learner for feedback and comments. At the end of the evaluation the learner is asked to complete all the exercises and test items, which are used to measure learner performance. The purposes of the evaluation are:

- To assess instruction features such as clarity, ease of use, sequencing, and completeness;
- To assess the learning effects of the instruction measured by test performance, practice performance, time completion, and job performance.

It is recommended to conduct this type of evaluation early in the development process of the material, often after the first draft of the material. A one-to-one could be conducted before, after and concurrent with expert review since they complement each other.

Gagné et al (1992) summarised the information obtained from one-to-one evaluation:

- Errors in estimating students capabilities and entry level;
- Lack of clarity in the presentation of the material;
- Unclear test questions and direction;
- Inappropriate expectations of learning gains;

Different gathering methods can be used to collect information in this type of evaluation through (Tessmer, 1993):

- Probing the learner to comment about instruction clarity, completeness, and audio/visual quality;
- Conducting a debriefing at the end of the evaluation session to ask questions about specific strengths and weaknesses in the instruction and about the learner's overall reactions to the instruction;
- Observing of how easy the instruction is to use, if directions are comprehended, if learners can sustain attention and interest, and if the materials are being used in the intended manner.

Think-aloud protocol is another technique used to collect data and information from learners and experts in the one-to-one evaluation and expert review. Basically, the learner, or the expert, in this method describes their thoughts as they work through the material. The advantage of this method or protocol is that it can help identify problems that might be missed in regular one-to-one evaluations because this method helps to record the covert thinking processes. However, the disadvantage of this method is that it consumes significantly more time than the regular one-to-one evaluation.

- One-to-one Learners

Some studies, in the literature, conducted one-to-one evaluation with differing numbers of learners. For example, Lowe and et al (1983) have used one target learner that resulted in valuable information and data for revision. Also, Baker, (1970), used two learners in one-to-one evaluations that resulted in producing instructional materials that improved the learner's post-test performance over unrevised materials. But recent authors, Dick and Carey (1996), recommended 3 learners from target learners with different levels of abilities, one learner above average and one who is considered average and one considered below average. Wager (1983) studied this before by developing three revised versions of the material. One version was revised according to the evaluation of three ability levels of learners low, medium, and high. The second version was revised according to the evaluation of three high ability students. The third version was revised according to three low ability learners. Subsequently, he found that target learners scored significantly higher with the different level version than the other versions. However, Tessmer (1993) reported that designers or evaluators have confused learner's knowledge with learner's ability explaining that each should be judged differently. Furthermore, he presented more issues in selecting learners that evaluators may consider:

- Learner's knowledge: subjects or learners knowledge could be judged using post-test or instructor judgement;
- Learner's ability: learner ability could be measured by test scores or professional judgement that mark the learner as potentially quick or slow;
- Number of learners: number of learners could be specified according to the number of learners that have similar level of knowledge, abilities, or motivation in the target population;

- Learner's characteristics: learner's personal characteristics such as self-confidence and ability to express their criticisms could make the evaluation more fruitful.

2.3.1.3 Small Group Evaluation

This type of formative evaluation usually conducted after expert and one-to-one evaluations to evaluate the revised material and to produce further revision data. The small group method uses a group of learners to evaluate the material and collect revision data but focuses on learner performance instead of the intrinsic quality of the material. Also, in this type of evaluation, there is no interaction between learner and evaluator that characterises the previous types of evaluation. The evaluator may act as an observer to note how both the instructor and learner use the material, which is considered the evaluation data, and manage any serious problems that occur during the evaluation. The instructor, as a user of the material, administers the group of learners to evaluate the material in an environment similar to that in which it will be used in real class. However, the evaluation does not have to be in a real classroom situation and the evaluation can be carried out using the learners either all at once or individually.

In order to collect data about the instruction, learners may be given pre-tests, post-tests and questionnaires to measure learner's entry knowledge, performance, and attitude respectively. The evaluator, after the evaluation, may conduct a debriefing session to evaluate learners' reactions towards the material. One of the advantages of small group evaluation is the use of a greater number and variety of learners which gives the evaluator a more accurate measure of learners' performance and a greater degree of confidence about the materials strengths and weaknesses. Hence, the small group evaluation can improve the material effectiveness, efficiency and its implementation in an almost real environment. Small group evaluation further provides a better information about the ease of use and attractiveness of the material (Tessmer, 1993, Dick & Carey, 1996).

- Small Group Learners

Nathenson and Henderson (1980) reported that the majority of studies, in the literature, used groups of size 5 to 50 learners, but the most popular figure falls between 25 to 40 learners. However, Dick and Carey (1996) indicate a smaller range of group size from 8 to 25 learners. Tessmer (1993) explained that the number of learners selected is often resolved by a balance between representation of target learners, where each type of target learner is represented in the group, and practically, where the size of data collected can be managed. . The evaluator can be more confidant in the evaluation data if the group has a mix of learner characteristics that reflect the target learners. The favourite selection method for group selection is to find learners of low, average, and high ability (Weston, 1987; Dick & Carey, 1996).

The selected learners should have the required pre-requisites or entry skills but not have studied the developed material before.

The instructor selected for small group evaluation should be one that has content knowledge, teaching experience and represents the target instructor.

A variety of tools can be used in this type of evaluation to collect the data and information needed from the learners and the instructors. The following table,**Table 2.8**, summarises some of these tools.

Tool	Purpose
Entry skills tests	The tests can be used to find out whether learner background allows them to study the developed material.
Pre-tests	These tests will determine how much the learner already knew about the content of the developed material. Also, these tests can be used to measure learning accomplishments.
Post-tests	Such tests are usually designed to find out whether the learners learned the objectives of the material by comparing it with the results of the pre-test.
Attitude and acceptance surveys	Can be used to measure satisfaction and usability of the material from learner and instructor points of view. The survey can also be used to measure attitude change toward the evaluated material.

Table 2.8: Summary of data collection tools used in small group evaluation

2.3.1.4 Field Test Evaluation

In this type of formative evaluation, the material is tested and evaluated in the real environment where the material is intended to be used. The purposes of the field test, or sometimes it is called beta test, are:

- Verify the revisions made in the previous formative evaluations;
- Produce further revision suggestions;
- Study the effectiveness of the material.

The material in this phase of the evaluation should be the most completed version used in the evaluation. The role of the evaluator is to observe the learners and the instructor while they are working through the material and note how well they are using the material. The material should be used in all its components such as equipment, guides, and tests.

The main issues that the field-test evaluators are concerned with are the effectiveness of the material and whether there is any component that needs revision. The evaluators observe and record problems during the implementation of the material and the use of the material. In the literature, the field test phase is necessary especially if new technology was used in the instruction or the material (Honey, 1990; Tessmer & Harris, 1992; Tessmer, 1993).

The weak point of conducting field tests is that it occurs too late in the development process to permit for considerable revisions. Due to time constraints, major changes such as media format, objectives, or instructional strategies, may not be possible. Tessmer (1993) explained that in this stage of formative evaluation any revision of one area might have a domino effect upon other parts of the instruction, which means that they might need to be revised as well. Also, because these revision suggestions come in the last phase of formative evaluation, their efficacy is questionable since this phase is considered the final phase and no further evaluation would be conducted. But evaluators may conduct field tests to discover implementation problems and the ease of use of the material.

Field test data is same as small group evaluation, but in greater quantity and less detail. Tessmer (1993) lists what data collected from field test might be:

- Learning Time: measured more accurately than small group evaluation;

- Learner performance: measured via entry tests, pre-test, practice, and post tests;
- Learner interest and acceptance of the material;
- Learner and instructor behaviour.

Tools used in the field test are the same tools as used in the small group evaluation. However, post-test analysis in small group evaluation will focus more upon patterns of errors on individual test items, whereas the analysis in the field test focuses upon group performances on individual objectives.

2.3.2 Alternative Evaluation Methods

As an alternative to the discussed evaluation methods, which are called the Traditional Formative Evaluation Methods, Tessmer (1994) presented 8 other methods. He reasoned that the birth of the alternative methods to a) the evaluation circumstances such as time, resource pressure, and geographic location forced the use of alternative methods and b) the creation of new tools for gathering evaluation information through the use of computers and electronic communication such as networks. The definitions and the advantages and the disadvantages of these methods are presented in **Table 2.9.**

Method	Definition	Advantages	Disadvantages
Two-on-One (Dyadic)	Two learners, each have a copy of the material, review the material with the evaluator.	-learner dialogue -learner agreement -possible time saving	-no pace/time data -no individual opinion -dialog distracting
Think –Aloud Protocol	Learners describe their thoughts, such as their reactions, plans, ideas and confusion, to the evaluator as they work through and learn the materials.	-data on mental errors -data on learning process	-learning intrusiveness -uncomfortable to use
Computer Interviewing	In traditional formative evaluation, interviews were conducted in face-to-face encounters or via phone. In Computer Interviewing the interviewer sends questions via electronics mail to experts or learners. Programs, such as Computer Assisted Data Collection (CADAC), can be used to automatically send questions, register replies, code them, store them and issue reports.	-remote subjects can be accessed -continuous evaluation	-time consuming analysis -need training and equipment
Self Evaluation	The developer(s) of the material act as expert and learner to evaluate the material	-easy to conduct -insider's view point	-not rigorously conducted -hidden problems
Panel Review	Directed and structured group interview where designers bring two or more experts together to review the material.	-expert dialogue -negotiated agreements	-may leave off task -less independence
Evaluation Meetings	A group of learners discuss the material before it is completed, often without the evaluator or the instructor. At the end of the meeting, representative of the group meets with the evaluator to discuss problems and possible changes in the material. After revising the material, these same learners are used again to try the material and determine the effectiveness of the revision.	-amount of group information -quick tryout and revision	-only easy changes made
Computer Journals	Computer network software, which allows students, who used the software, to write their reactions to the software being used. The instructor accesses the group's journal for evaluation data.	-continuous evaluation -cost/time effective	-need equipment and software -user literacy level -no evaluator present
Rapid Prototyping	A working portion of the final product is developed and immediately implemented with a group of learners or reviewed by experts.	-assess new strategies -assess new technologies	-time and cost to develop -undisciplined design

Table 2.9: Definitions, advantages and disadvantages of the alternative evaluation methods (Source Tessmer, 1994, modified by the author)

2.4 Conclusion

The open and distance learning environment was an alternative to the traditional learning environment that served many people. The environment evolved over generations of technologies from slow medium, with no face-to-face communication, to a faster medium that will, in the near future, imitate traditional classroom teaching. Different combinations of technologies were used. In general, it could be divided into four categories: telephone, computers, audiographic and video technology. Currently, the computer is the amalgam of these technologies that can be integrated with the Web environment. Many educators in traditional and non-traditional educational organisations appreciated the resultant environment but distance learning organisations are expected to utilise it more efficiently. For example, the UK Open University is attempting to integrate most of the available technologies in preparation for the next millennium.

In the last decade, computer technology was used to deliver learning in the form of computer programs called Courseware, or Computer-Based Instruction (CBI) utilising the power of multimedia. The literature provided some guidelines in developing such programs as an accessory to or as a replacement for the traditional classroom. CBI was used as tutorial, drill and practice, simulation and game to deliver learning, and as an aid to construct and administer tests. The learning effectiveness of these programs, as many studies concluded, was in no difference than traditional classroom. However, CBI programs are closed in terms of the content and the information provided is static.

More attention was given to computers in providing learning when the Web facilities became accessible. The Web can offer the learners a variety of information resources as well as new methods for learners' social interaction and dialogue. This fact made some educators believe that using such technology to deliver education might not be an option, any more, but a necessity. The attention of many of these educators now is to develop a Web-Based material that benefits from the environment's unique features. Recent literature provided strategies to develop Web-Based Instruction (WBI) from different angles. However, an evaluation of such material might be needed to improve its quality. Previously, when a new technology was used to deliver educational material, formative evaluation was conducted to test and improve the quality of that material. The purpose of such evaluation was to test the material whilst under development.

There are two main approaches, depending on the source of feedback, to formative evaluation. The first is to use experts, hence called expert review, to evaluate the developed material and revise it accordingly. For example, using Subject Matter Experts (SME) to review the material. The second is to use learners and learners' data, such as their performance in the test, in finding the material weaknesses and then make revisions accordingly. Learners' data could be collected through, mainly, three methods: one-to-one, small group and field-test evaluation.

However, it is recommended that formative evaluators call upon experts, such as SMEs, to examine the developing material from their point of view and record the required revisions in an organised manner. The problem of using SMEs is that they might not approach the material as learners. Thus, subject sophisticates (domain student) or discipline reviewers, who have less knowledge in the subject but who are at the same time experts or lecturers in other areas in the discipline, might also improve the quality of the material as well. The result of such an investigation might add to or confirm the findings of many empirical studies that had shown that formative evaluation methods improved the developed material. In the next chapter, more information is presented about the empirical research of expert review and learner evaluation in improving the developed material.

Chapter Three

Literature Review

3.0 Introduction

The previous chapter presented a review of formative evaluation definitions and methods. In this chapter, the empirical studies that have been done on formative evaluation methods are explained.

The concept of formative evaluation is not new, especially for teachers who implicitly implemented formative evaluation in their classes. They have always used their experience with students to improve the quality of the instruction they delivered. As a research topic, formative evaluation studies have been conducted since 1920. For example Baghdadi (1980) reported that in 1927 a massive field test was conducted that involved thousands of students in more than 300 schools. The collected data was then used to revise the instructional material.

Formative evaluation is usually presented as a step in many instructional design models (Gustafson, 1991). Most of these models involve linear development steps where the Formative Evaluation step usually is presented at the end of these instructional design models. McAlpine (1992) argues that, when brought to practice, these models suffer from ill-fitting and there is a mismatch between concepts and reality since the instructional design process rarely matches the linear progression of steps as these models describe. As an alternative, McAlpine presented formative evaluation as a continuous, iterative process that occurs throughout the design.

Formative evaluation usually involves collecting feedback data from experts, learners, or a combination of both, in order to use it to revise the instructional materials (Dick & Carey, 1996). Research in instructional design indicates that formative evaluation improves learning (Weston et al 1997; Byrum, 1992; Davidove & Reiser, 1991; Dupont & Stolovitch, 1983, Kandaswamy et al, 1976). In spite of the importance of formative evaluation to the developers, in discovering the strength and weakness of the developed material, some studies gave an explanation of why formative evaluation has not been widely used. For example, Byrum (1992) listed some possible reasons for not performing formative evaluation on Computer Assisted Instruction (CAI).

First, the cost of the process in time and money, from data collection to revision. Second, the need for staff training and, third, the problem of choosing the appropriate method needed in the process.

Over the last 30 years, text-based instruction has been the educational material type that has been most formatively evaluated. Other types of instructional material such as film, video, multimedia, and Computer-Based Instruction (CBI) have also been evaluated. As a matter of fact, the research literature supported the use of formative evaluation whenever a new technology is intended to be used to deliver education. For example, it was used to evaluate film production (e.g., Fleming, 1980, VanderMeer & Montgomery, 1980), text-based material (e.g. Baker & Alkin, 1973), text-based and audio-visual material (e.g. Crooks & Lamy, 1995), interactive television (e.g., Flagg, 1990; Price & Repman, 1995), and Computer-Assisted Instruction (Byrum, 1992; Mark & Greer, 1993; Webster, 1995). In other words, formative evaluation could be used to evaluate any form of instructional material with any size of instruction such as a unit, lesson, course, or curriculum. In practice, evaluators, due to the cost, select and thoroughly evaluate smaller segments that may allow them to generalise their finding and revisions to unevaluated segments.

3.1 Formative Evaluation Models

Instructional designers consider formative evaluation as an essential part of the design of instructional material in order to highlight the difficulties and problems that may exist in the material. This can be seen in many design models that include formative evaluation as an integral step in the design (Dick & Carey, 1996; Gagné et al, 1992; Alessi & Trollip, 1991). Byrum (1992) reported that out of 40 instructional design models, analysed by Andrews and Goodson (1980), 38 models included formative evaluation procedures. In most of these models of instructional design, formative evaluation follows the early development of the instructional material (Geis, 1987).

Different models of formative evaluation were presented in the literature. These models could be categorised into three main models. The first presented formative evaluation as a process that continues beyond the design and the development of the instruction to provide target user verification and revision as long as the instruction is used (Komoski & Woodward, 1985). The second presented formative evaluation as a step that comes after other steps to try out the instruction in its draft stage (Dick &

Carey, 1990). The third presented formative evaluation as an iterative process that occurs throughout the design of instruction (McAlpine, 1992; Northrup, 1995).
Weston et al (1995) studied formative evaluation literature and presented a model, shown in **Figure 3.1** that provides, as they explained, a common language and framework for understanding formative evaluation. The model was a result of reviewing 11 textbooks covering the area of formative evaluation published over the last 20 years.

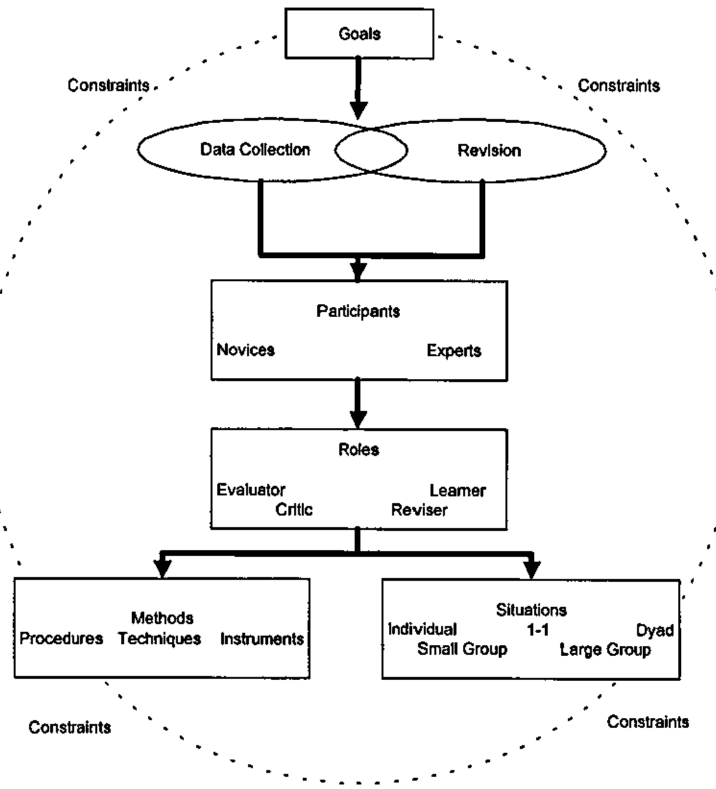

Figure 3.1: Formative evaluation model (Source Weston et al, 1995)

In this model, formative evaluation was identified by four components: who participates in the evaluation, what rôles do the participants take, what methods can be used, and in what situations these can occur. At the outset, the model clarifies the goals of the evaluation. These goals could investigate the material in terms of the following:

- Effectiveness: measured by the verification of whether the intended achievement was reached, or whether the content was accurate, comprehensive and up to date.

- Efficiency: measured by the verification of whether the instruction worked the way it was intended to work, whether learning occurred within the timeframe, or whether the material was user friendly.
- Appeal: measured by the verification of whether the instruction keeps the learners attention and whether learners find it attractive, likeable, interesting or acceptable.

Formative evaluations were represented as a process that occurs within the goals and constraints of a particular instructional project. Goals and constraints limit the choices that can be made about how to conduct the formative evaluation. Weston et al (1995) described the model as a generic model that can be used to guide decisions regardless of the particular context.

3.2 Effect on Learning Outcomes

In the literature, different media were used in the developed material where the effect of formative evaluation on learning outcome is questioned. The approach used, in most of these studies, was to measure the effect of formative evaluation on improving learning outcome by comparing the post-test result of the revised version(s) against the unrevised version(s) of the material. Gropper and Lumsdaine, (1980), conducted formative evaluation on instructional television material and found that the learner did better with the revised version. Others, Rosen (1980), Baker (1970), implemented formative evaluation on programmed instructional material and all their results favour the revised version(s). More recent studies, explained later, that compared different methods of formative evaluation or compared different experts had used post-tests to measure the learning outcome. All of these studies supported the revised versions of the material over the unrevised one.

3.3 Expert Review - SMEs versus IDs

Saroyan (92/93) conducted an exploratory study that compared ID's data against SME's to examine whether IDs and SMEs complement or duplicate each other's activities. A think-aloud technique, where the subjects verbalise their thoughts, was used to collect data. As a result of the study, Saroyan explained that the Instructional

Designers (ID) group have a larger repertoire of revision strategies at their disposal than Subject Matters Experts (SME), and, the Instructional Designers, seemed to perceive the material as means to learning that invokes effective strategies for revision. The ID group acted as learners and used the learning outcomes as an evaluation criterion while SMEs acted strictly as expert reviewers.

The finding of the above study may lead to the belief that using less knowledgeable persons than SMEs, in the subject of the reviewed material, could produce effective strategies for the revision process and that may result in a higher quality of revised material. In this study, reviewers with less knowledge in the subject of the developed material are introduced and investigated. These reviewers are experts in other areas of the discipline of the developed material.

3.4 Teachers as Experts

Some studies investigated the usefulness of incorporating teachers in the development process of instructional material and the influence of their existence in the development on making the material more acceptable to other teachers. For example, Char and Hawkins (1987) worked on a project to produce an integrated multimedia set of material for children in the upper-elementary school. The primary goal of the project was to present a new form of learning about science and mathematics using television and interactive technologies, such as computer simulation games and other software. In the project they incorporated teachers as curriculum advisors, reviewers, field testers, and code developers. They concluded that teachers are essential as consultants and contributors to the development process. Also, they strongly recommended that teachers and students should be involved early in the research and development process. Another study conducted by Davidove and Reiser (1991) compared instructional material revised by teachers against instructional material revised by instructional designers. They kept a copy of the original, unrevised material, in order to study the effectiveness of the revision process. Also in this study, they wanted to measure the acceptability and attitude of other teachers to all three versions. The teachers used as subjects were distributed over three groups. Each group was asked to go through one version of the material and complete a questionnaire, designed to measure their acceptance of the material as they found it. The results of their study were a) after conducting three students' sessions to study the effectiveness of the materials, both modified versions of the material, the teacher-revised and the instructional designer-revised material, were more effective than the original material, and b) contrary to their expectations, teacher-revised material was not more acceptable to other teachers than instructional designer-revised material. They explained that teachers did not have the opportunity to compare the three versions. If they had been given that opportunity, perhaps the differences among the three versions would have led the teachers to view one version more favourably than others. In future research studies, they recommended that such comparisons should be allowed.

In the above study, teachers were seen as the users of the developed material, hence their willingness to use the material was seen as an important issue to be measured. However, student's satisfaction and acceptance was not measured. Students could be considered as the users of the material especially if the material was developed to be self-managed and suitable for distance learning. A research methodology that considers student's satisfaction and allows comparisons might add to the evaluation process.

3.5 Experts and Learners in Formative Evaluation

Some studies in the literature, have used experts only, such as SME or ID, to investigate and compare the effectiveness of each expert on the learning outcome. Other studies have used learners only to investigate and compare formative evaluation methods such as one-to-one and small group. As a result, some authors suggest involving a combination of experts and learners in the evaluation to balance the picture since experts and learners are thought to integrate each other. Weston (1987) reported that experts, on one hand, should be used to identify problems within their area of professional competence. Learners, on the other hand, should be relied upon to provide feedback about their reactions to the material and whether the objectives of the material were met. In the study, Weston (1987) used mixed media such as filmstrip, audiotape, and a text manual. The experts were two SMEs, two IDs, and eight graduate students with backgrounds in the subject of the material and instructional design. The target learners were 168 high school students. The results of the study showed that SME's were the only group who criticised the content accuracy and currency. A common area of criticism between graduate students and the SME group was the comprehensiveness of the presentation. ID's and graduate students criticised the lack of clarity of the objectives and the organisation of the material. Learners and the ID group criticised the narration and the visual presentation of the material.

Although the study showed that there were common criticisms between SMEs and graduate students on one hand and between IDs and the graduate students on the other, the study did not investigate whether graduate students are as effective as SMEs or IDs in producing an enhanced learning outcome, which might be a cost effective strategy in some cases.

3.6 Comparing Formative Evaluation Methods

Many studies have been conducted to find the most appropriate and cost effective method of formative evaluation. For example, Abedor (1972) described the one-to-one evaluation method as a time consuming procedure and subject to the idiosyncratic responses of individual learners and tutors. However, Lowe et al (1983) found the method to be both cost effective and efficient, furthermore providing the developers with critical information about the material for revision.

To find the appropriate method of formative evaluation, studies in the area of Learner Verification and Revision (LVR) have focused on the comparative effectiveness of revising the material based on different methods of gathering feedback from students. For example, Kandaswamy (1976), Banazak (1974), Baghdadi (1980) and Wager (1983) compared one-to-one against small group methods. The findings of these studies were similar in that both methods produced materials that were more effective in improving learning outcomes than the unrevised material and neither was superior over the other. Wager (1983) concluded that employing both the one-to-one and small group stages of formative evaluation might not be necessary for the effective revision of instruction. In other words, they found that revisions based on one-to-one were as effective as small group methods and hence more cost effective.

These studies were conducted to evaluate text-based material. Similar studies were conducted to evaluate material based on different media. For example, Byrum (1992) conducted a study to examine the differential impact of these two methods on Computer-Assisted Instruction (CAI) material. The result of the study showed significant improvements in post-tests over the original version of the program, while the two methods showed little difference and confirms the findings of earlier studies conducted with other media.

3.7 Revisers Usage of Expert's and Learner's Data

The above studies have compared two methods of formative evaluation on the basis of student's performance in both versions that have been revised according to the data collected in each method. Some studies, however, questioned whether the revised material is effected by revisers interpretations of learners' data and their ability to resolve aspects of the material that are considered problems. Baker (1970), for example, presented evidence that shows individual differences among revisers who made revisions to the instructional material using the same input of data. However, Baghdadi (1980) found that individual differences among revisers did not produce differences in the effectiveness of revision using one-to-one or small group methods. Kandaswamy (1976) summarised some factors that might influence the work of the revisers. These factors are:

- The type of data collected;
- The method of collection and revision;
- The training level of the evaluator.

In an attempt to study the priorities that revisers established among data sources, such as learners' and experts' data, Le Maistre and Weston (1996) found that revisers significantly used their own knowledge more than learners' or experts' data. Further research conducted by Weston et al (1997), attempted to study the influence of formative evaluation participants on learning outcomes. They collected and analysed the feedback from all formative evaluation participants: Subject-Matter Experts (SMEs), learners, and revisers by distributing the draft material, text-based instructions, to a group of learners and to six Subject Experts (SMEs). The learners were asked to answer a pre-test, give verbal feedback while reviewing the material and answer a post-test. The SMEs were asked to think aloud while reviewing the content of the material and give feedback about problems they expect the learners will face when studying the material. In order to study the usage of learners' and experts' data in the revision process and their effects on learning outcome, they recruited four revisers. Each one was given different input as a guide to revise the material. The first received the data from both experts and learners, whilst the second received just the learners' data and the third was given the experts'. The fourth did not receive any input. They found that 74% of the revisions were based on revisers own knowledge and that the revisers used learners' data more than experts'. The other part of the study was to measure the effect of the revisers' revisions on learning outcomes. The authors used six groups of students to study the materials, the original and the four revised versions of the material, leaving the sixth group with just the post-test. They concluded that:

a) The version with the combination of feedback from learners and SMEs had the most impact on improving learning;
b) The version with learners' data influenced learning outcome more than the version with SMEs' data;
c) All the revised versions influence learning outcome more than the unrevised.

Although the revision data and process, in the above study, were effective in enhancing the learning outcome, large parts of the revisions were enhanced by the revisers own data. A method that provides better guidance might be needed. Typical revision data may include deletion, addition, substitution and reorganisation of content (Saroyan & Geis, 1988; Bracewell et al, 1979; Cowen, 1980, Somers 1980; Nathenson & Henderson, 1980). A method that translates the collected feedback into transactions of three simple types add, delete, and modify could provide better guidance in the revision process.

3.8 The Effect of Different Participants' Rôle

Some studies have extended the research work to investigate the effect of the participants' rôle in the evaluation. Geis (1987) explained that the rôle of the prime participants, learners and evaluator could be:

- Active: where the learners are asked to go through the material to indicate the difficulties and problems while the evaluator engages the subject to probe for problems and confusions;
- Passive: where the learner is treated as a traditional student to go through the material and write comments while the evaluator is seen as an observer.

Since the purpose of formative evaluation is to improve the material, Medley-Mark and Weston (1988) argued that comparative studies of formative evaluation methods presented important findings but gave little insight into the rôle of participants, active or passive, and the effect of that on the collected data and, subsequently, the revision process. They further explained that the differences in the data obtained from comparing methods of formative evaluation are least likely to be reflected in the components of the data collection process (e.g., pre-test, post test, or questionnaire). Their study was designed to compare the quantitative and the qualitative nature of the data collected from different formative evaluation methods. They explained that data collected from these procedures should be compared prior to transforming it into revisions. In this study, learners with different abilities and with different rôles, passive or active - enforced by the evaluator, were used. They compared three groups of learners with different rôles and abilities using two methods of formative evaluation. One group conducted a one-to-one method and two groups conducted small group methods. In the one-to one group, they used a think aloud technique for a high achievement learner with an active rôle and an evaluator with passive rôle. In one small group they used two medium achievement learners with an active rôle and an evaluator with semi-active rôle. The other group consisted of three learners with different achievement levels, low, medium and high with a passive rôle and an evaluator with a passive rôle also. They found that one-to-one with the applied technique identified the highest frequency of problems overall, the most detailed type of problem, and the most unique problems. The first small group identified the second highest frequency problems overall and the most redundant problems. The second small group identified the fewest problems overall, the least unique problems and the least problems at detailed level.

The purpose of the above study was to find the appropriate evaluation method concentrating on learner's methods such as one-to-one and small group. Less attention was given to expert review in finding the appropriate review methods.

3.9 Conclusion

Most of the studies presented in this chapter have concentrated on learners' feedback to improve data. Learners have been used in different methods, rôles and numbers. In the latter studies, less attention was given to expert review although some concluded that such a process improved the quality of material.

It was mentioned in this chapter that the methodology used in most of these studies did not allow subjects to compare the revised version against the unrevised one where subjects were divided into groups providing feedback. Subjects, such as students, could be considered users of materials that were developed to be self-learning or distance learning. Measuring students' satisfaction might be a critical issue in the implementation of such materials. Allowing subjects to compare the revised version against, at least, the unrevised one was a recommendation made by some authors (Davidove and Reiser, 1991).

Furthermore, some studies introduced graduate students as a reviewers in expert review sessions (Weston, 1987). The study described and compared the data collected from the new reviewers and SMEs. The data collected was not used to actually revise the material and investigate whether these reviewers were effective in improving the quality of the material compared to SME reviewers.

Other research work presented in this chapter, studied revision data, collected either from experts or learners, and its use by the revisers of the material (Weston et al, 1997). It has been shown that a large part of the revisions were enhanced by the revisers' own knowledge. Translating data into transactions of three simple types (add, delete, and modify) might guide revisers to use and apply the collected data more accurately.

The next chapter explains the methodology of this research used to address these issues through constructing hypotheses, tools and experiments. Furthermore this study introduces a new type of reviewer, a discipline reviewer. Also, presented in later chapters are issues concerning the development of Web-based material and the media used in the material.

Chapter Four

Research Methodology

4.0 Introduction

The purpose of this chapter is to explain the methods and tools used to collect and analyse data in the research. In order to give a complete picture about the research methodology, the chapter starts with a presentation of the aims and objectives of the study and sets out the hypothesis to be investigated. The experiment used in the investigation process is explained in the Research Experiment section. The research investigates not only the main hypotheses, but also the other issues regarding the development of the material. Several data collection tools, used in the research, are detailed in a section on Research Tools. The data analysis and the tests used to validate the hypotheses are explained in Research Analysis Tools.

As explained in previous chapters, formative evaluation has been conducted to test and improve the quality of the material for several technologies that deliver educational material. Experts and learners are the participants to carry out the evaluation process providing suggestions and feedback about the material. The data collected in the evaluation process is used to revise the material resulting in higher quality material. Currently, the development of Web-based multimedia material, as a new mechanism to deliver education, is the focus of many educators. An evaluation of such material might, also, be needed to assess the quality of the developed material.

At Loughborough University, for example, a Distance Learning Initiative (DLI) started in 1996 to develop Web-based multimedia material. The primary aim of the project was to gain experience in creating, delivering and managing educational material in both flexible and, where applicable, distance learning modes using information technology. The results of this endeavour sought to inform the University's strategic policy makers as to the appropriateness and best methods of Flexible/Distance Learning (DL) and the potential role of technology in this domain.

As the process of transferring traditional lectures to multimedia DL format requires much time and training on behalf of the lecturers (to absorb any new technology and methods, e.g. Hypermedia), a team of technical authors was assigned to work with the lecturers. The technical authors came from different educational and professional backgrounds. Their main task was to convert the lectures from the traditional, textual/verbal form to a more open and dynamic format suitable for self-managed, distance learning. Technical authors may not appreciably understand the material they are dealing with but, on the other hand, bring to the lecturers accumulated knowledge and skills associated with multimedia technology and Distance Learning. Therefore, the authoring of Web-based multimedia lectures required a full co-ordination between all parties involved in this mission such as lecturers, technical authors, reviewers and students.

It is the tenet of this thesis that this combined effort does require more attention to be paid to the review process than the lecturer would traditionally have paid to their own lecture notes. As the target students of the material are intended to be distant, where the level of the knowledge of the students can not be judged at first hand, it is imperative that the preparation of the material be as thorough as possible. To this end, a formative evaluation of the material produced by the lecturer-author combination is needed to review the quality of the material prior to release. Whilst it is generally agreed in the literature that reviewing the material is an important phase in the development of instructional material, Saroyan (1992/1993) explained that it is not evident how it can best be carried out to produce optimum results.

McAteer and Shaw (1994) suggested that "the best methodology for a quality review of your own courseware before piloting would obviously depend upon the type of package you are producing and the use to which it may be put." As a basic rule of thumb, to review the material, they suggested two evaluative runs through the entire package. First the producer of the material could envisage himself as a learner to examine and go through the material, second the material could be reviewed by the most "reliable colleague" who would report all errors, mismatches or glitches.

4.1 Aims and Objectives of the Study

This study aims to establish the most desirable, yet efficient, methods for such preparation and review prior to first delivery. Expert review, as a formative evaluation method, was seen as an important method to evaluate the material prior to release. In such a review, Subject-Matter Experts (SMEs) were the most common experts used. Geis (1987) states that despite the importance of reviewers, there has been little research on the reviewing process. Although the literature strongly suggests that expert review improves the material, he continues, there is relatively little research evidence to support such belief. He further comments that there is even less to guide us in determining whether to use experts, how to choose them, how to guide their task or structure their output. In the literature, an expert review has been conducted to review the quality of the material and revise it according to expert's suggestions. Saroyan (1992, 1993) noted that research on the role of experts has been limited. The studies that have been conducted in this area used Subject-Matter Experts (SMEs) and Instructional Designer Experts (IDEs).

This research aims to fill some of the gaps found in some studies in the literature in an attempt to add to or confirm the finding of these studies. In summary the investigations of this study are based on the following:

- Tessmer (1993) explained that formative evaluation was used to improve all types of instruction: Computer-Based Instruction (CBI), text, simulations and games, and multimedia using different evaluation methods such as expert review, one-to-one evaluation, small group, and field test. This study investigates whether an expert review improves a Web-based multimedia material.
- Weston (1987) described the data collected from domain students as reviewers of the material without revising it and investigating the effectiveness of these reviewers. This study investigates the effectiveness of using domain students (graduate students) fully in the review process of a Web-Based multimedia material.
- Davidove & Reiser (1991) reported that subjects were not allowed to evaluate and compare more than one version of the material and recommended those comparisons in future research. Furthermore, Tessmer (1993) reported that historically, most formative evaluation studies ignored measures of student attitude or acceptance and focused on students' performance gains. More attention was given in this study to student's satisfaction since they were considered as the users of the developed material. An experiment that has been designed so that the quality of the material is measured by student's satisfaction in addition to student's learning.

- Le Maistre and Weston (1996) and Weston et al (1997) studied revisers use of data collected from learners and experts and concluded that revisers tend to revise the material using their own judgement more than the collected data. In this research a method that translates the collected feedback into transactions of three simple types (add, delete, and modify) has been used.

This study attempts to fill these gaps in the literature and uses the recommendations provided by some of the above studies. Also, this study describes a review experiment to assess how the level of subject expertise, amongst differing categories of reviewers, impinges upon the effectiveness of the developed material. Four reviewers were used in the study:

- Domain Knowledge Lecturer (or SME): a lecturer who is in the domain of the developed material (a lecturer and a subject expert - SME).
- Discipline Knowledge Lecturer: a lecturer who is in the same discipline of the developed material (a lecturer but not a subject expert).
- Domain Knowledge Student: a graduate student who is in the domain of the developed material (a student and a subject expert or subject sophisticate[7]).
- Discipline Knowledge Student: a graduate student who is in the discipline of the developed material (a student who is not a subject expert).

The experiment, explained later, evaluates the quality of the materials, in terms of student's satisfaction and learning, revised according to the data collected from each review. However, a copy of the first developed material, used as an input for the review, would be kept without any revision from any of the reviewers for the purpose of finding whether the reviews effect student's learning and satisfaction.

In summary, the objectives of this are:

- To deliver clear evidence, based upon the experimental results, to assess the appropriateness of each of the reviewers to the central task i.e. improving the quality of the material in terms of students' satisfaction and learning.

- To provide some evidence concerning the effect of multimedia in the material and demonstrate that perceptions of quality are closely linked to perceived usefulness.
- To review and report the costs involved in the development and review processes in terms of academic skills, development time and personnel power.
- From amongst the students test subjects, to report upon the acceptance of multimedia based distance learning as a form of teaching and learning.

4.3 Research Hypothesis

The Alessi and Trollip (1991) model to develop CBI material was presented in chapter 2. They explained their model through steps required for any CBI material development. The final step was the evaluation step, which implies that the lesson has been implemented on the computer. The step includes three sub-steps:

- Reviewing the material with subject experts and other instructional designers to assess the content, appearance etc (Expert Review).
- Reviewing the material with representative students to collect detailed feedback on its quality (Learner Evaluation).
- Validating the material under normal circumstances.

The first two steps are part of formative evaluation, whilst the third could be summative evaluation. Alessi and Trollip (1991) explained that the evaluation step is very important to the production of a high-quality lesson and skipping it is a big mistake.

Some studies have used teachers and lecturers as subject experts to review educational materials (Char & Hawkins, 1987; Weston, 1987). In universities, such as Loughborough, subject experts are either lecturers or graduate students (research students). At the time of writing, there is nothing in the existing literature that questioned whether review by graduate student, as a subject expert, would be as effective as SMEs to produce a higher quality material than the original or unrevised material. Using graduate students to conduct such a review might be more efficient

[7] Tessmer, (1993), p. 52.

than using SMEs since they are more available and they cost less financially. This study also introduces new types of reviewers, discipline reviewers, for the following reasons:

- A lecturer in the discipline of the subject can be considered as an intelligent learner whose input might be very valuable in assessing the material.
- A lecturer in the discipline of the subject has pedagogy expertise.
- Graduate students can be considered as intelligent learners whose input might be very valuable in assessing the material.
- Graduate students form a kind of hybrid between learners and content experts that might offer a unique perspective.
- Graduate students are more available and they cost less financially.

The first hypothesis of this study investigates whether expert review, using lecturers and graduate students in the domain and discipline of the developed material, will produce a higher quality material measured by students' satisfaction and learning. It states that:

1. **Any review by a domain or a discipline knowledge person will result in a higher quality material than its original (unreviewed) material.**

Investigating this hypothesis may support or add to the results of previous studies that expert review is effective in producing higher quality material.

It should not be a surprise that sometimes students with only discipline knowledge might be observed to be more effective than the lecturers with domain knowledge in teaching the subject to other students (Anecdotal). It was explained in chapter 2 that subject experts could have communication problems (Tessmer, 1993) which may affect their effectiveness in the review process. Also, Alessi and Trollip (1991) caution that a careful revision needs to be made to note the reading level of the material and whether there are technical terms that need more explanation.

In reviewing Web-Based lectures that are intended to be taught at a distance, where the student's background knowledge could not be judged at first hand, discipline reviewers might be as effective as, or even better than, both SMEs (lecturer and student) in producing effective learning strategies and hence produce higher quality material. It is the second hypothesis that investigates whether discipline knowledge is better than domain knowledge in the review. It states the following:

2. **Discipline knowledge reviewers will provide a higher quality material than domain knowledge reviewers.**

Rejecting this hypothesis supports SMEs position in the literature and in reviewing Web-based material. On other hand, if the study showed that the hypothesis could be accepted two things could be learnt. First, the choice of reviewers is broadened to include discipline knowledge personnel. Second, discipline knowledge students would be, at least, as good as domain knowledge lecturers (SME). In the case of graduate students it could be very cost effective in the development process, since graduate students are not as expensive as lecturers.

Since the study investigates both graduate students and lecturers as reviewers it would be interesting to find out whether domain or discipline students are as effective as domain or discipline lecturers in reviewing Web-based material. The third hypothesis does not predict but, states that

3. **Although students and lecturers have been investigated as reviewers, no prior hypotheses existed with respect to their efficacy.**

Such an investigation might reveal that the use of graduate students is effective in producing high quality material that is no different than from the lecturer's and, as such, can reduce the development cost since they are usually available to do this work at less cost than lecturers.

4.4 Research Subjects

Three subject categories were used to carry out the research: 4 reviewers, 10 pilot students and 40 students conducted the evaluation. The reviewers were two senior lecturers and two graduate students all from Computer Science Department in Loughborough University. The topic of the developed material, explained later in this chapter, focused on the microcontroller's management of an automotive engine. Therefore, one of the lecturers was an expert in the developed material topic, e.g. Microcontrollers, providing domain knowledge and the other was an expert in

Artificial Intelligence and Neural Networks providing discipline knowledge. In the case of graduate students, one of them had a good knowledge in the topic of the developed material and was working on a project concerning microcontroller providing domain knowledge. The other was working on CASE Tools for formal systems providing discipline knowledge.

The second category of subjects used was pilot students. They were graduate students from three Engineering Departments: Automotive, Electrical and Mechanical with three years experience in the industry applying for an MSc degree in the Department of Aeronautical and Automotive Engineering and Transport (AAETS). Since the topic of the developed material was required in their module, these students were considered as potential students or users of the material. These students were Ford Motor Company employees and they came for only two weeks to complete the required module and return back to their base. They were invited to study the original (unreviewed) material, as self-managed distance students, and give feedback about it.

The last category of subjects used in the research was evaluation students. Since the lectures of the developed material were usually taught to Computer Science and Electrical and Electronic Engineering students in their final year, the sample that conducted the evaluation were students in their 2^{nd} year or above from the departments of Computer Science and Electrical and Electronic Engineering.

4.5 Research Experiment

In order to validate the hypotheses put forward, a series of experiments were carried out. The following figure, **Figure 4.1**, illustrates the steps of the experiment.

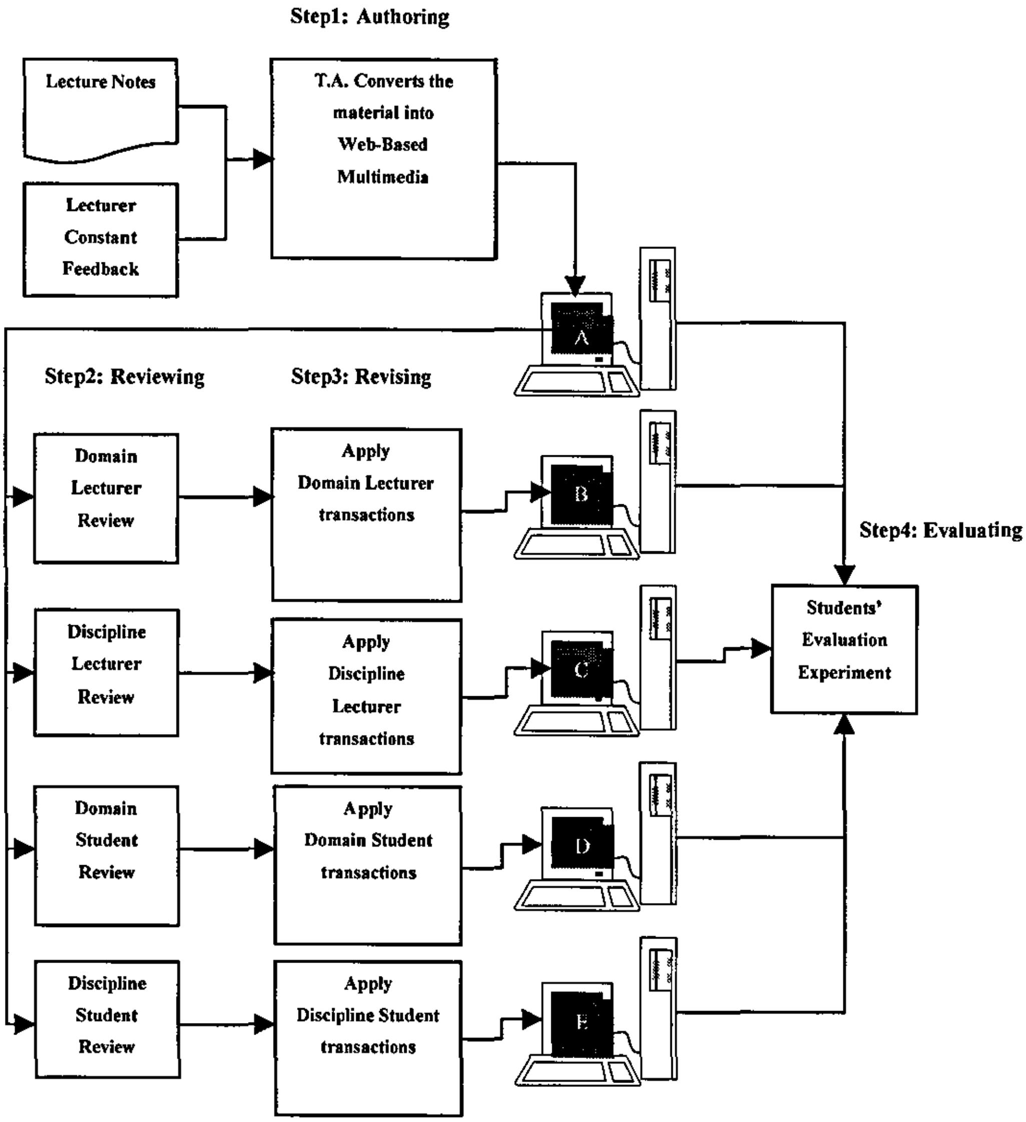

Figure 4.1: Experiment steps

1. Authoring the material. Authoring, in this study, is the process of producing multimedia Distance Learning (DL) material from traditional lecture notes. Computer applications and Information Technology (IT) were used to produce and deliver this material. As the authoring process was an untried challenge, the DL team was divided up in order to work on different tasks using different authoring techniques and software as MS Office, Sound Editor, Video Editor,

Authorware and Lotus Notes. The purpose of this was to learn and investigate how to build multimedia material using different techniques. Some team members reported that software, such as Authorware, required a long time to learn and use it efficiently. However, other users report success with this software. The author and the material originator followed another route, a technique which was called 'present-it-author-it', explained more in the next chapter.

2. Reviewing the quality of the material. In this study, the review process was conducted with four different reviewers in order to assess the material and each review was examined separately. The reviewers used a Recommendation Sheet (**Appendix B**) to record any required changes or modification as three types of transactions: Add, Modify, and Delete.
3. Revising the material according to the data collected from each review. In this process the Recommendation Sheet, after conducting a walkthrough with the reviewer to verify it, was used as an input to this process. The modifications were recorded as transactions used to create a version of the material. Each version was given a code explained as follows:
    - Version A: This version was the original material, unreviewed, that was used as input for each review.
    - Version B: This version was the result of the review conducted with the Domain Knowledge Lecturer (lecturer and subject expert).
    - Version C: This version was the result of the review conducted with the Discipline Knowledge Lecturer (lecturer but not subject expert).
    - Version D: This version was the result of the review conducted with the Domain Knowledge Student (student and subject expert).
    - Version E: This version was the result of the conducted review with the Discipline Knowledge Student.

4. Conducting students' evaluation. This evaluation would be carried out using an experiment that seeks to discover which versions most satisfied the students and separately measures the learning accomplishment.

4.5.1 Experiment Design

Since the main purpose of the study was to investigate the proposed hypotheses, an experiment design that validates them was needed. The main issues of the hypotheses are to measure the effectiveness of each review in terms of students' satisfaction and students' learning and whether there is some preference for specific versions against other versions. Basically, comparisons between versions have to be made (Garrett, 1964). Each version was evaluated and compared against all the other four versions. Subjects in this experiment evaluated two versions of the material, allowing them to compare and choose the version that most satisfies them. A bias might occur in evaluating a version that always comes first. This is called an order effect (Kinnear & Gray, 1995). To control such effects, a counterbalancing procedure was used where a total of eight students evaluated a version as the first, and another eight evaluated the same version as the second. The following table, **Table 4.1** best illustrates this:

Evaluation No.	First	Second
1, 21	A	B
2, 22	A	C
3, 23	A	D
4, 24	A	E
5, 25	B	C
6, 26	B	D
7, 27	B	E
8, 28	C	D
9, 29	C	E
10, 30	D	E

Evaluation No.	First	Second
11, 31	B	A
12, 32	C	A
13, 33	D	A
14, 34	E	A
15, 35	C	B
16, 36	D	B
17, 37	E	B
18, 38	D	C
19, 39	E	C
20, 40	E	D

Table 4.1: Evaluating each version in different order against the other four versions

Since students' response to conduct the evaluation was very low, especially at the end of the term and in the summer where students leave campus, total of 40 students was seen as a reasonable number since each combination of any two versions was tried twice.

Five groups of students were formulated for the evaluation of version A, B, C, D and E. As the group code indicates, group A is the group of subjects who would evaluate version A against other versions, and group B is the group of subjects who would evaluate group B etc. As each group member was to evaluate two versions, a total of 80 evaluations would take place. In each group, a total of 16 evaluations were formulated, 8 with the coded version as the first and 8 as the second. The tools used for evaluating and comparing one version against another were a questionnaire and a post-test, both designed to measure students' satisfaction and learning respectively. The evaluation procedure, shown in **Figure 4.2**, was planned as follows:

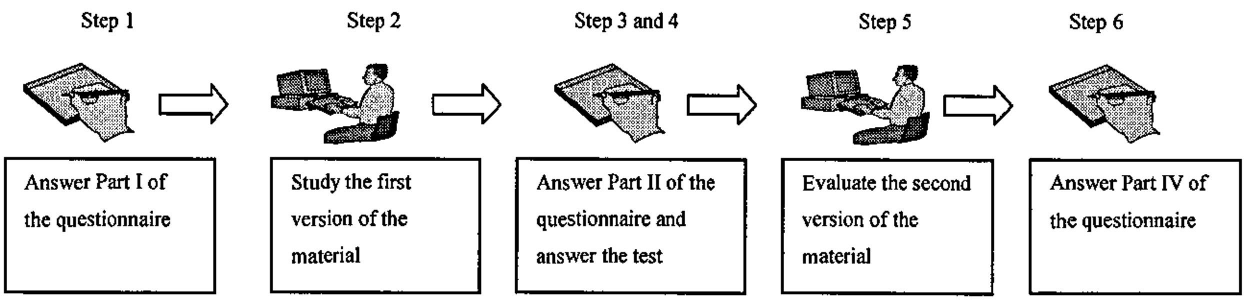

Figure 4.2: The steps of the evaluation as the students answer Parts I, II, III and IV of the questionnaire

1- Subjects receive a two-digit code representing the two versions that would be evaluated. For example, if the code is C-B, then this would mean that the student will evaluate version C first, then version B (See **Appendix F.1**, Instruction Page). Subjects were assigned these codes randomly without any prior knowledge of this coding system or the hypotheses of the study.
2- Subjects answer Part I of the questionnaire. This part was used as a filtration of the subjects with a potentially strong background in the material and as a base of measuring the change of student's preference. (**Appendix F.2**, Part I).
3- Subjects study the version of the material coded as the first version and evaluate it by answering a specific part of the questionnaire measuring the quality of the material in terms of their satisfaction. (**Appendix F.3**, Part II).
4- Subjects answer test questions that cover the objectives of the material measuring the quality of the material in terms of students' learning. (**Appendix F.4**, Part III).
5- Subjects study the version of the material coded as the second version according to the given code.
6- Subjects evaluate the second version of the material by answering the last part of the questionnaire, measuring the quality of the material in terms of their satisfaction, and then compare the evaluated versions (**Appendix F.5**, Part IV)

4.6 The Case Study

The developed material consisted of two lectures from a module on Advanced Computer Architectures. These lectures, as mentioned earlier, were usually taught to the undergraduate students as part of the course in the Computer Science Department. Undergraduate students in the Electrical and Electronic Engineering Department also study the same lectures as part of their course. The lectures have also been taught as part of a module given to graduate MSc. students.

The two lectures developed were authored to be suitable for self-learning or distance learning using multimedia and information technology. All of the material could be viewed using a standard HTML Browser. The developed material represents about four hours of traditional class lectures that were taught using lecture notes. The lectures were not covered by a suitable textbook and usually were taught as the seventh and the eighth lectures in the module sequence. However, they stood fairly independently and as such were ideal for extraction and independent presentation. Lecture seven introduced The Microcontrollers and The Otto Cycle whereas lecture eight specifically covered The 8096 Microcontroller and explained how the 8096 controlled the Otto Cycle. The objectives of the lectures were to:

- Understand why Microcontrollers were developed
- Understand the Otto Cycle
- Understand the need to move from 8-bit to 16-bit Microcontrollers
- Understand how the 8096 Microcontroller controls the ignition in the Otto Cycle
- Calculate critical parameters in the ignition process

The first version of the developed material was about three hours and fifteen minutes long. It was this version of the material that acted as an input to the review process. Since students need to evaluate two versions of the material (as explained in the Research Experiment), it was significantly clipped so that the whole process of the evaluation might take about three hours. This was done with the co-ordination of the material originator in order to keep the material in harmony with the lecture's main objectives.

4.7 Research Methods and Tools

In the literature, different methods such as questionnaires, interviews, observations and tests are used to collect data (Dey, 1993). Formative evaluation, as Gagné et al (1992) explained, is the process of collecting data about the feasibility and the effectiveness of the material and making decisions about how to revise it whilst it is being developed. The data could be collected by means of an observational record, questionnaires and/or tests. Feasibility of the developed material could be decided by observation, observing the difficulties experienced by instructors or students when using the material. Whilst the effectiveness could be measured by using:

- Observation reports: observing how the material was used compared to the intended use of the material.
- Questionnaire: students and instructors attitude toward the developed material could be measured using questionnaires.
- Tests: tests could be used to measure students' performance.

Most of the empirical studies used questionnaires to measure students' attitude towards a specific objective, e.g. satisfaction, and used tests to measure students' performance (Weston, 1987; Davidove & Reiser, 1991; Egan et al, 1993; Tessmer, 1993; Said, 1997). Depending upon the study, an appropriate method should be selected.

In this research, data was collected from a variety of sources using a variety of data gathering methods and tools. Various methods were needed to record and administer the development procedure, the review procedure and the evaluation procedure. For example, a Timing Sheet was designed to measure the cost of the development procedure, questionnaires were used to collect evaluation data from evaluation participants (reviewers, technical authors, students), and tests were used to measure students' performance (learning outcome). The following table **(Table 4.2)** summarises the methods used and the purpose of each. The next section discusses these tools in detail.

Name	Used As	Designed For	Purpose
Timing Sheet[8]	Recording Sheet	Technical Authors	To measure the cost of each task in the development process [9]
Reviewer's Recommendation Sheet	Recording Sheet	Reviewers	To record each modification as a transaction of three types: Add, Delete, Modify
Reviewer's Questionnaire	Evaluation questionnaire	Reviewers	To evaluate the material from the reviewers point view
DL Team Questionnaire	Collecting information	Technical Authors	To collect information regarding the authoring process and compare the findings
Pilot Student's Questionnaire	Evaluation Questionnaire	Pilot Students	Preliminary evaluation of the developed material and testing the questionnaire
Experiment Evaluation Questionnaire Part I, II, III, IV	Evaluation questionnaire	Target Students	To evaluate each version of the material in terms of student's satisfaction and learning

Table 4.2: Summary of tools used in the research

4.7.1 Measuring Authoring Cost in Time

Authoring multimedia material is a very costly process. Measuring the authoring process in time may provide a better estimate of the financial cost of it. The process could be considered as a collection of many tasks such that in order to measure the cost of it, each task involved needs to be identified and recorded. A Timing Sheet was used in this study to record these tasks where each task was given a number and a name (**see Appendix** A). The time absorbed by any task was recorded in units, where each unit was equal to 15 minutes.

4.7.2 Reviewer's Recommendation Sheet

It was explained earlier that some studies concluded that after collecting data from experts (reviewers) or learners, revisers tend to revise the material using their own judgement more than the collected data (Le Maistre & Weston, 1996; Weston et al, 1997). Reviewer Recommendations Sheet was a method developed in this research to record reviewer's data as transactions of three simple types: add, delete, and modify.

[8] See Appendix A, B, C, D, E and F.
[9] Only the developer sheet was analysed whilst other technical authors did not used it.

Each transaction consists of a location code (page number), transaction code (e.g. 1=ADD) and classification code (e.g. 10=Animation) (**see Appendix B**). For example, if one reviewer decided that animation was needed in some part of the lecture, then the transaction would be written as 710, 1, and 10. Since each screen of the material was numbered, this would mean that an animation (10) need to be added (1) on page 10 of lecture 7. A comment box was provided to give the reviewer a space to write specifically what was needed. After the review, a walkthrough with the reviewer was conducted to check the transaction requirements. The author performed the walkthroughs and the revisions on the developed material.

4.7.3 Reviewer's Questionnaire

Hague (1993) classifies three types of questions that a questionnaire might include: behavioural, attitudinal and classification. In this study the questionnaires are of the second type with a closed question style. [10] The purpose of these questionnaires was to collect information and measure attitudes. These questionnaires were deemed to be efficient, specific and relatively easy to complete (Robson, 1993; Potter et al, 1972).

The first questionnaire developed was the reviewer's questionnaire. Since the reviewers in this experiment were considered a valuable source of feedback, their evaluation of the material in general was also seen to be valuable. The reviewers were provided with a questionnaire after the review. The questionnaire was divided into three parts (**see Appendix C**). The first part consisted of six questions, in which they were asked to rate six categories of the reviewed material. These categories were Integration of the material, Clarity of concepts, Material design, Navigation of the material, Multimedia used in the material and, finally, the Presentation of the material. In the second part of the questionnaire, they were asked to approximate the percentage of changes, according to their view, needed in the material. Although this kind of question was hard to estimate, it was an attempt to record their subjective view of the material after they went through it.

[10] A style of questions in the questionnaire where the respondent is asked to choose one or other of the fixed response categories.

The purpose of the last part of the questionnaire was to find out in general whether some specific element or category needed to be improved or reworked.

4.7.4 Distance Learning Team Questionnaire

Distance Learning (DL) team was a group of technical authors employed to author multimedia and distance learning material allied to another project. It was seen as beneficial to capture data and information from them and compare it with the data collected in the development of the research material (the analysis is provided in the next chapter). The questionnaire used to collect DL team data is presented in **Appendix D**. The questionnaire was divided into three parts:

- The hardware and software used to develop the multimedia and distance learning material.
- An estimation of the cost of developing one hour of multimedia material.
- Difficulty in developing the material per task type and the time consumed to complete them.

4.7.5 Pilot Students' Evaluation

An opportunity existed for a pilot evaluation on the non-revised material after it was reviewed with the material originator. Students on the Ford (Loughborough University) MSc were invited to use, study, and evaluate the non-reviewed material (Version A) in a distance learning mode. The students were asked to answer a preliminary questionnaire as an evaluation tool after studying the material. The pilot students studied the material in distance learning mode in the university's laboratory but any live interaction with the lecturer was restricted to being only through e-mail. After studying the material, these students were asked to evaluate the material by answering a questionnaire. The piloted questionnaire was divided into four parts. The purpose of each part in presented in **Table 4.3. (See Appendix E)**.

Part	Purpose
Personality Preference. Questions 1, 2, 3	To find out whether personal preference effects the student evaluation of the material.
Quality of the Material. Questions 4 through 12	To obtain the students' evaluation of the quality of the multimedia used in the material.
Satisfaction and Ease of Use Questions 13 through 19	To find out whether students: • Feel that they understand the material • Were satisfied with material • Found the material easy to use.
Open Ended Questions Comments and Feedback Questions 20 and 21	To take some feedback from their comments about the material.

Table 4.3: Pilot students' questionnaire

4.8 Experiment Tools

In order to investigate research hypotheses, an experiment was needed. The aim of this experiment was to measure the quality of the reviewed material in terms of students' satisfaction and learning. A questionnaire and a test were prepared to measure student's satisfaction and learning respectively. The questionnaire was divided into four parts, the purpose of each is explained in the following tables: (**Table 4.4** through **Table 4.6**).

4.8.1 Questionnaire Part I

The first part constitutes four questions and subjects were asked to answer this before going through the material (See **Figure 4.2**). These questions were designed to collect data about subjects' preference to study, background knowledge and the effects of possible discussion with subjects who had already done this evaluation. The nature and the purpose of each question are shown **Table 4.4**.

Nature of question	Purpose
1) How would you prefer to study your courses? 2) Do you think that you could learn using computer based lectures?	- To record student's preference to study before going through the material. This question is repeated in different words in Part II recording subject's preference after going through the material and discovering the change in their answers. - To check whether personal preference influences the subject answers (bias, for or against).
3) How do you rate your background knowledge of the developed material?	- To measure the effectiveness of the material by determining subject knowledge before the evaluation and comparing it to the test answers after the evaluation. - To filter out subjects with strong background.
4) Have you discussed any aspects of this evaluation with other students who have evaluated the material before?	- Since the subjects will evaluate the material in-groups, adding this question would be appropriate to establish whether the subject was or was not influenced by answers of another subject.

Table 4.4: The nature and the purpose of students' questionnaire Part I

4.8.2 Questionnaire Part II

This part of the questionnaire includes five main questions for the purposes of the following:

- Tracing subject's preference (1,2): represented by two questions related to Part I to trace whether a change in subject's preference had occurred.
- Measuring the quality and usefulness of the media (3): to find out whether they consider the quality of media, such as the quality of any video, as a major ingredient to its usefulness
- Evaluating the material (4,5): to measure subject's perception of the material in terms of ease of use, usefulness and their satisfaction with the material.

The evaluation of the material, questions 4 and 5, was represented by 12 questions. Numerical scale type answers were used ranging from '1' to '7', signifying strong disagreement and strong agreement respectively. Each term of the evaluation (ease of use, usefulness, satisfaction) was represented by four questions where two questions were worded positively whilst the other two were worded negatively for the purpose of minimising conditioning (Said, 1997). All 12 questions were distributed in non-sequential order so that any two consecutive questions would seem unrelated. However, the negatively worded statements would be corrected for the analysis by subtracting the given rate from 8, because they were worded in an opposite tone to their appropriate category.[11]

Subject's overall satisfaction was measured by combining these three categories as explained in the Analysis Section. It is this part of the questionnaire, which was needed to validate the hypotheses and test the quality of the material in terms of students' satisfaction. The following table, **Table 4.5**, shows the nature of the questions and the purpose of each.

Nature of question	Purpose
1) After going through the material, I think that Co. L (>,=,<) T. C. L.[12] 2) I would prefer to study computer lectures, such as these for (the whole of, part of, or none of) the course.	To check whether a change in the subject's preference had occurred by comparing the answers with Q1 of Part I.
3) How do you rate the *quality* and the *usefulness* (in terms of learning) of each of the following media used in the material: An, Ad, Tx, Vd, Ic, Pc, and Ps[13]. 4) How do you rate the navigation of the material? A seven point rating scale is used in these two questions where the middle point (4) is considered as a fair rating. Three points from either side of the middle rating gives enough feedback about the strength or weakness of each media used.	1- To assess whether subjects rate the quality of the media different from the usefulness of the media. 2- To establish a base line from the subject's evaluation of the first version of the material against which a second evaluation can be compared. 3- To find whether subjects consider the quality of the media as a key factor of its usefulness.
5) To what extent do you agree or disagree with the following statements: A seven point Agreement/Disagreement scale is used in this question where the middle point (4) is considered as a neutral opinion. Three points from either side from the middle (4) give enough feedback about the strength of agreement or disagreement with the statements.	To measure subject's perception of the material from three angles: • Ease of use of the material • Usefulness of the material • Satisfaction with the presentation of the material.

Table 4.5: The nature and purpose of students' questionnaire Part II

[11] For example, if a student gave a rating of 7 for one negative statement, strongly agree, and a rating of 1 for another, these two statements would be corrected to 8-7=1 and 8-1=7 for the first and the second statement respectively.

[12] Co. L = Computer Lectures, T.C.L. = Traditional Class Lectures, (>, =, <) = (better, same, worse)

[13] An = Animation, Ad = Audio, Tx = Text, Vd = Video, Ic = Icons, Pc = Pictures, Ps = Presentation.

4.8.3 Questionnaire Part III

In the literature, students' performance is measured by students' test scores (Saroyan, 1992/1993). As an objective measure to verify the quality of the material in terms of students' learning, students' test scores are used as a performance measure to validate the hypotheses. 10 multiple-choice questions were given to the subjects. Each question was weighted as 1 point for each correct answer so that the maximum weight of correct answers is 10. The test was given only after the first evaluation in order to measure the effectiveness of each version independently (See **Figure 4.2**). The questions were designed to cover the main aims and objective of the material. These aims and objectives are presented in **Table 4.6**. The number of correct answers obtained measured the quality of material in terms of learning. The score of correct answers is a ratio that is considered appropriate for a parametric test, such as the t-test.

Nature of question	Purpose
Multiple choice questions testing the comprehension of the material. (e.g. For each question, tick just one answer that you understand from this material best fits the question?)	10 test questions would be given to the subjects to measure their learning from the material. The test covers the five aims and objectives of the lectures. These aims are: • Why Microcontrollers were developed? 1,2 • The Otto Cycle. 3, 4 • The need to move from 8-bit to 16-bit Microcontrollers. 5 • How the 8096 Microcontrollers controls the ignition in the Otto Cycle. 6, 7. • How to calculate critical parameters. 8, 9, 10

Table 4.6: The nature and purpose of students' evaluation Part III - Test's objectives

4.8.4 Questionnaire Part IV

This part of the questionnaire was provided for subjects evaluating and comparing the second version against the first version of the material. It includes six questions, where the last two were considered as open-ended questions. The first three questions are exactly the same questions as used in Part II to evaluate the quality and usefulness of the media used in the material and to measure student's satisfaction. The purpose of the following question (4, 5) was to elicit comparisons between the two versions of the material viewed. In question 4, students compare the two versions according to some specific elements. Question 5, however, was designed to find out which version satisfied the student overall and whether the reviewer's modifications, given as a list of reasons for choosing the version, was the explanation for choosing one version over the other. Also, an opportunity was provided to explain their position in case of not preferring any version. The last question was open-ended to allow comments and feedback. The nature and the purpose of each question are shown in **Table 4.7**.

Nature of question	Purpose
Questions 1, 2 and 3 are same as questions 3, 4 and 5 respectively of part II.	To evaluate the second version of the material in absentia of any comparison with the first version viewed.
The remaining questions seek to elicit comparisons between the two versions of the material viewed. Question 4. Choose the version that satisfies you most according to the following categories:	To find out explicitly the version that satisfies the subject according to the: • The material in its entirety per version • Page design • The clarity of concepts • The ease of use of the material • The navigation of the material • The media used:- especially sound, animation, presentations.
5) A) Which of the two versions you saw satisfied you most overall? B). The reasons I chose one version over the Other were: C). Neither version was individually preferable because:	To find out explicitly which version satisfies the subject overall. To find out whether and why subject preferred one version over the other. A list of reasons was given. This list reflects the major changes that the reviewers recommended, which were specifically targeted to validate and evidence the hypotheses. To find out the reasons for not preferring either version of the material.
6) Feedback	To allow the subject to provide open feedback about the material.

Table 4.7: Students' evaluation questionnaire Part IV

4.9 Hypotheses Analysis

The objective of the analysis is to accept or reject the proposed hypotheses and to highlight other important findings. To test the hypotheses, it is very important to state each hypothesis in simple statements in order to use statistical tests that result in acceptance or rejection of each statement. The first hypothesis states that:

1. **Any review by a domain or a discipline knowledge person will result in higher quality material than the version that is not reviewed.**

This hypothesis could be evidenced by eight simplified sub-hypotheses, shown in **Table 4.8** as the alternative (a) of the null hypotheses that implies no difference between the compared versions.

H1a	Students are satisfied with version B more than version A. [14]
H2a	Students are satisfied with version D more than version A.
H3a	Students are satisfied with version C more than version A.
H4a	Students are satisfied with version E more than version A.
H5a	Students studying version B score more in the test than students who studied version A. [15]
H6a	Students studying version D score more in the test than students who studied version A.
H7a	Students studying version C score more in the test than students who studied version A.
H8a	Students studying version E score more in the test than students who studied version A.

Table 4.8: The 8 sub-hypotheses H1 - H8 derived from the first hypothesis

The second hypothesis states that:

2. **A review by discipline knowledge person will result in higher quality material than a domain knowledge person.**

This also could be evidenced by eight further sub-hypotheses, H9 to H16 presented in **Table 4.9.**

H9a	Students are satisfied with version C more than version B.
H10a	Students are satisfied with version C more than version D.
H11a	Students are satisfied with version E more than version B.
H12a	Students are satisfied with version E more than version D.
H13a	Students studying version C score more in the test than students who studied version B.
H14a	Students studying version C score more in the test than students who studied version D.
H15a	Students studying version E score more in the test than students who studied version B.
H16a	Students studying version E score more in the test than students who studied version D.

Table 4.9: The 8 sub-hypotheses H9 - H16 derived from the second hypothesis

The third hypothesis states that:

3. **Although students and lecturers have been investigated as reviewers, no prior hypotheses existed with respect their efficacy.**

[14] A is the version that is not reviewed. B is the version that is reviewed by a domain knowledge lecturer. C is the version that is reviewed by a discipline knowledge lecturer. D is the version that is reviewed by a domain student. E is the version that is reviewed by a discipline student.

[15] Tests are given only after evaluating the first version.

Four further sub-hypotheses, H17 and H20 presented in **Table 4.10** could evidence the third hypothesis. These hypotheses are the null hypotheses.

H17	Students are satisfied equally will version C and version E.
H18	Students studying version C score the same in the test as students who studied version B.
H19	Students are satisfied equally will version D and version B.
H20	Students studying version B score the same in the test as students who studied version D.

Table 4.10: The 4 sub-hypothesis H17 - H20 derived from the third hypothesis

4.9.1 Analysis Tools

Descriptive statistics are used to summarise and analyse the data (Norušis, 1997). Statistics such as sum, mean and standard deviation are commonly used to provide summaries of information. However, different tests are needed to accept or reject research hypotheses. In this research, an experiment was designed to compare students' evaluations of different versions of the developed material and validate the proposed hypotheses. The method selected was to use group comparisons where five groups of subjects, between them, assessed the five versions of the material. Two main categories need to be measured: students' test score and students' satisfaction with the material, providing both objective and subjective evaluation data. Two common statistical tests were planned to be used: the Mann-Whitney U test and the t-test comparing the two categories across pairs of groups (Norušis, 1997; Knaji, 1993). The t- test is a parametric test that was appropriate for comparing the mean of the test scores between two groups of subjects. However, the Mann-Whitney test is more appropriate for non-parametric data such as subjects' satisfaction for comparing the mean of such data between two groups of subjects (Conover, 1980; Diamantoploulos & Schlegelmlich, 1997). Norušis (1997, p269) reports a problem of using many t-tests in groups comparisons known as the multiple comparison problem. When many comparisons are made, as Norušis explained, the probability of rejecting the null hypothesis when it is true increases. In other words, one or more comparisons will turn out to be significant, even when all the population means are equal. To resolve this problem two tests are recommended: first, a one-way analysis of variance (One-way ANOVA) that tests the equality of groups' means and second, if the result is false or not equal, a Bonferroni procedure (a multiple comparison procedure). All these statistical tests are performed using a statistical package called SPSS® version 7.5.

To test the research hypothesis in terms of students' satisfaction, three categories of the questionnaire data were intended to be analysed: subjects' perception of the ease of use of the material, subjects' view of the usefulness of the material and subjects' satisfaction. First, the means of each category of each version need to be calculated. For example, μ_{CE}, μ_{CU}, μ_{CS} are the means for ease of use, usefulness, and the perceived satisfaction of version C respectively. Overall students' satisfaction with version C (μ_{CO}) is the mean of the above three means ($\mu_{CO} = (\mu_{CE} + \mu_{CU} + \mu_{CS}) / 3$).
However, a note has to be made in using the statistical tests to validate the hypotheses that deal with student's satisfaction. All of the statistical tests mentioned above assume that tested groups are independent. Test scores are considered independent since the test was given only once, after the first version. However, the evaluation data that measures subject's satisfaction was given twice, after the first and the second version of the material. Therefore related data existed in each group. For example, when using Mann-Whitney test to compare group A against group B, there are 4 subjects in each group who evaluated the same versions but in a different order (A-B and B-A), hence related data existed. But, since more than 75% of the data was already independent and the related data was distributed equally in all groups, the groups are treated as independent[16]. Using the whole group as an independent group gives a better result since all subjects' data could be used in the test.

Conclusion

This chapter has provided a theoretical framework for the empirical phase of this study and has covered in detail: the aims and objectives of the study, the hypotheses, the methods and tools to collect data, and the experiment. This study attempts to fill some gaps in the literature and uses the recommendations provided by some of the studies. These gaps are translated into objectives of the research utilising different tools such as questionnaire, tests, and other tools.
The chapter has also covered the statistical tests planned to be used to validate the hypotheses. The analysis along with results of the tests is discussed in-depth in

[16] As Richard Buxton (a statistician) explained that the test might be less sensitive in finding the difference because the effect existed in both groups.

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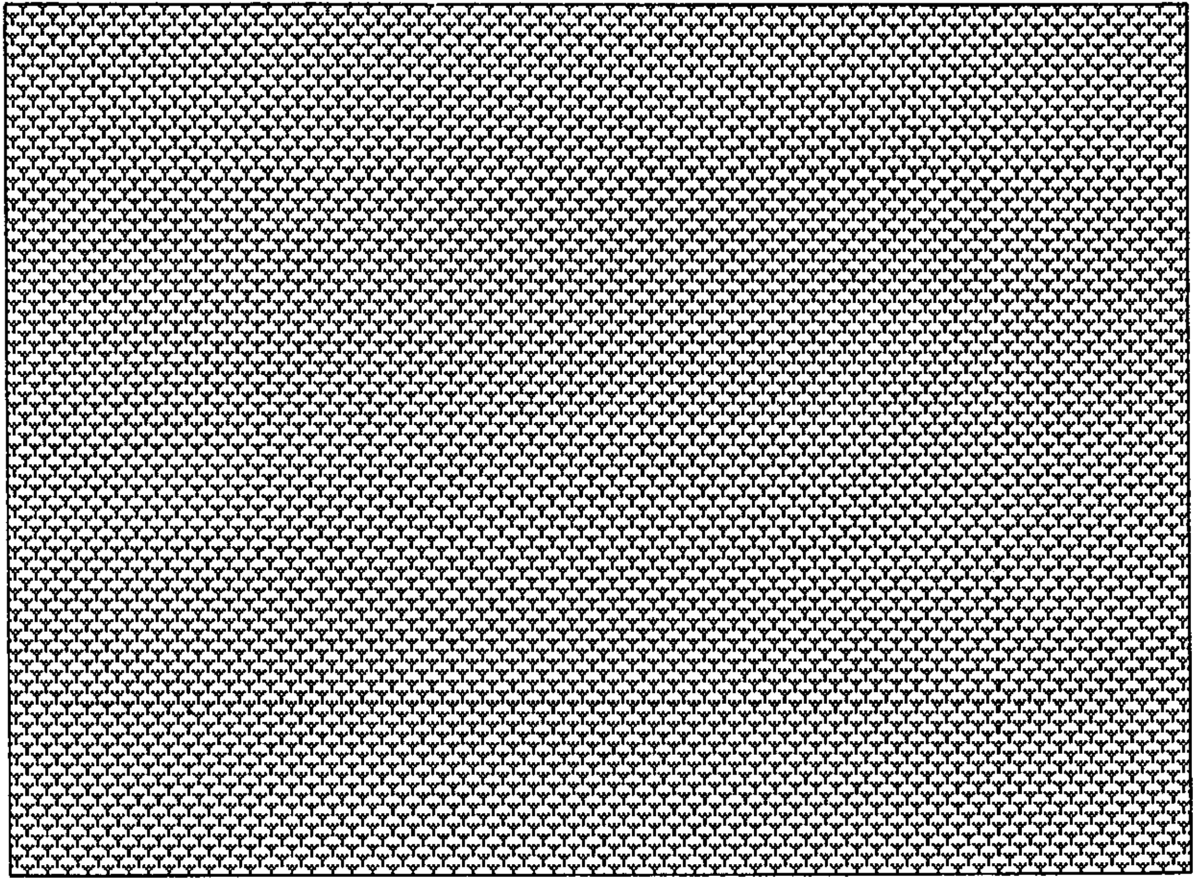

chapter 6. Next chapter, however, presents the results of the development process of the material and the reviewers sessions.

Chapter Five

The Development of the Material

5.0 Introduction

In the last chapter, the research hypotheses were presented with an explanation of the experiment and tools planned to investigate these hypotheses. This chapter presents the bases of these hypotheses, the development of the material and the reviewing sessions. The development process is explained along with the cost of such development in time compared to other developers data. Also presented in this chapter are the results of the reviewing procedures that were conducted with the four reviewers and a description of the four resultant versions.

5.1 The Development of the Material

It was explained in the previous chapter that, as a case study, two lectures from a module on Advanced Computer Architectures were developed to be suitable for self-learning or distance learning using multimedia and Information Technology. Since most of the literature covering the development of Web-based material was published after the start of this research, computer-based instruction literature, specifically Alessi and Trollip (1991), was used as a guide in the development of the material. It was explained in chapter 2 that they presented a model of 10 steps to develop CBI material. The following steps are presented as a reflection of their model:

1. Goals and objectives of the material: the presentation of the goals in the material and the learning types are presented in **Table 5.1**.

Goals	Location Lecture – section	Type of learning
Understand why Microcontrollers were developed	7-1 Introduction to Microcontrollers 8-1 Introduction To Intel MCS-96 Microcontrollers	Verbal learning[17]
Understand the four strokes of the Otto Cycle	7-2 The Four Stroke Cycle Inlet, Compression, Ignition, Expansion, Exhaust	Verbal learning, Concept learning
Understand the need to move from 8-bit to 16-bit Microcontrollers	8-1 Introduction to IntelMCS-96 Microcontrollers, 16-bit CPU	Verbal learning, Concept learning
Understand how the Intel MCS-96 Microcontroller controls the ignition in the Otto Cycle	8-3 Controlling The Otto Cycle	Verbal learning
Calculate critical parameters in the ignition process	7-2 Timing, Assessment 8-3 Controlling the Otto cycle, Assessment	Problem solving, Concept learning

Table 5.1: The presentation of goals in the material and the learning type of each goal

Students, after studying the material, are expected to achieve these goals and answer test questions dealing with these goals. However, students are expected to have the following characteristics prior to using the material:

1.1 Be familiar with the use of the Web;

1.2 Know how to do simple multiplication and divisions to calculate cycle (revolution) in seconds when given revolutions per minute and calculate one degree time from one revolution time.

1.3 Be familiar with some computer terms such as interruption, subroutines and memory.

2. The collected resource for the material were:
   - Subject resources: Intel MSC-96 Microcontroller manual, lecture notes and presentations from material originator, Advanced Computer Architecture books, the material originator;
   - Instructional design resources: text books on Computer-Based Instruction and surfing the Web for design ideas;
   - Media resources: Web pages and the literature.

[17] According to Dick & Reiser, 1989; Gagné et al (1992)

3. Learning the content: the developer was from the discipline of the material that learned the content while developing the material.
4. Generating ideas: presentation and animation ideas all resulted from meetings with the material originator.
5. Step 5 through step 9 (designing, storyboarding and programming procedures) were applied using a technique explained in the following section with the exception of flowcharts (step 6) which were only done for some sections
6. No complete flowchart, only for some sections.
10. Evaluating the quality of the material: the following table, **Table 5.2**, shows the result of each phase.

Quality Review Phase	Results
Language and grammar	- The reading level of the material was thought to be appropriate since the material was used in real classes. - The material included a glossary of terms for most technical terms. - Some spelling and grammar mistakes were found the review sessions. A spelling checker should be used especially with the new HTML editors.
Surface features of the display	- Browsers display font sizes differently. - Text describing icons appeared crowded in some pages.
Pedagogy Issues	- Student controls the learning sequences through navigation buttons in the header frame. - Interaction was provided through group e-mail.
Subject Matter	- The content was checked with the originator of the material.

Table 5.2: Some quality review phases according to Alessi and Trollip (1991)

5.2 The Design of the Material

A human skeleton metaphor, developed by Dr. P.A. Lawson of the Computer Science Department at Loughborough University, was suggested as the design structure of the developed material. Each Web-base lecture or unit is represented as a human skeleton (upper torso **Figure 5.1**).

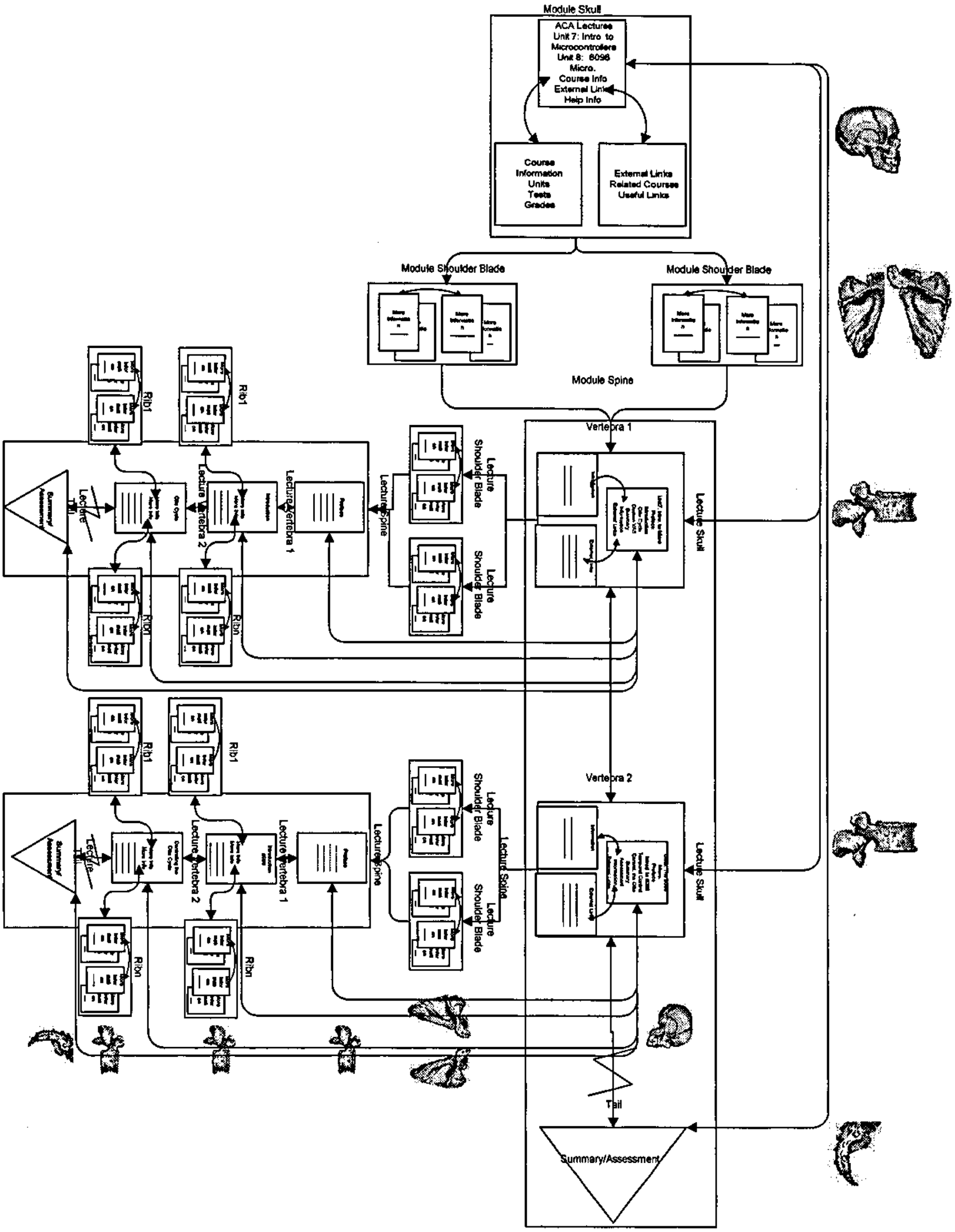

Figure 5.1: Human Upper Torso as a metaphor used in the design of the material

The metaphor was applied in the following manner:

- First, the Skull contains all the introductory material together with adjuncts such as:
    - Index map or a hyperlink guide through the material together with brief notes on each unit;
    - Coursework information or assessment procedure, if any;
    - References that the material draws upon;
    - Information on any tools or techniques that will be required for the following units.

- Second, Shoulder Blades are used to provide help information, specifically, for using the system and specifying or linking to the prerequisite units or knowledge required before commencing.
- Third, the Spine is the main theme of the material. Sections in the lecture are represented as the spine's vertebrae with the associated ribs of each vertebra. Just as the chapter of a book is divided into sections that cover the main topic of that chapter, the spine is divided into vertebrae. Each vertebra explains part of the topic covered in the lecture. Each vertebra can be considered to contain the minimum set of nuggets (elements of the section consisting of lecture notes, multimedia material, self assessment etc.), such that a student who is proceeding well will only need to work with it, the core material. The ribs are the help materials to assist some students who may struggle or face difficulties in understanding or remembering elements of the material covered by the vertebra. A rib of the vertebra is therefore more information about some elements in the vertebra. Each vertebra may also possess some assessment material, which if this forms a barrier to progression to the next vertebra, can be visualised as the disc.
- Finally, the Tail of the upper torso is the end of the lecture that may contain a summary of the lecture, self-assessment exercises and, possibly, any summative assessment.

It is worth noting that the complete lecture course for the whole module is in itself represented as a skeleton in its own right. Equally, if any given vertebra is deemed to be too large or too structured to be presented as a collection of nuggets within a vertebra, each vertebra can in itself contain another skeleton, as illustrated in **Figure**

5.1. The effectiveness of this metaphor in providing students with a navigational mental map and navigational tools is not the direct concern of this study and is the ongoing research of the concept developer.

Applying such a metaphor might give the students a natural path to follow when they explore the material through the vertebrae down the spine from head to tail.

5.3 Present-it-Author-it Technique

The technique used to author the material maybe described as: present the material in a real class using computer presentation features and then use that presentation to author the Web-based multimedia material. The technique is intended to be simple so that others can use it and reduce the cost of such a process in time and money. This technique, although un-proven, is not considered to be the research concern of this study. The main steps followed to author the material were:

1- From the lecture notes, computer-based presentations were built using software that supports the use of multimedia to enhance the presentation. These presentations were then used in a real class more than once to permit modifications. It is common, nowadays, that lecturers develop their own computer-based presentations and use them in their class. Well-known software to develop such a presentation is Microsoft PowerPoint, which was used by the material originator to develop the presentations of this material and had been in use for about 5 years.

2- In class activity and talk was captured through the use of a tape recorder and video camera.

3- The PowerPoint presentations were exported to World Wide Web pages. The author used Microsoft Word and PowerPoint but other ways are also available.

4- A storyboard of the material that shows the skeleton design was outlined through dividing the presentations' text into vertebrae and ribs (sections and help sections). The author used a white board as a storyboard to sketch the vertebrae (sections) and ribs (help sections) of the material but other ways are also available.

5- A transcript of the recorded tape was prepared to match the presentation's slide with the appropriate talk.

6- The recorded tape was transformed to wave files (PC audio files). These files were edited and divided into audio clips that match the vertebra contents. The author used Windows 95 WaveEditors software to edit and re-record audio files.

7- At the time of development of this material, the procedure of transforming analogue video clips into digital video files was very expensive in terms of disk space. Therefore, only parts of the videotape were transformed to AVI files (PC video files). These files were edited to show a clip of a class discussion.

8- Animation clips were used to clarify concepts. The author used animator packages that are compatible with WWW such as the PowerPoint Animator and the AutoDesk Animator.

9- The WWW pages were edited to insert hyperlinks in the HTML files for the navigation, audio clips, video clips and animation files.

5.4 Cost of Authoring

Four issues could determine the cost of authoring Web-based multimedia material. First, the cost of the software used to author the material. Second, the time required learning the software. Third, the machine that runs the software. Fourth, the time required to author the material. The software used in the technique explained above, used the most common software that comes on almost every new PC nowadays. If the authoring procedure uses most of the available resources, then the development of such material would cost less. In the framework of a lecturer who is likely to place their material into Web-base instruction format, learning to use such software is not considered to be a problem because a lot of lecturers may be using much of this software already. However, the time required to author and produces the material was considered an important issue that needed investigation. It is important in any project to consider a cost/effectiveness analysis. An answer to questions such as "how much does it cost, in time, to produce a one-hour's worth of traditional material as a Web-based multimedia material?" might need thorough investigation.

5.4.1 Measuring the Cost of Authoring in Time

A Timing Sheet was used as a tool to record the time consumed by each task (**see Appendix A**). The author used a PC platform in the development of the material. In total, the author spent 202 hours to produce multimedia Web-based material that was worth about 4 hours of traditional lecture time. In other words, the cost of authoring one-hour of traditional class, transformed to multimedia Web-based material, was about 50 hours of development. The tasks involved in the authoring process and the time required to accomplish these tasks are shown in **Table 5.3**. More than quarter of the time was spent, as shown in **Figure 5.2**, on two tasks: transcribing lectures from the tape recorder and editing the audio files. Both of these tasks were considered difficult tasks because of the time required and the repetitive work that is needed to accomplish them. These tasks could consume less time if the quality of recording was high at the time of the live lecture.

Task No.	Task Name	Units	Comments
100	Watching lectures video Tapes	14	These lectures were part of Ford students module
150	Reading about Windows 95	44	Changing from Windows 3.1 Platform to Win95
151	Reading about Office 95	36	Reading about Office new features in PowerPoint, Excel and Word
200	Moving the materials from server	12	Moving Presentation files
250	Recording the lectures live	16	These were the same lectures presented to undergraduate students
300	Transcribe the lectures	96	Transcribe the tape
350	Typing the transcript	6	Estimated time by the secretary
400	Transforming the material to HTML	65	Fix problems and rebuild the material
500	Reading and training	48	Learning HTML effects + multimedia
600	Redesign the material	68	Breaking the material into vertebrae to build the spine of the material
650	Building the templates	60	Building page layout
660	Reading more about the material	42	Ribs' (More Information pages)
670	Reading and building the material	16	Writing Ribs pages
700	Fixing errors	20	Correcting links
750	Changing from absolute addressing	38	Using relative addressing
900	Recording the introduction	16	Re-recording some sound files
950	Loading the sound to computer	6	Recorded tape was transformed to wave files
960	Editing the sound file	132	Breaking the sound file into smaller files.
970	Putting sound file in the material	4	Match sound with presentation slide
1050	Working with videos	22	Capture parts of the lectures from the video tape
1100	Working with animation	30	Using PowerPoint and AutoDesk Animator
1300	Building glossaries	30	Selected terms were used in the glossary
	Total Units	809	
	Total Hours	202	
	Total lecture hours	4	
	Units / Hour of the material	50.5	

Table 5.3: The cost of developing the material

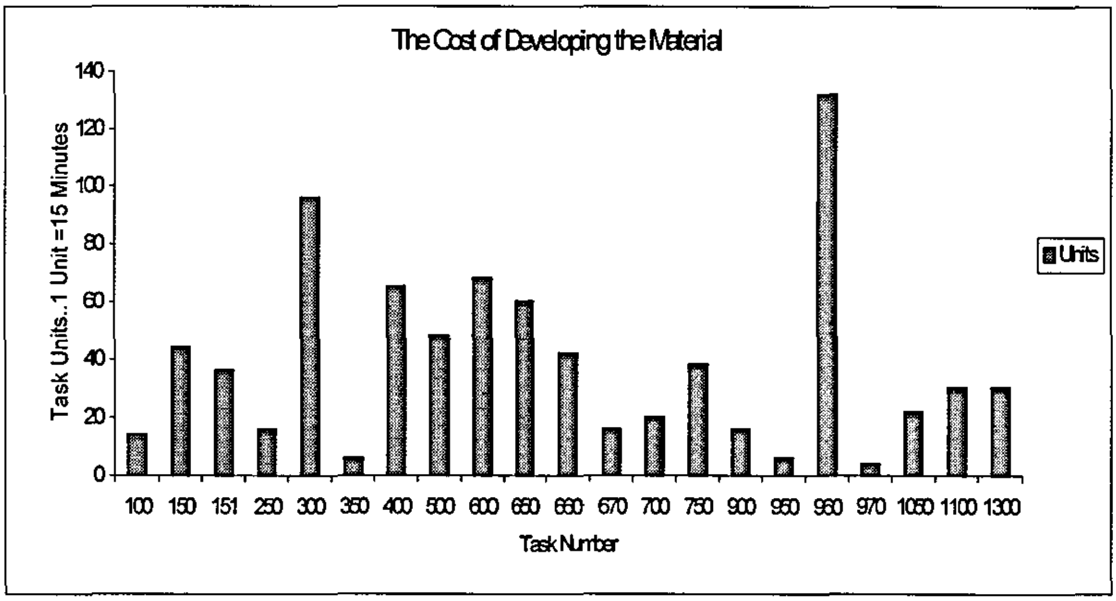

Figure 5.2: The time spent on each task in the development of the material

5.4.2 Analysis of DL Team Questionnaire

It was explained in the last chapter that a questionnaire, shown in **Appendix D**, was prepared to collect information from the DLI team in an attempt to compare it with this research finding.

In the development of the material, technical authors used Authorware and LotusNotes plus the other software. They used a Sun machine as a server and for, the development of the material, they used MACs, and most of the time PCs.

Despite being based upon their own experience at that point in time, the technical authors were not sure about the cost of developing one hour's worth of Web-based multimedia material. Two of them thought that one hour of a 'good quality' multimedia material would need more than 100 hours of authoring. The other two, as **Figure 5.3** shows, had different opinions about this matter. One thought that it would take less than 50 hours and the other thought it would take about 50 to 75 hours of authoring. These two authors' expectations came close to the findings of this research. (See **Table 5.1**)

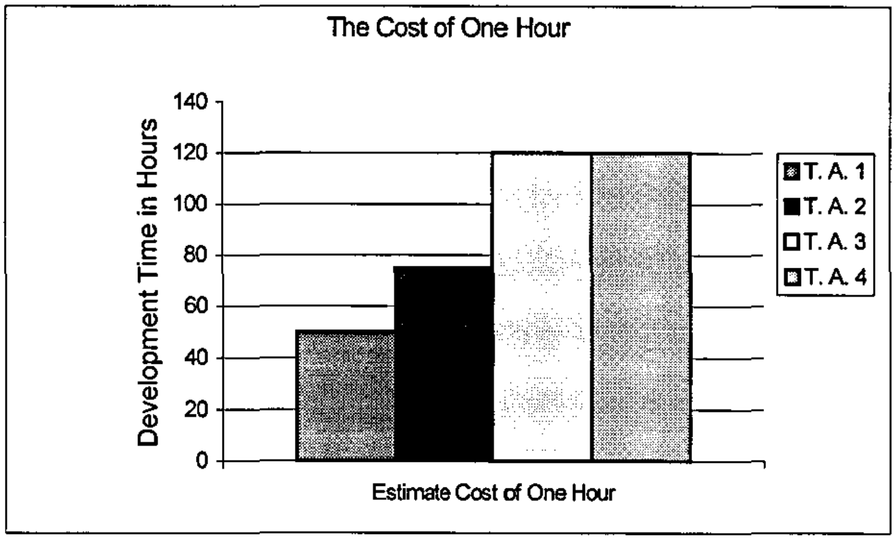

Figure 5.3: Technical Authors' estimation of one-hour multimedia production

When the technical authors were asked to arrange tasks according to the time consumed to accomplish them, their responses were not consistent. As shown in **Table 5.4**, each technical author answered differently due the job specification of each author. Transcription of lectures was also found by one T.A. to be the most time consuming task but animation production was the most difficult task as assessed by two authors. Only one technical author, shown in **Table 5.4** and **Table 5.5**, answered that animation production was the most difficult task and the most time consuming.

They were also asked to estimate the time percentage for each task involved in the development of multimedia material. Their response is shown in **Figure 5.4**. Their answers were inconsistent but confirm the results of the previous question.

	Task Most Time Consuming
T. A. 1	Learning of the packages
T. A. 2	Transcription of the lectures and Review with material originator
T. A. 3	Producing Authorware Animation
T. A. 4	Typing the lecture

Table 5.4: Authors' most time consuming task

	Task Most Difficult
T. A. 1	Animation Production
T. A. 2	Review with material originator
T. A. 3	Animation Production
T. A. 4	Integration

Table 5.5: Authors' most difficult task

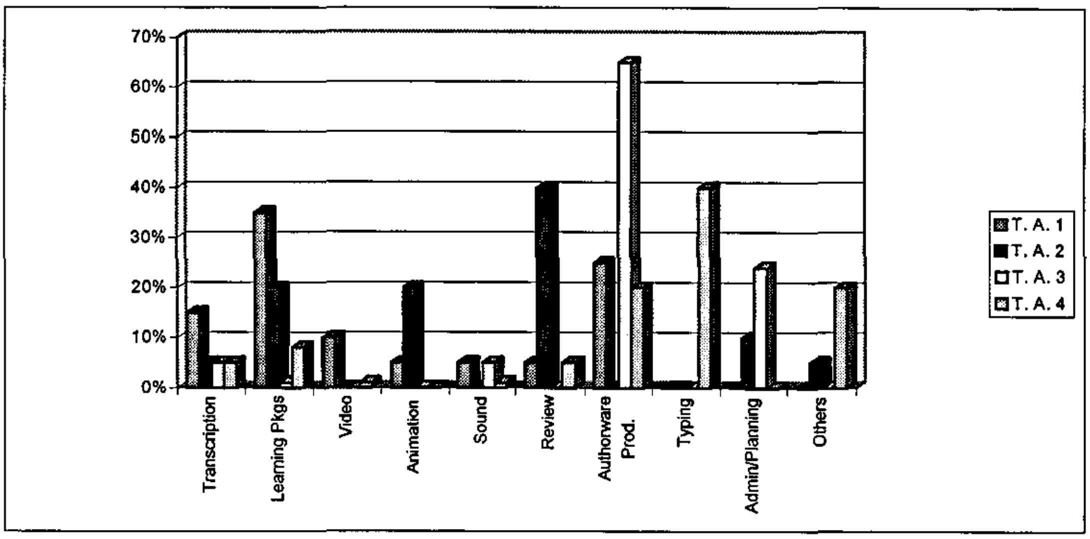

Figure 5.4: Authors' estimation of time percentage of each task

Regarding the author's knowledge in the content of the developed material, presented in the questionnaire as the background issue, and whether they consider it mandatory in authoring the DL material, their responses were different. Two of the technical authors strongly agreed that background knowledge is very important for authoring the material. As for the other two, one disagreed with background issue and the other did not know.

An open-ended question was provided at the end of the questionnaire to allow them to comment about their work in order to use these comments as a feedback for future work. One of the technical authors commented upon the background issue and explained that knowledge in the "presentation and educational process is more important than actual material contents. So knowledge of these is a priority". The second one wrote "a lot of temporary factors have influenced the development of courseware: division of labour, delivery strategy, and development strategy". The third technical author commented that "learning packages and producing specialist material (e.g. Authorware, graphics, video) takes a great deal of time ... having experienced and technical staff to convert author's ideas into end-user material is a good idea."

5.5 The Review Process

In each review conducted, a Recommendation Sheet was used to collect reviewers' notes and recommendations as transactions of three simple types. Each review session was recorded using a tape recorder to go in parallel with data collected. The reviewers conducted the review in separate sessions. Only the domain reviewer asked to go through the material first then conduct the review in one session whilst the others asked to break the review into multiple sessions. As the reviewers went through the material they were asked to fill the Reviewer Sheet and make comments on each transaction. To reduce the review time and make the review more productive, the reviewers were given 19 classification codes that could describe the transaction. The reviewers were not limited to those codes and could add a new classification codes as they were needed. The result sheets of the transactions made by the four reviewers are shown in **Appendix G**.

5.5.1 Domain Lecturer Review

The domain lecturer was a lecturer teaching Microcontrollers and other modules. The reviewer asked to go through the material by himself then conduct the review session. The review was conducted in one session and lasted for about two hours. The main comments from the review are shown in **Table 5.6**. The transactions marked with an asterisk were the main transactions used in the revision process and were listed in the last part of the subject's evaluation questionnaire as possible reasons for choosing this version (see **Appendix F.5**).

Transaction	Classification	Comments
Modify	Control of video screen	How do we get out of the movie?
Modify	Text	Correct the content in one of help sections that cover PWM
Modify	Navigation	Navigation difficulty
Modify	Icon Text	Next button is often crowded
Add*	Navigation Icon	Do we always have to use Netscape "back" to go back?
Modify*	Audio	Voice needed proper recording
Add*	Text	Summary file for each audio file
Add*	Audio Bullets	Break the audio file into bullets

Table 5.6: Main transactions made by the domain lecturer

The reviewer was concerned with the content, grammar and spelling mistakes. He suggested dividing some long audio files into small audio files and presenting these as bullets. In this way students can listen to the audio file as a whole or play the audio bullets, letting them specifically choose the required bit of the audio. Also, he suggested providing a summary of the main points that cover the talk of the audio file and to use more multimedia in some parts of the lecture instead of just a summary file.

5.5.1 Discipline Lecturer Review

The discipline lecturer was a senior lecturer teaching artificial intelligence and neural networks. The review was conducted in three sessions and, in total, lasted for about four hours. The main comments made by discipline reviewer are presented in **Table 5.7**.

Transaction	Classification	Comments
Modify	Problem	The reviewer was using a Mac which required some changes in file names
Modify*	Audio	Some audio files need to be re-recorded
Add	Navigation Icon	Preface needed Back icon
Modify	Icon Text	Next button is often crowded
Modify	Audio Control	Need more control in playing audio files
Add*	Text	Add summary file presented as bullets for each audio file
Add*	Animation/Presentation	Audio should go with bullets (keep learner more busy with the material) – Animated Bullets
Modify	Text	Add more text about Compression Ratio as a help section

Table 5.7: Main transactions made by the discipline lecturer

The reviewer was more concerned with presenting the material in a way that keeps the subject busy all the time. He also recommended a textual summary of the talk for each audio file and providing another option to play audio and summary as a presentation where the current point is highlighted to attract the subject's eyes. In other words, he suggested that the subjects should be involved with more than one sensory channel in the learning process. The reviewer was also concerned with the quality of the audio and adding more text to help explain the content more.

5.5.2 Domain Student Review

The domain student was a research student working with Microcontrollers. The review was conducted in two sessions and lasted for about three and a half hours. The main comments of the review are shown in **Table 5.8.**

Transaction	Classification	Comments
Modify *	Page Design	Split the screen vertically into two frames using the left frame as an index and the right frame as a load area
Modify	Page Design	Move the next icon to the bottom of the page
Modify	Control of video screen	Frame containing AVI file should have more control features
Modify	Presentation	Text in the presentation needs to go with the audio file

Table 5.8: Main transactions made by the domain student

The reviewer was concerned with the page design, where the index is shown on the left of the screen and the body of the text on the right. He gave an example of Windows 95 Explorer where folders are shown on the left and files on the right. Also, he recommended re-working some of the slide show presentation.

5.5.3 Discipline Student Review

The discipline student reviewer was a research student working on Case Tools. The review was conducted in two sessions and lasted for about three hours. The main comments of the review are in **Table 5.9.**

Transaction	Classification	Comments
Add *	Link and Design	There is a need for a status bar or Icon that can tell the users where they are and which parts they have finished
Modify *	Page Design	Divide the screen into two frames and use skeleton graph as an index to reflect the design metaphor
Modify/Add	Presentation Control	Need more control of the slide show presentations e.g. backward and forward movement
Modify/Add	Video Screen	The video screen is too small. "The idea was very attractive but if the screen were bigger I would have enjoyed it much more"
Add *	Audio	Add an audio title for each vertebra to remind the user of what is covered in each section of the lecture
Modify/Add	Audio	There is a need to rewind the audio file
Modify	Pictures/Ambiguous	Blue colour used in some images title thought to be a link
Add *	Multimedia/Animation	Use more multimedia files such as presentations with audio files (Text + Audio)

Table 5.9: Main transactions made by the discipline student

This reviewer was concerned with the page design, the use of a graphical index, image maps, and more use of multimedia such as Animation. The main revision transactions, made by the discipline student reviewer were marked with an asterisk and used in the last part of questionnaire **(See Appendix F.5)**.

The evaluator explained to each reviewer what the modification would look like to make sure that a common understanding was reached.

5.5.4 Analysis of the review process

Lecturers' comments were mainly about the content of the material, the grammar and the involvement of learners in more than one channel while studying the material. Students were more concerned with the appearance of the page, in presenting the material as an index on the left of the page and a body on the right. Discipline reviewers' common comments were about the use of more multimedia, such as animated bullets. Domain reviewers' common comments were about the navigation through the material. **Figure 5.5** shows the comments and modifications, or transactions, made by the four reviewers. Although some comments made by some reviewers were recorded as one occurrence, each could be considered as more. For example, some comments made by the domain lecturer were about the modification of the content of a whole page, e.g. Rib page. The reviewer recorded this as one transaction, whilst it could be recorded as several transactions.

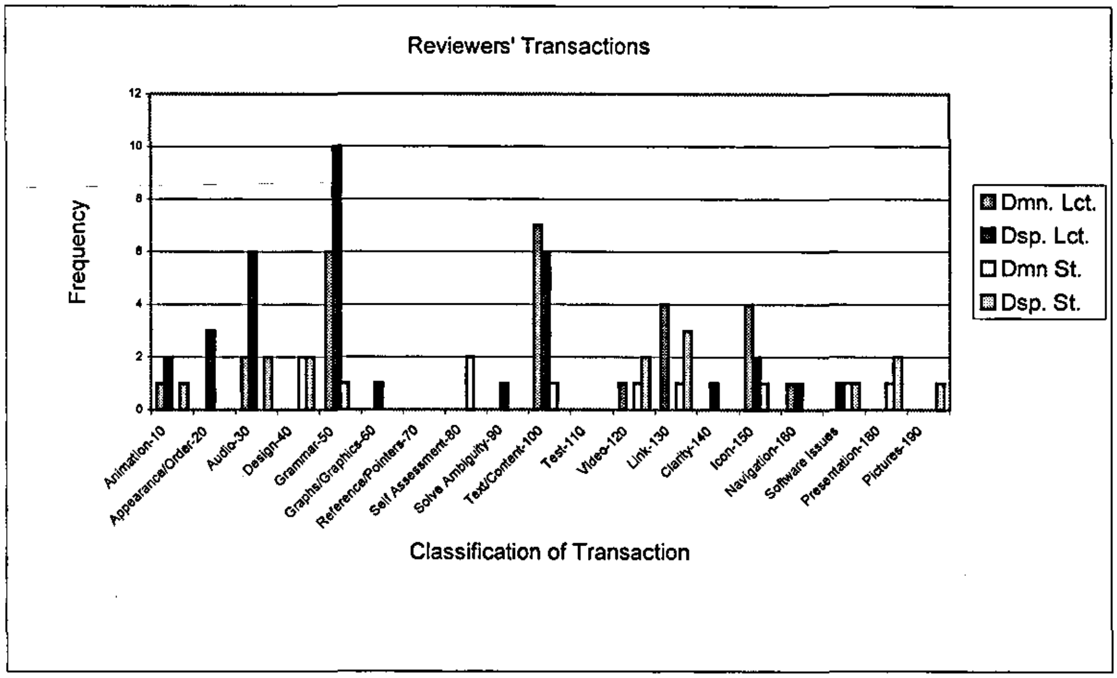

Figure 5.5: Frequency of transactions made by the four reviewers

The domain lecturer's modifications concentrated on text grammar and spelling, material content, page links and navigation, whereas the domain student focused upon the appearance, the order of the text within the page and the overall design of the material. The discipline lecturer encouraged the use of more animation with good quality of audio to involve the learner in more than one channel, e.g. animated bullets with audio. The discipline student modifications centred on the use of more multimedia e.g. animation, the use of graphical index that represented the skeleton metaphor, and providing a way that enhance the navigation of the material e.g. a status bar.

The modifications recommended by each reviewer, shown in **Table 5.10,** were listed in Part IV of the questionnaire (**see Appendix F.5**). Comments about missing pages and missing glossary terms were modified for all versions including the original. Comments about controlling the audio and video files were considered to be application problems. The machines used in the experiment were loaded with a better application, or better plug-in, providing more control features for playing audio and video files.

The main modifications suggested by each reviewer were listed as reasons for choosing a particular version over the other	B	C	D	E
1. Sound quality	✓	✓		
2. Sound summary	✓	✓		
3. Slide show with the sound file (animated bullets)		✓		✓
4. Big sound files were broken into small files showing the sound as bullets	✓			
5. Navigation buttons in the bottom of the screen (e.g. Index, Back)	✓	✓	✓	✓
6. The pages were broken vertically into index on the left and the body of the material on the right, which shows the content of the active point of the index			✓	
7. The graph index on the left of the screen and the content on the right, which shows the active index graphically				✓
8. The status bar on the bottom of the screen, which acts as an index, shows all visited sections of the material				✓
9. The audio at the beginning of the lecture and in the beginning of each section (vertebra), which highlights the content of the lecture and the content of the current section (vertebra).				✓

Table 5.10: The main modifications, listed as reasons for choosing a particular version over the other

5.5.5 Analysis of Reviewers' Questionnaire

The result of the first part of the reviewers' questionnaire is shown in **Figure 5.6**. The result shows that, on average, all reviewers agreed that, with the exception of multimedia used, the material in terms of the rated categories was good but needed some reworking regarding the quality of some media, such as audio, and using more multimedia, such as animation.

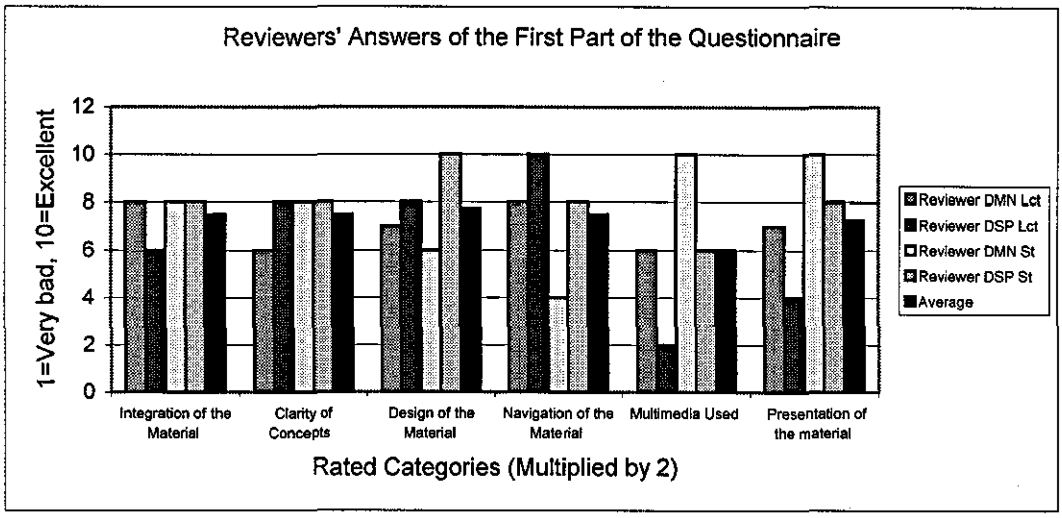

Figure 5.6: The first part of the reviewers' questionnaire

The purpose of the second part the questionnaire was to approximate the percentage of modification according to the reviewer's view. Domain reviewers, as shown in **Figure 5.7**, felt that 20% of the material needed modification. Discipline reviewers felt that more of the material needed modification.

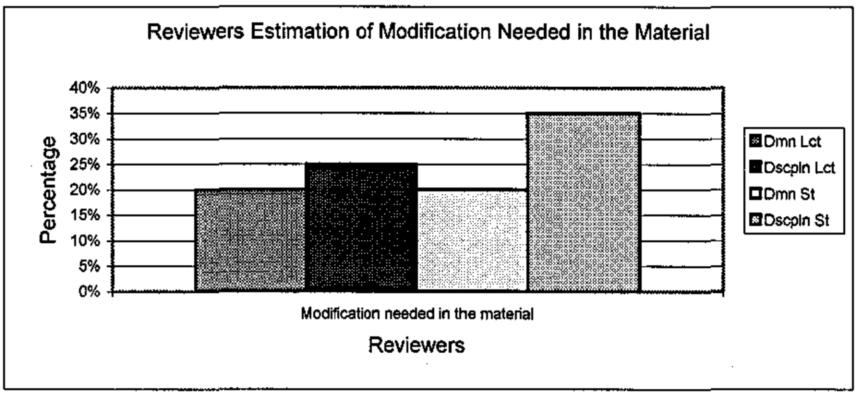

Figure 5.7: Estimated percentage of modifications needed as perceived by reviewers

The third part of the questionnaire was designed to capture reviewers' thoughts of what categories needed most modification, the best part and the worst part they found in the material. As shown in **Table 5.11**, lecturers criticised the quality of audio and students criticised the page design. Navigation was thought to be the best part in the material by the domain lecturer, whilst it was thought to be the worst part by the domain student. Overall, modifications were needed to: improve the quality of some audio files, improve navigation through the material and provide more multimedia.

Both students thought that the presentation of the material was the best thing in the material.

	Changes in	Best Part	Worse Part
Reviewer DMN Lct	Sound	Navigation	Sound
Reviewer DSP Lct	Sound	Design	Sound
Reviewer DMN St	Page Structure	Presentation of the material	Navigation
Reviewer DSP St	More Media Mix	Mix and Presentation	Navigation

Table 5.11: The result of the second part of reviewers' questionnaire

5.6 The Revised versions of the Material

As a result of the review process, four versions of the material were developed where each version was given a letter code[18]. The result of each review was reflected in each version. Despite the review process, the presentation of the material is similar in the five versions from the index page, or the skull shown in **Figure 5.8**, down to the spine of each lecture. Unit 0 in the index page is a help page, shown in **Appendix K** that explains the metaphor used in the design and an explanation of the screen layout for each version. Provided also in unit 0 is an explanation of the icons used in the material.

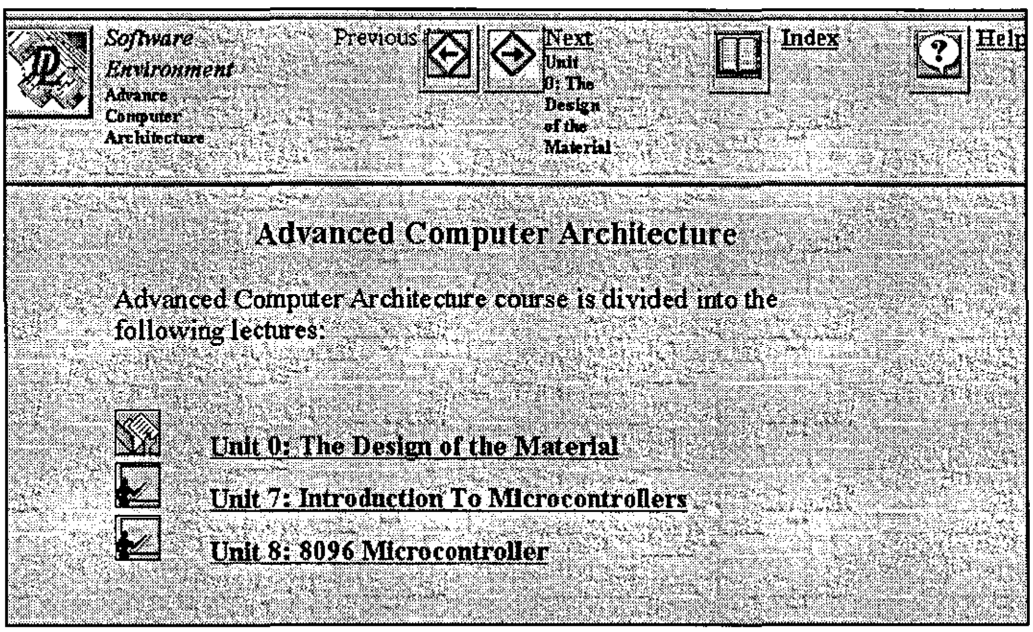

Figure 5.8: The index page, or the skull page, of the ACA module

[18] A = The original material (unrevised); B = Domain lecturer modifications; C = Discipline lecturer modifications; D = Domain student modifications; and E = Discipline student modifications

5.6.1 Version A – The Original Version

Each page of version A, shown in **Figure 5.9**, was divided into 3 frames: header, body and footer. The header frame contains information to navigate the material at the top level, to navigate through the lectures. At the bottom level, the header could be used to explore a lecture and navigate its sections (Vertebrae). The header contains three kinds of information that help the subjects to:

- Find their location in the lecture. The lecture title and the current section, or vertebrae, are shown as text at the left of the header. In **Figure 5.9**, for example, the lecture title is Microcontrollers (this is also a hypertext link that returns to the index page or head of the lecture, and the section title is Introduction (a bold text shows that it is the active or current section);
- Navigate through the lecture using the Back, Next or the Index Icons. The corresponding text of the icons was also used as a hypertext.
- Help information about the project in general was provided through clicking the icon in the left of the header (DL icon) and information about the material through clicking the icon in the right (Help icon).

The body frame contains the lecture notes, e.g. text, graphs, pictures etc. The footer frame was used in this version for the glossary of terms. In the glossary page, a menu of terms was written as a hypertext, which allows students to click any of the terms to find the explanation. The student can go back from the glossary page by clicking the browser's back button, or by clicking the right button of the mouse and then choose back. (it was not possible at that time to create a generic "go back" button in the textual content of the page)

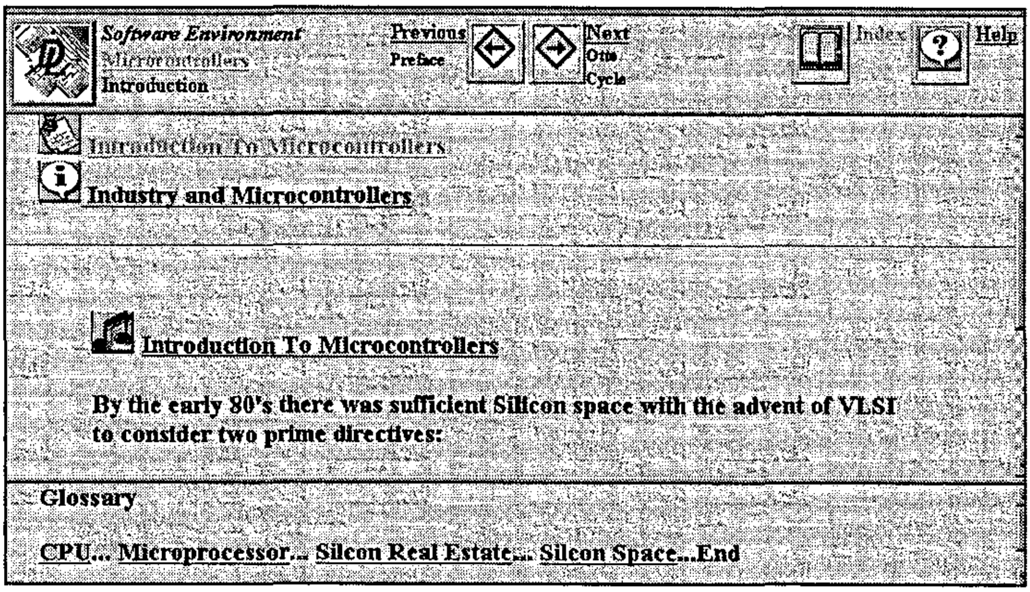

Figure 5.9: The screen of versions A, B and C contains three frames header (top), body and footer (bottom)

5.6.1.1 Pilot Test

10 students carried out the pilot evaluation studying only the original material, version A, since the other versions were not developed at that point. The following are the results of the pilot evaluation:

- The questionnaire needed further modification for the experiment.
- Some browser problems were solved.
- Install better players to control audio and video files.
- The students gained some learning after studying the material, with an average test result of 63.3.

5.6.2 Version B – Domain Lecture's Version

The screen layout of version B is basically the same as in version A. The difference is in the twofold use of the footer frame for the glossary of terms and the summary of audio files. With each audio file, as recommended by the reviewer, a summary of the main points that the talk covers was supplied. When the hypertext link of 'summary of sound' is clicked the file is downloaded, as shown in **Figure 5.10** into the footer frame.

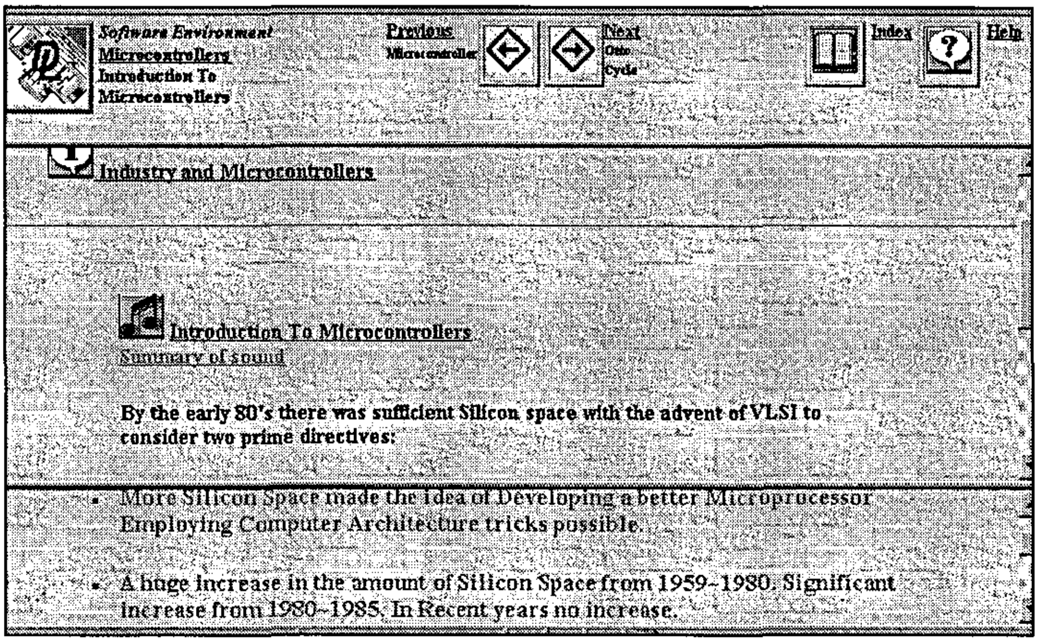

Figure 5.10: Version B - Summary of audio file loaded in the footer frame

The navigation buttons in the bottom of the screen are shown in **Figure 5.11**. These added buttons allow sequence navigation of the material at any level, navigating the material vertebra by vertebra from the top to the bottom and vice versa. For example, if the next button is clicked in the index page, or the skull of a lecture, this would link to the first vertebra of the lecture and not the next lecture as the next icon of the header frame does. This was recommended by the reviewer to add, at the bottom of the page, an option to navigate the material sequentially in a consistent manner or page by page. The links of these buttons are the same for the other revised versions.

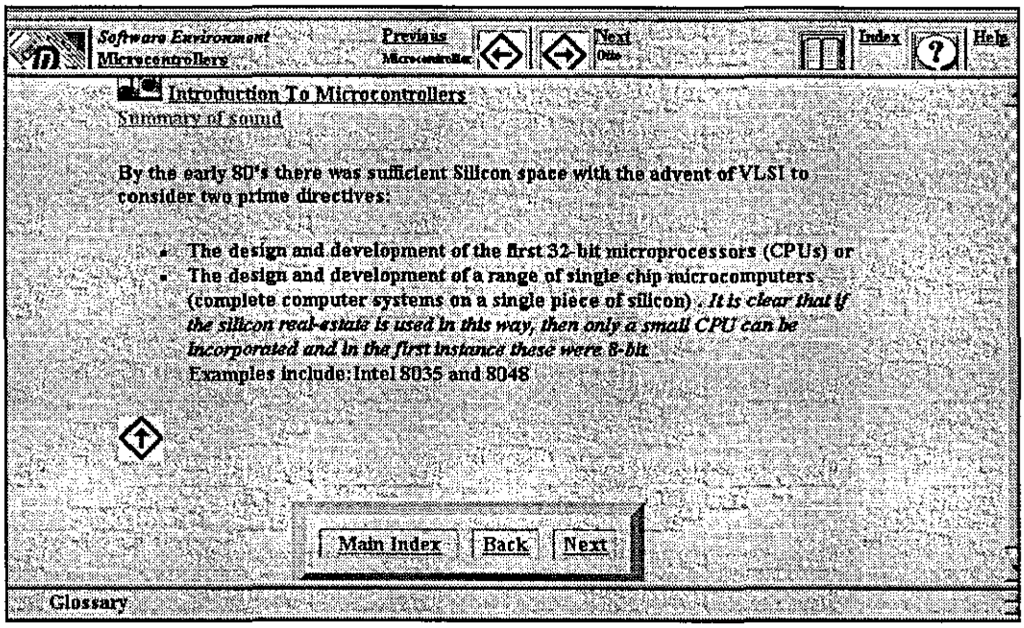

Figure 5.11: Version B - The navigation buttons suggested by the reviewer

The reviewer's suggestion to break the long audio file into bullet points is shown in **Figure 5.12** where the student has the choice to play the file as a whole or play it in parts. This feature was used specifically for a particular section, the Timing Section. In addition, the reviewer suggested the use of more multimedia presentation instead of just a summary file. The subject in this case has the choice to play the whole presentation that cover the Timing Section in one go or play each presentation separately as a sub-sections.

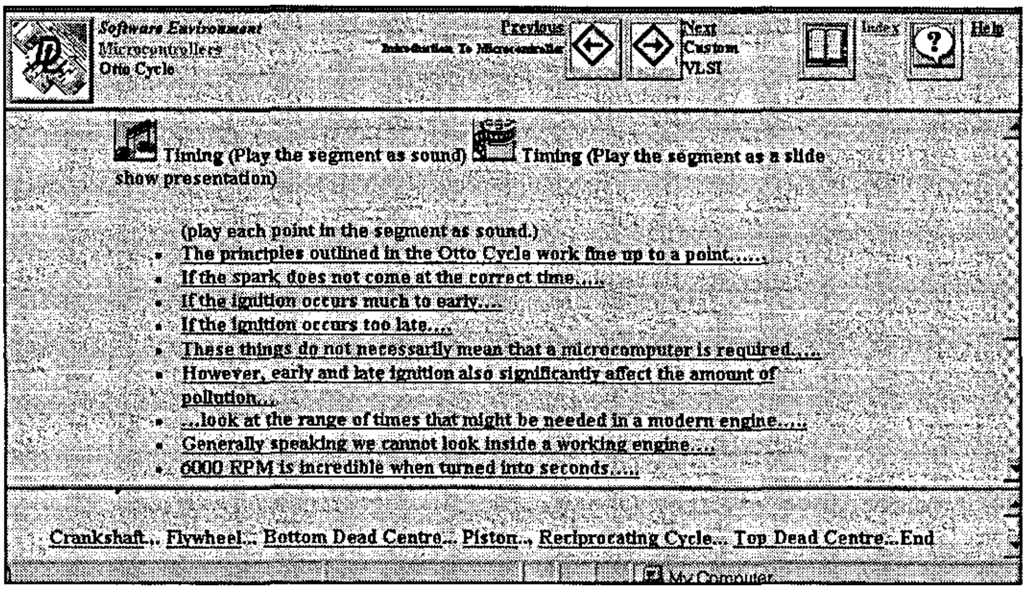

Figure 5.12: Version B - The audio file presented as bullet points

5.6.3 Version C – Discipline Lecture's Version

The screen layout of this version is the same as in versions A and B. The reviewer recommended the addition of a summary of the main point(s) covered in each audio file together with an option, shown in **Figure 5.13**, to play the audio as animated bullets. This was applied by using a slide show presentation for each audio file where the talk goes with highlighted bullet points.

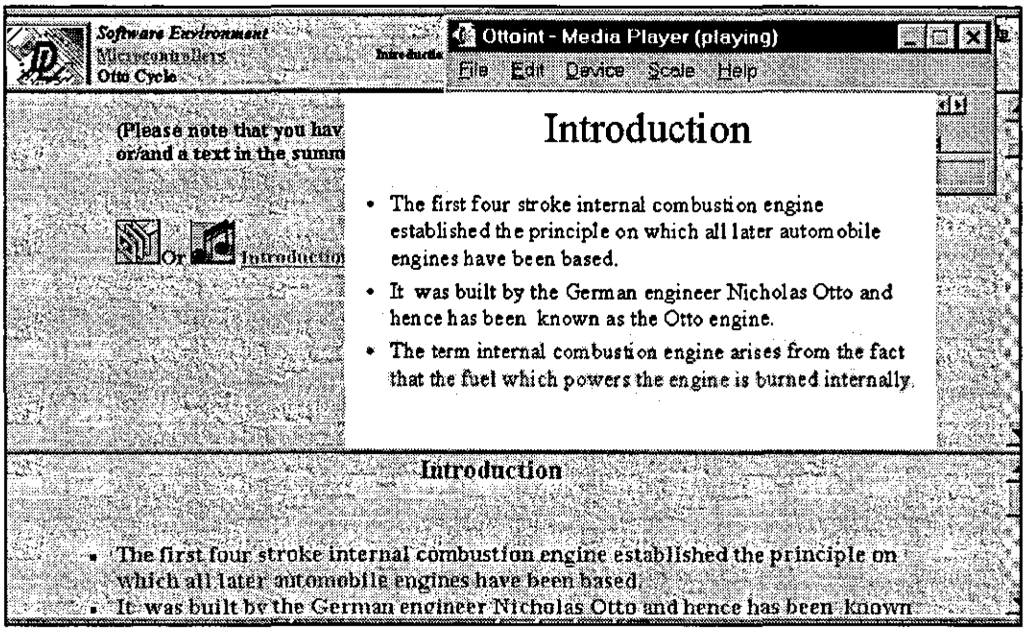

Figure 5.13: Version C - More choices were provided: audio file, summary of audio and slide show presentations

5.6.4 Version D – Domain Student's Version

The screen layout of this version is different from the other versions. The screen, shown in **Figure 5.14**, is divided into 3 frames: index, body and footer. The index frame contains the sections (vertebrae) titles that allow the subject to choose their navigation path. Whenever an item of the index is clicked the corresponding text appears in the body frame. The current section (vertebra) is always in black text and white background to indicate the location in the lecture. The footer frame is used for the glossary of terms.

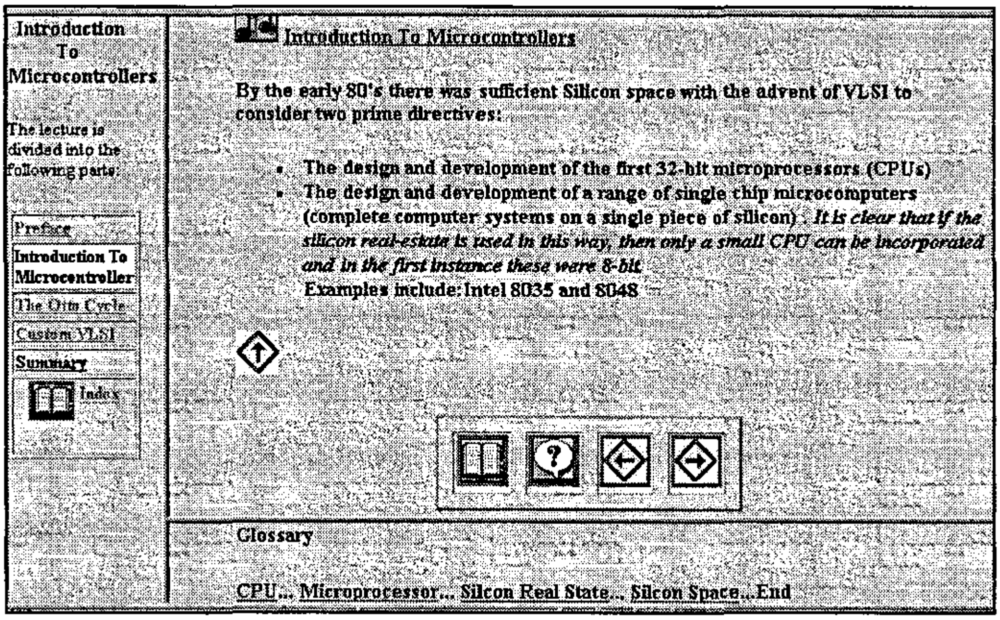

Figure 5.14: Version D - The screen layout

5.6.5 Version E – Discipline Student's Version

The screen layout of version E is similar to the screen layout of version D. The differences rest in the index frame where an image map, shown in **Figure 5.15**, was used as an index. The purpose of using the image map was to emphasise the metaphor used in the design of the material as recommended by the reviewer. As another recommendation was to use more multimedia where the students had the choice, as in version C, to play the audio file or play a slide show presentation that highlights the theme of the audio file. Also the reviewer recommended the use of a status bar, as shown in **Figure 5.16**, that shows which parts of the lecture have already been visited.

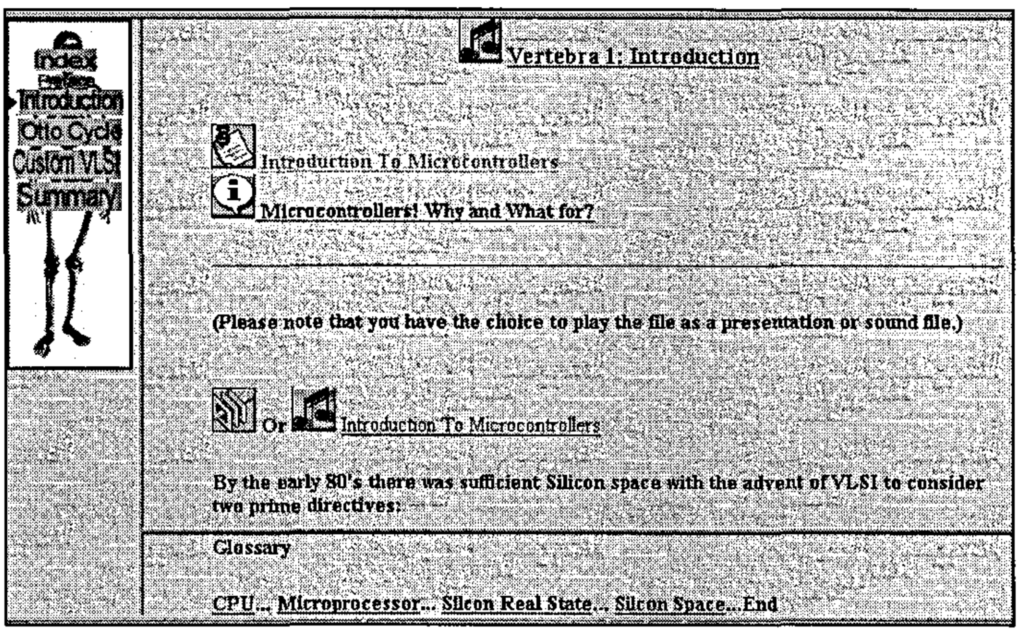

Figure 5.15: Version E - The screen layout showing the image map and audio title

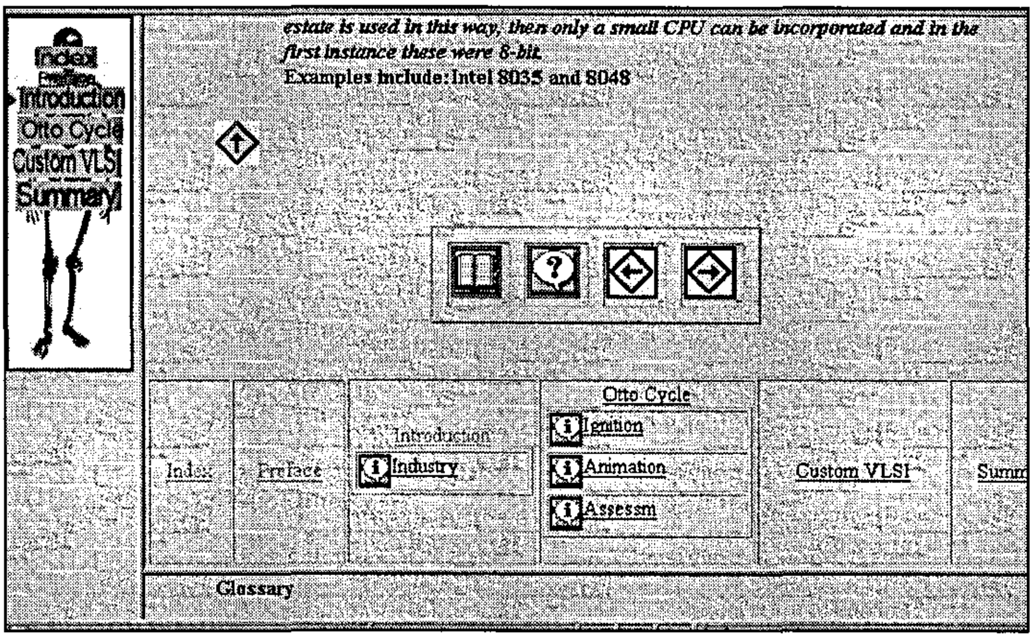

Figure 5.16: Version E - The status bar recommended by the reviewer

5.7 Conclusion

Two lectures of the "Advanced Computer Architectures" module were developed as Web-based multimedia material. A human skeleton metaphor was used in the design of the material where the skull represents the index page and the spine represents the theme of the material. The technique used to develop the material utilised fairly common software. The reason for using such software was to reduce the cost of the development process in terms of both money and time.

The cost of authoring the lectures, which were worth four hours of traditional lectures, was assessed to be 202 hours. In other words, each hour of traditional lecture costs about 50 hours in development time. This figure could have been reduced if the live lectures had been recorded in a better quality.

Although no study was found that measures the cost of development, in order to compare the result, an attempt was made to verify the result through collecting some development information from Distance Learning Initiative (DLI) team. The analysis of the data collected showed that the team members, or technical authors, have different opinions about the development process. However, half of them agreed with the findings in regard to the cost analysis and the development task analysis.

As part of the research, the developed material was used as input for four review sessions. Each review was conducted with a different reviewer who used a recommendation sheet to organise the modifications and translate them into transactions of three simple types: Add, Modify and Delete. The reviewers were two lecturers and two graduate students that were divided by their background expertise in the subject of the material into domain and discipline knowledge reviewers. The analysis of the review process, as lecturers and students, showed that lecturers were concerned more with the content of the material and the use of multimedia features. The material should reach and involve learners by more than one channel e.g. audio and vision. Students were concerned about navigation and the screen layout where the material is represented as an index frame in the left and a body frame on the right. However, as domain and discipline reviewers, the analysis of the review process showed that domain reviewers commented more about the navigation of the material, but discipline reviewers commented about the need for more use of multimedia.

As a result of the review process, four versions of the material were developed. Each version was given a letter code[Ψ] ranging from the letter A, the original material, to the letter E, Discipline student version. The main modifications, or transactions, used in each version that mark the reviewers were also used as part of the evaluation experiment (see Part IV of evaluation questionnaire - **Appendix F.5**).

The reviewers were also asked to evaluate the original material. The results of their evaluations showed that the material needed some modification to improve it.

Presented in the next chapter are the test results of the research hypotheses that investigate the quality of the revised versions in terms of students' satisfaction and students' learning.

[Ψ] The five versions code are: A - Unrevised;
B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer;
D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

Chapter Six

Research Analysis

6.0 Introduction

This chapter focuses on the research analysis, which is based on the methodology discussed in chapter 4. The analysis starts with a crosstabulation of Parts I and II of the questionnaire, that were designed to measure subjects' attitude toward Web-based lectures before and after the evaluation, and a crosstabulation of subjects' background and learning outcomes. The second part of the analysis focuses on the quality and usefulness of media through finding the correlation between the two variables. The third part of the analysis is the test of the research hypotheses. Finally, frequency analysis was carried out to analyse the last questions, 4 and 5, of Part IV of the questionnaire.

6.1 Crosstabulation Analysis

Crosstabulation of Parts I and II of the questionnaire was used to analyse the following:

- Subjects' preference and attitude to Web-based lectures before and after the experiment;
- Subjects' background and learning outcomes after studying the developed material.

6.1.1 Subjects' Preference Analysis

The first two questions of Part I of the questionnaire were designed to record subjects' attitude toward Web-based lectures before the evaluation (See **Appendix F.2**). These questions were linked to the first two questions of Part II, which were answered after the evaluation (See **Appendix F.3**). A crosstabulation method, shown in **Table 6.1**, was used to link and analyse these questions.

How would you prefer to study? * Preference After CBL Crosstabulation

			Preference After CBL			
			Whole Course	Some Lectures	Traditional	Total
How would you prefer to study?	Solely-Traditional	Count			2	2
		% of Total			5.0%	5.0%
	Solely-Non traditional	Count	1	1		2
		% of Total	2.5%	2.5%		5.0%
	Mix	Count	4	29	3	36
		% of Total	10.0%	72.5%	7.5%	90.0%
Total		Count	5	30	5	40
		% of Total	12.5%	75.0%	12.5%	100.0%

Table 6.1: Crosstabulation of questions 1 and 2 of Part I and Part II (N=40)

The data, presented in the above table, shows three types of subjects' preference of studying before and after the evaluation:

- Extremely traditional: these subjects represent only 5% of the sample, 2 students. They were not sure if they could learn through Web-based lectures but after the evaluation one subject thought that the material was the same as traditional material whilst the other thought it was worse (See **Table 1** in **Appendix H.1**).
- Extremely non-traditional: these subjects represents also 5% of the sample, 2 students. In contrast to the previous subjects, both thought they could learn through Web-based lectures and after the evaluation rated the material as better than traditional (See **Table 1** in **Appendix H.1**).
- Mix of the two: these subjects were the majority, 90% of the sample. Three students, 8% of these subjects, switched to preferring traditional methods after the evaluation, although 2 of them thought that the material was the same as traditional lectures. The rest of the subjects thought the material was better, 44%, or the same as a traditional class 50% (See **Table 4** in **Appendix H.1**).

The above result shows that the majority of the subjects were in favour of using a mixed mode of studying and a minority preferred only one mode. An explanation of why subjects choose to study in mixed mode maybe the use of a graphical interface, ease of use, and the willingness to use the World Wide Web. However, there were some subjects who preferred to study only in traditional mode and some switched from mixed mode, before the evaluation, to traditional mode, after the evaluation. What might explain this are their comments about the need for interaction with the lecturer where "questions need to be answered on the spot". Although the evaluator explained to these subjects that a group e-mail system was available to interact with the lecturer, they still insisted on the need for face-to-face or immediate interaction. Most of the switching occurs because of this issue (See the section about Subjects' Comments Analysis). The use of video conferencing technology might change these subjects' attitudes.

In summary, 95% of the subjects were willing to study in a non-traditional class, 10% of these were willing to study the whole course and the other 85% were willing to study part of the course as Web-based lectures (Percentages were derived from a crosstabulation and frequency tables provided in **Appendix H.1**).

6.1.2 Subjects' Background and Test Score Analysis

Question 3 of Part I was designed to record how the subjects rated their background knowledge in the developed material. Although the use of a pre-test would be more appropriate to assess subject's background, it was not used due to the added time required to conduct the evaluation. As an alternative, this question was used as a checkpoint for the evaluator to make sure that the subject had not studied the developed material. Although the experiment was limited to those subjects who had not studied the module, 25% of the subjects assessed their background knowledge as satisfactory. Their actual background was either in Microcontrollers or Automotive Engineering in general. In other words, the subjects did not have any actual background knowledge of the developed material.

The crosstabulation of the background variable and the test score, presented in **Table 6.2** and **Figure 6.1,** shows that 85% of the subjects answered more than 60% of the test questions correct. This seems to show that most subjects gained some knowledge after studying the material.

Background Knowledge * TESTSUM Crosstabulation

			TESTSUM							Total
			4.00	5.00	6.00	7.00	8.00	9.00	10.00	
Background Knowledge	Satisfactory	Count		1		3	5		1	10
		% of Total		2.5%		7.5%	12.5%		2.5%	25.0%
	Poor	Count	1	2	2	6	3	3		17
		% of Total	2.5%	5.0%	5.0%	15.0%	7.5%	7.5%		42.5%
	Very Poor	Count		2	2	3	5	1		13
		% of Total		5.0%	5.0%	7.5%	12.5%	2.5%		32.5%
Total		Count	1	5	4	12	13	4	1	40
		% of Total	2.5%	12.5%	10.0%	30.0%	32.5%	10.0%	2.5%	100.0%

Table 6.2: Crosstabulation of background knowledge and the test sum (N=40)

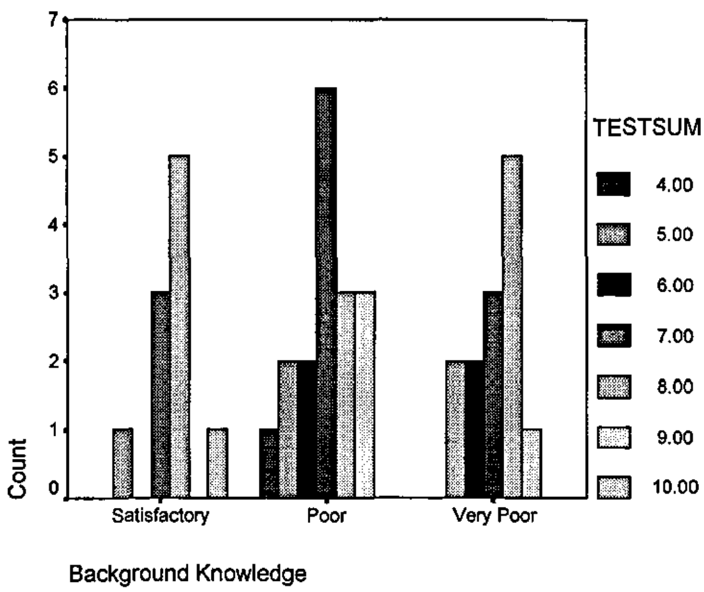

Figure 6.1: Crosstabulation of background knowledge and test sum (N=40)

The result of the last question of Part I, which was concerned with checking whether subjects had discussed the evaluation with others before the experiments commenced, is presented in **Table 6.3**. Their answers were 100% negative, which suggest that other subjects did not influence subjects' answers.

Discuss

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	40	100.0	100.0	100.0

Table 6.3: Students' answers of the last question of Part I (N=40)

6.2 Analysis of Quality and the Usefulness of the Media

The data collected regarding the media used to present the material was in two categories: the rated quality and the rated usefulness of the media used as perceived by the subjects in the evaluation. These media were Animation, Audio, Text, Video, Icons, Pictures, and Presentations. The analysis aims to answer two questions:

1. Did the subject rate the quality of the media different than its usefulness?
2. Is there significant correlation between the quality and the usefulness of the media?

To assess whether the subjects rated the quality of the media different than it's usefulness, a non-parametric test for paired data was an appropriate test since the data was of ordinal type. Two tests were used to compare the two variables, the Wilcoxon test and the Sign test. The reason for using both tests was to confirm the result of the first test since the first, Wilcoxon test, is considered a more powerful test but requires a symmetric distribution of the difference value between the two variables, Quality – Usefulness, while the sign test does not (Norušis, 1997 – p316). For each media, the null hypothesis that denies any difference between the two variables was tested. The results of the test, presented in **Table 6.4**, show that quality of media was significantly rated different than its usefulness for the Animation, Audio, Text, Video and Presentation. But in the case of Icons and Pictures they were not rated significantly different where $p = .261$ for the Icons and $p = .115$ for the Pictures (Full test results are shown in **Appendix H.2**).

Test	Hypothesis	Wilcoxon	p	Sign	P	Result
The rating of the quality of the Animation is the same as the rating of its usefulness	H0: $Q_{Anm} = U_{Anm}$ Ha: $Q_{Anm} \neq U_{Anm}$	-3.47	0.001	-3.00	0.003	Reject H0
The rating of the quality of the Audio is the same as the rating of its usefulness	H0: $Q_{Aud} = U_{Aud}$ Ha: $Q_{Aud} \neq U_{Aud}$	-4.99	0.000	-5.03	0.000	Reject H0
The rating of the quality of the Text is the same as the rating of its usefulness	H0: $Q_{Txt} = U_{Txt}$ Ha: $Q_{Txt} \neq U_{Txxt}$	-2.21	0.027	-2.05	0.040	Reject H0
The rating of the quality of the Video is the same as the rating of its usefulness	H0: $Q_{Vdo} = U_{Vdo}$ Ha: $Q_{Vdo} \neq U_{Vdo}$	-4.72	0.000	-4.38	0.000	Reject H0
The rating of the quality of the Icons is the same as the rating of its usefulness	H0: $Q_{Icn} = U_{Icn}$ Ha: $Q_{Icn} \neq U_{Icn}$	-1.12	0.261	-1.60	0.109	Accept H0
The rating of the quality of the Pictures is the same as the rating of its usefulness	H0: $Q_{Pct} = U_{Pct}$ Ha: $Q_{Pct} \neq U_{Pct}$	-1.57	0.115	-1.35	0.175	Accept H0
The rating of the quality of the Presentation is the same as the rating of its usefulness	H0: $Q_{Pst} = U_{Pst}$ Ha: $Q_{Pst} \neq U_{Pst}$	-3.48	0.000	-2.87	0.000	Reject H0

Table 6.4: Testing the null hypotheses of the quality and usefulness of the media

6.2.1 Correlation Analysis

Studying the interrelationship between the quality of media and its usefulness might explain whether the quality of the media was perceived as an important factor for its usefulness. Correlation coefficient tests are used to measure the degree of linear association between two variables. The result of the test is given by the value of the coefficient *r*, which ranges from '-1' to '+1'. When $r \neq 0$, the value of one variable could be used to estimate the value of the second variable. The closer the value to one end, '+1' or '–1', the stronger the relationship. If the value was toward '+1' this means that as the value of one variable increases the value of the second increases also, positive correlation. But if the value of *r* was toward '-1', this means that as the value of one variable increases the value of the second decreases. When $r = 0$ this means there is no linear association or correlation between the two variables.

Two tests were used to find the correlation coefficient of the two variables, quality and usefulness. The non-parametric Spearman's rho test was an appropriate test to find the correlation coefficient of the two variables since the data was of ordinal type. The second test, Pearson coefficient, was used to confirm the result of the first. The results of the tests, presented in **Table 6.5** and in **Appendix H.3** for more detail, shows that there is a positive correlation between the two variables for all media used ranging from r=0.306 to r=0.693 for Spearman's rho correlation coefficient and from r=0.316 to r=0.592 for Pearson Coefficient. With the value of $p < 0.05$, the null hypotheses is rejected and the alternative hypotheses is accepted, which in this case means that there was a positive correlation between the two variables. In other words, the higher the subjects rated the quality of media, the higher they rate its usefulness. It can be concluded that, across a broad spectrum of media, quality of media was found to be important factor for its usefulness and the media was more useful when the quality of the media was perceived high. In order to visualise the above results, **Table 6.5** and **Figure 6.2**, shows the mean of the rated quality and the rated usefulness.

Test	Hypothesis	Spearman's rho - *r*	Pearson *r*	Result
There is no correlation between the rating of the quality of the Animation and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.528**[19]	0.545**	Reject H0
There is no correlation between the rating of the quality of the Audio and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.306**	0.316**	Reject H0
There is no correlation between the rating of the quality of the Text and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.636**	0.579**	Reject H0
There is no correlation between the rating of the quality of the Video and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.413**	0.527**	Reject H0
There is no correlation between the rating of the quality of the Icons and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.634**	0.575**	Reject H0
There is no correlation between the rating of the quality of the Pictures and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.443**	0.400**	Reject H0
There is no correlation between the rating of the quality of the Presentation and the rating of its usefulness.	H0: r = 0 Ha: r ≠ 0	0.693**	0.592**	Reject H0

Table 6.5: Testing the correlation between the quality and usefulness of media (N=80)

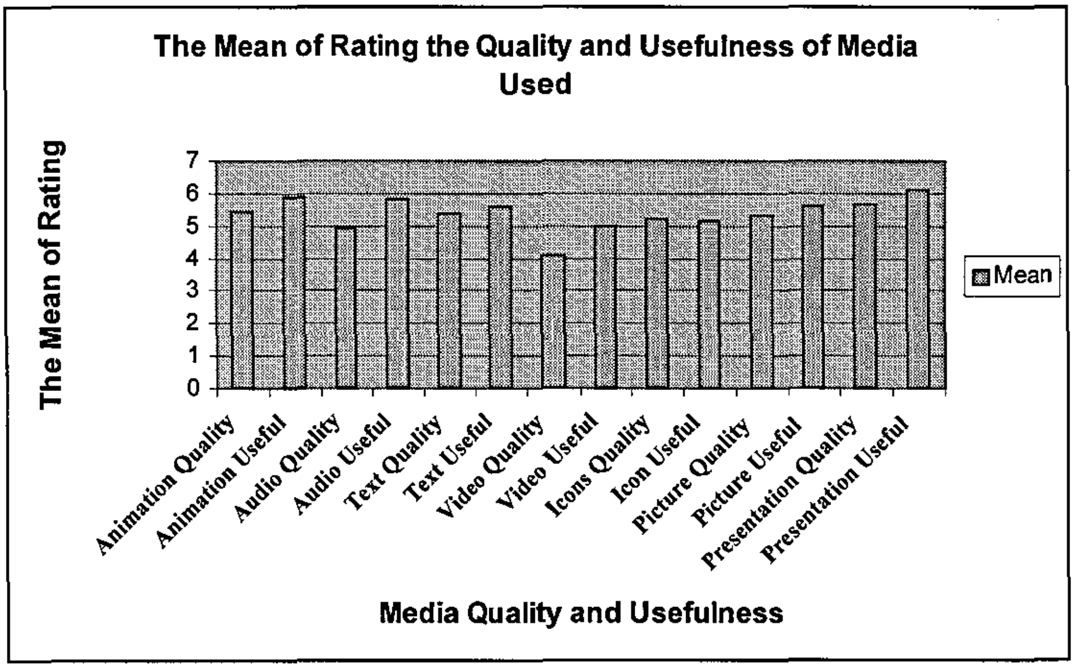

Figure 6.2: The mean of rated quality and rated usefulness (N=80; Range is 1-7)

Descriptive Statistics

	Mean	Std. Deviation	N
Animation Quality	5.44	1.09	80
Animation Useful	5.86	1.04	80
Audio Quality	4.91	1.19	80
Audio Useful	5.83	1.10	80
Icons Quality	5.23	1.29	80
Icon Useful	5.13	1.21	80
Picture Quality	5.34	1.25	80
Picture Useful	5.59	1.17	80
Presentation Quality	5.65	1.37	80
Presentation Useful	6.09	1.02	80
Text Quality	5.35	1.14	80
Text Useful	5.59	1.14	80
Video Quality	4.08	1.53	80
Video Useful	4.96	1.44	80

Table 6.6: The mean of rated quality and rated usefulness (N=80; Range is 1 - 7)

6.3 Research Hypotheses Analysis

The three main research hypotheses were divided into 20 sub-hypotheses, H1 through H20. H1 through H8 were derived from the first hypothesis, where H1 through H4 test the quality of the material in terms of subjects' satisfaction and H5 through H8 test the quality of the material in terms of subjects' learning. The purpose of these hypotheses is to investigate whether the revised Web-based materials are of a better quality than the unrevised material. H9 through H16 were derived from the second hypothesis, where H9 through H12 test the quality of the material in terms of subjects' satisfaction, and H13 through H16 test the quality of the material in terms of subjects' learning. The purpose of these hypotheses is to investigate whether discipline reviewers are better than domain reviewers. Finally, H17 through H20 were derived from the third hypothesis where H17 and H18 test the quality of the material in terms of subjects' satisfaction, and H19 and H20 test the quality of the material in terms of subjects' learning. The aim of these hypotheses is to investigate whether there is a difference between lecturers and students as reviewers of Web-based material.

[19] ** Correlation is significant at the 0.01 level (2-tailed). Total number of cases = 80

6.3.1 Analysing the First Hypothesis

Two categories need to be tested for each version of the material, subjects' satisfaction (provided through questionnaire data) and subjects' learning (provided through test data). It was out of the scope of this research to compare these categories with any traditional learning equivalent due to the research emphasis in comparing reviewer's contributions in producing a high quality material.

Subjects' satisfaction is measured by the mean of ratings of the three categories: ease of use, usefulness, and satisfaction. It was calculated as follows:

Overall Satisfaction = Sum (S1[20], S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13) / 12

Since the data was of ordinal type, non-parametric tests were used for the hypotheses that deal with subjects' satisfaction. The analysis starts with using a test to find whether overall satisfaction was rated differently in the five versions. The Kruskal-Wallis Test for several independent samples, that compares two or more groups of cases on one variable, was used to test the null hypotheses that denies any differences of subjects' rating of the five versions[Ψ]. As a result of the test the null hypothesis, with $p = .052$ shown in **Table 6.7,** was rejected which confirms that the five versions were significantly rated differently in regard to subjects' satisfaction.

[20] S1: Statement 1 in questions 5 and 3 of Part II and IV.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

Ranks

	Version Code	N	Mean Rank
Over All Satisfaction	A	16	32.94
	B	16	42.66
	C	16	50.38
	D	16	29.69
	E	16	46.84
	Total	80	

Test Statistics[a,b]

	Over All Satisfaction
Chi-Square	9.400
df	4
Asymp. Sig.	.052

a. Kruskal Wallis Test

b. Grouping Variable: Version Code

Table 6.7: The Kruskal-Wallis test results (N=16 for each group)

6.3.1.1 Testing H1 through H4 – Satisfaction

Since the rating of overall satisfaction was of ordinal type, the non-parametric Mann-Whitney test was used to validate H1 through H4. The details of the test results are presented in **Appendix H.4** and the summary of the tests is presented in **Table 6.8.**

Test No.	Test	Hypothesis	Mann-Whitney	One-tailed *p*	Significant at .05
H1	Group A perceptions toward satisfaction are the same as group B.	$H0{:}\mu_A = \mu_B$ $Ha{:}\mu_A < \mu_B$	93.5	0.096	Accept H0
H2	Group A perceptions toward satisfaction are the same as group C	$H0{:}\mu_A = \mu_C$ $Ha{:}\mu_A < \mu_C$	69	0.013	Reject H0
H3	Group A perceptions toward satisfaction are the same as group D	$H0{:}\mu_A = \mu_D$ $Ha{:}\mu_A < \mu_D$	112	0.27	Accept H0
H4	Group A perceptions toward satisfaction are the same as group E	$H0{:}\mu_A = \mu_E$ $Ha{:}\mu_A < \mu_E$	84.5	0.05	Reject H0

Table 6.8 Test results of H1 – H4 (N=16 for each group)

The results of tests are as follows:

- Accept the null hypothesis of H1. This means that version B[Ψ], with mean of rank = 18.66, was not significantly more satisfactory than version A, with mean of rank =14.34.
- Reject the null hypothesis of H2. The alternative hypothesis, that is version C was more satisfactory than version A, is accepted since the value of one-tailed p is less than 0.05.
- Accept the null hypothesis of H3. The mean of rank of version A =17.50 and version D = 15.50 which means that version D was not more satisfactory than version A.
- Reject the null hypothesis of H4. The alternative hypothesis, that is version C was more satisfactory than version A, is accepted since the value of one-tailed p is less than 0.05.

Two versions, C and E, were significantly rated more than version A, but versions B and D were not. For the latter versions, the mean of rank of version B was more than version A but for version D, it was less. As a result, versions C and E were found more satisfactory than version A. Version B was also found more satisfactory, but not significantly more, than version A. Version D was not more satisfactory than version A.

It can be concluded that, in terms of subjects' satisfaction, not all revised materials were better than the unrevised material. The material reviewed by the discipline reviewers (implemented as versions C and E) gained subjects' satisfaction more than the unreviewed material, version A. But the material reviewed by the domain reviewers (implemented as versions B and D) were not significantly better than the unreviewed material.

What might explain subjects' satisfaction with versions C and E is the presence of more features in these versions than versions B and D (See Frequency Analysis

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

Section for more about these features). It seems that the more features there are in the material the more satisfied students would be.

6.3.1.2 Testing H5 through H8 – Learning

H5 through H8 is the second part of the first hypothesis. This part of the hypothesis examines the quality of the material in terms of learning outcome. Since the data is of scale type, parametric tests such as ANOVA and t-test could be used. One-way Analysis Of Variance (ANOVA) is used to determine whether the five versions[Ψ] have equal means by testing the null hypothesis that states that the mean test score for all five version is the same. The t-test is used to compare the mean of two groups by testing the null hypothesis that the mean of the two groups is the same. These parametric tests assume a normal distribution of the tested variables.

- Normal Distribution Test

The normal distribution tests were used to examine the distribution of test score values in the five group. The results of the test are presented in **Appendix H.5**. Since the values of p of the normal distribution tests, Kolmogorov-Smirnov and Shapiro-Wilk are small for the five groups, the normal distribution of the values is doubtful. For this reason two tests are used to examine the equality of means of the five versions, a parametric test, that requires normal distribution and a non-parametric test that does not require normal distribution of the values.

- ANOVA Test (Parametric) and Kruskal-Wallis Test (Non-Parametric)

The analysis starts with using tests to find whether the test score was different in the five versions. The One-way analysis of variance (ANOVA) and Kruskal-Wallis Test was used to test the null hypothesis that assumes the equality of the test score of the five versions.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

The result of the ANOVA test, shown in **Table 6.9**, shows a significant difference with F(4) = 4.070 and p = 0.008 among the five groups. The Kruskal-Wallis Test, shown in **Table 6.10**, with χ^2=13.20 and p = 0.01 confirms the result and rejects the null hypothesis. This leads to the acceptance of the alternative hypothesis that the five group test scores were different.

ANOVA

TESTSUM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22.150	4	5.538	4.070	.008
Within Groups	47.625	35	1.361		
Total	69.775	39			

Table 6.9: The result of the ANOVA test (N=8 for each group)

Ranks

	Version Code	N	Mean Rank
TESTSUM	A	8	11.38
	B	8	21.00
	C	8	28.00
	D	8	15.13
	E	8	27.00
	Total	40	

Test Statistics[a,b]

	TESTSUM
Chi-Square	13.200
df	4
Asymp. Sig.	.010

a. Kruskal Wallis Test

b. Grouping Variable: Version Code

Table 6.10: The Kruskal-Wallis Test (N=8 for each group)

- ANOVA Post Hoc Test

The Bonferroni multiple comparison procedure was used as a post hoc analysis of the group means. The results, presented in **Table 6.11,** identify a significant difference ($p < .05$) between version A and versions C and E. Since the normal distribution was doubtful and the significant level of this procedure is reduced to 0.01, (Norušis, 1997 - p269), further comparisons were conducted separately through the use of t-test and Mann-Whitney as explained next.

Multiple Comparisons

Dependent Variable: TESTSUM
Bonferroni

(I) Version Code	(J) Version Code	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
A	B	-1.2500	.583	.391	-2.9974	.4974
	C	-1.8750*	.583	.028	-3.6224	-.1276
	D	-.3750	.583	1.000	-2.1224	1.3724
	E	-1.7500*	.583	.049	-3.4974	-2.56E-03
B	A	1.2500	.583	.391	-.4974	2.9974
	C	-.6250	.583	1.000	-2.3724	1.1224
	D	.8750	.583	1.000	-.8724	2.6224
	E	-.5000	.583	1.000	-2.2474	1.2474
C	A	1.8750*	.583	.028	.1276	3.6224
	B	.6250	.583	1.000	-1.1224	2.3724
	D	1.5000	.583	.145	-.2474	3.2474
	E	.1250	.583	1.000	-1.6224	1.8724
D	A	.3750	.583	1.000	-1.3724	2.1224
	B	-.8750	.583	1.000	-2.6224	.8724
	C	-1.5000	.583	.145	-3.2474	.2474
	E	-1.3750	.583	.241	-3.1224	.3724
E	A	1.7500*	.583	.049	2.561E-03	3.4974
	B	.5000	.583	1.000	-1.2474	2.2474
	C	-.1250	.583	1.000	-1.8724	1.6224
	D	1.3750	.583	.241	-.3724	3.1224

*. The mean difference is significant at the .05 level.

Table 6.11: The results of Bonferroni procedure (N=8 for each group)

- Separate Comparison Using t-Test and Mann-Whitney Test

To compare the mean of test score for version A[Ψ] against the other four versions, two tests were used the t-test and the Mann-Whitney Test. The reason for using the non-

[Ψ] The five versions code are: A - Unrevised;

parametric Mann-Whitney test with the parametric t-test is to confirm the result of the t-test since this test assumes a normal distribution of the variable while the latter does not. The results of testing the hypotheses H5 through H8 are shown in **Table 6.12.** More detail is presented in **Appendix H.6.**

Test	Test	Hypothesis	Mann-Whitney	One-tailed *P*	t-test	One-tailed *P*	Result
H5	The test scores of group A are the same as group B.	$H0{:}\mu_A = \mu_B$ $Ha{:}\mu_A < \mu_B$	15.500	0.036	-1.961	0.035	Reject H0
H6	The test scores of group A are the same as group C.	$H0{:}\mu_A = \mu_C$ $Ha{:}\mu_A < \mu_C$	6.00	0.025	-3.910	0.01	Reject H0
H7	The test scores of group A are the same as group D.	$H0{:}\mu_A = \mu_D$ $Ha{:}\mu_A < \mu_D$	25.500	0.241	-0.587	0.2835	Accept H0
H8	The test scores of group A are the same as group E.	$H0{:}\mu_A = \mu_E$ $Ha{:}\mu_A < \mu_E$	8.000	0.005	-3.300	0.0025	Reject H0

Table 6.12: Testing H5 - H8 using Mann-Whitney and t-Test (N=8 for each group)

The results of the tests are as follow:

- Reject the null hypotheses of H5, H6 and H8, since the *p* value of one-tailed for Mann-Whitney test and t-test is < 0.05. The alternative hypothesis that the test scores of groups B, C and E were more than the test score of group A is accepted.
- Accept the null hypothesis of H7 since the value of one-tailed for both tests is more than 0.05. The mean of test score for version A is 6.12 and for version D is 6.5.

The null hypothesis was rejected in the case of hypotheses H5, H6, and H8. We can conclude that subjects who studied version B, version C, or version E scored more in the test than version A. But the null hypothesis, H7, was accepted which concludes that subjects who studied version D did not score significantly more than version A with a mean rank of 9.31 and 7.69 for versions D and A respectively. We can clearly cite cases B, C and E as proving that reviewing the material significantly enhances learning outcome but, in the case of version D, reviewer D was not as good as the

B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer;
D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

other reviewers. But it can be concluded that, in terms of students' learning, all revised materials were better than the unrevised material.

In summary the above results show the following about the first hypothesis:

- It has been shown that a review by discipline knowledge reviewers resulted in a higher quality material, in terms of students' satisfaction and learning, than the unrevised material.
- It has been shown that a review by a domain lecturer resulted in a higher quality material, in terms of students' learning, than the unrevised material.
- It has been shown that a review by a domain lecturer resulted in quality of material, in terms of students' satisfaction, that is not significantly higher than unrevised material.
- It has been shown that a review by a domain student resulted in quality of material, in terms of students' satisfaction and learning, that is the same as the unrevised material.

6.3.2 Analysing the Second Hypothesis

Again the second hypothesis was divided into 8-sub hypotheses H9 – H16 that test the quality of the material in terms of student's satisfaction and learning. The Mann-Whitney test was applied to examine H9 through H12 that investigate subjects' overall satisfaction and the t-test plus the Mann Whitney to examine H13 through H16 that investigate the learning outcome.

6.3.2.1 Testing H9 through H 12 - Satisfaction

A summary of the results of testing the null hypothesis of H9 through H12 is presented in **Table 6.13**. The detail of these tests is shown in **Appendix H.7**.

Test No.	Test	Hypothesis	Mann-Whitney	One-tailed *P*	Result
H9	B[Ψ] group perceptions toward satisfaction are the same as group C.	$H0:\mu_{BO} = \mu_{CO}$ $Ha:\mu_{BO} < \mu_{CO}$	95.500	0.11	Accept H0
H10	C group perceptions toward satisfaction are the same as group D.	$H0:\mu_{CO} = \mu_{DO}$ $Ha:\mu_{CO} > \mu_{DO}$	65.000	0.0085	Reject H0
H11	B group perceptions toward satisfaction are the same as group E.	$H0:\mu_{BO} = \mu_{EO}$ $Ha:\mu_{BO} < \mu_{EO}$	113.500	0.292	Accept H0
H12	D group perceptions toward satisfaction are the same as group E.	$H0:\mu_{DO} = \mu_{EO}$ $Ha:\mu_{DO} < \mu_{EO}$	81.000	0.038	Reject H0

Table 6.13: Testing H9 - H12 using Man-Whitney test (N=16 for each group)

The results of the tests are as follow:

- Accept the null hypothesis of H9. This means that version C, with a mean of rank = 18.53, was not significantly more satisfactory than version B, with mean of rank =14.47.
- Reject the null hypothesis of H10. The alternative hypothesis, that is version C was more satisfactory than version D, is accepted since the value of one-tailed p is < 0.05.
- Accept the null hypothesis of H11. The mean rank of version B = 15.59 and for version E = 17.41 which means that version E was not significantly more satisfactory than version B
- Reject the null hypothesis of H12. The alternative hypothesis, that is version E was more satisfactory than version D, is accepted since the value of one-tailed p is < 0.05.

The results shows that versions C and E were significantly rated more than version D, but not significantly more than version B. As a result, versions C and E were found more satisfactory than version D but not significantly more satisfactory than B.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

It can be concluded that discipline reviewers produced higher quality material, in terms of students' satisfaction, than a domain student reviewer. However, discipline reviewers produced same quality material, in terms of students' satisfaction, as domain lecturer.

6.3.2.2 Testing H13 through H16 – Learning

A summary of the results of testing the null hypothesis of H13 through H16 is presented in **Table 6.14**. The detail of these tests is shown in **Appendix H.8**.

Test	Test	Hypothesis	Mann-Whitney	One-tailed *P*	t-Test	One-tailed *P*	Result
H13	The test score of group B[Ψ] are the same as group C.	$H0{:}\mu_B = \mu_C$ $Ha{:}\mu_B < \mu_C$	20.000	0.0915	-1.106	0.1435	Accept H0
H14	The test score of group C are the same as group D.	$H0{:}\mu_C = \mu_D$ $Ha{:}\mu_C > \mu_D$	11.000	0.0105	2.646	0.0115	Reject H0
H15	The test score of group B are the same as group E.	$H0{:}\mu_B = \mu_E$ $Ha{:}\mu_B < \mu_E$	22.000	0.1365	-.821	0.2125	Accept H0
H16	The test score of group D are the same as group E.	$H0{:}\mu_D = \mu_E$ $Ha{:}\mu_D < \mu_E$	13.000	0.0195	-2.252	0.0205	Reject H0

Table 6.14: Testing H13-H16 using Mann-Whitney and t-Test (N=16 for each group)

The results of the tests are as follows:

- Accept the null hypothesis of H13 since the value of one-tailed *p* for both tests are more than 0.05. The mean of the test score for version B = 7.37 and for version C = 8.00.
- Reject the null hypothesis of H14. The alternative hypothesis, that is version C was more satisfactory than version D, is accepted since the value of one-tailed *p* is < 0.05.
- Accept the null hypothesis of H15 since the value of one-tailed *p* for both tests is more than 0.05. The mean of test score is 7.37 for version B and 7.87 for version E.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

- Reject the null hypothesis of H16, since the value of one-tailed p for Mann-Whitney test and t-test is < 0.05. The alternative hypothesis that the test score of group E was more than the test score of group D is accepted.

The results show that subjects who studied versions C or E scored significantly more than version D and more than, but not significantly, those who studied version B. In other words, the quality of version C and E was higher than version D in terms of learning outcome.

In summary the above results show the following about the second hypothesis:

- It has been shown that a review by discipline knowledge reviewers resulted in a higher quality material, in terms of students' satisfaction and learning, than a review conducted by a domain knowledge student.
- It has been shown that a review by discipline knowledge reviewers resulted in a quality of material, in terms of students' satisfaction and learning, that is the same as a review conducted by domain knowledge lecturer.

6.3.3 Analysis of the Third Hypothesis

The third hypothesis was stated as the null hypothesis:

- Lecturers (versions B and C) and graduate students (versions D and E) as reviewers produced the same quality of material in terms of student's satisfaction and learning. The hypothesis was divided into 4-sub hypotheses – H17 to H20.

6.3.3.1 Testing H17 and H18 - Satisfaction

A summary of the results of testing the null hypothesis of H17 through H18 is presented in **Table 6.15**. The detail of these tests is shown in **Appendix H.9**.

Test No.	Test	Hypothesis	Mann-Whitney	One-tailed *P*	Result
H17	B group perceptions toward satisfaction are the same as group D.	$H0: \mu_{BO} = \mu_{DO}$ $Ha: \mu_{BO} > \mu_{DO}$	81.000	0.038	Reject H0
H18	C group perceptions toward satisfaction are the same as group E.	$H0: \mu_{CO} = \mu_{EO}$ $Ha: \mu_{CO} > \mu_{EO}$	124.500	0.4475	Accept H0

Table 6.15: Testing H17 - H18 using the Mann-Whitney test (N=16 for each group)

The results of the tests are as follows:

- Reject the null hypothesis of H17. The alternative hypothesis, that is version B was more satisfactory than version D, is accepted since the value of one-tailed *p* is < 0.05.
- Accept the null hypothesis of H18. This means that version C, with a mean of rank = 16.72, was the same as version E, with a mean of rank =16.28.

The results show that versions B[Ψ] was rated significantly more than version D. That means that subjects were more satisfied with version B than version D. However there was no significant difference between versions C and E. That means that subjects were similarly satisfied with version C and version E. What might explain subjects' heightened satisfaction with versions B is the presence of more features in version B more than version D (See Frequency Analysis Section for more about these features).

It can be concluded a domain lecturer review produced a higher quality material, in terms of students' satisfaction, than a domain student review. However, the quality of the material resulting from the discipline lecturer review, in terms of students' satisfaction, was found to be the same as the discipline student review.

6.3.3.2 Testing H19 and H20 – Learning

A summary of the results of testing the null hypotheses of H19 and H20 is presented in **Table 6.16**. The detail of these tests is shown in **Appendix H.10**.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

Test	Test	Hypothesis	Mann-Whitney	One-tailed *P*	t-Test	One-tailed *P*	Result
H19	The test scores of group B are the same as group D.	H0:$\mu_B = \mu_D$ Ha:$\mu_B > \mu_D$	22.500	0.1465	1.240	0.118	Accept H0
H20	The test scores of group C are the same as group E.	H0:$\mu_C = \mu_E$ Ha:$\mu_C > \mu_E$	31.000	0.455	.284	0.391	Accept H0

Table 6.16: Testing H19-H20 using the Mann-Whitney and the t-Test (N=8)

The results of the test are as follows:

- Accept the null hypothesis of H19 since the value of one-tailed *p* for both tests are more than 0.05. The mean of the test score for version B = 7.37 and for version D = 6.50.
- Accept the null hypothesis of H20 since the value of one-tailed *p* for both tests are more than 0.05. The mean of the test scores for version C = 8.00 and for version E = 7.87.

The results show that there was no difference between versions C and E in terms of subjects' satisfaction and subjects' learning. But in the case of versions B and D, B was more satisfactory than version D, but the test scores were the same. In other words, subjects who studied version D (that was reviewed by a domain student) scored the same in the test as subjects who studied version B (that was reviewed by a domain lecturer).

In summary, the above results show the following about the third hypothesis:

- It has been shown that a review by a domain knowledge lecturer resulted in a higher quality material, in terms of students' satisfaction, than a review by domain knowledge student.
- It has been shown that a review by a domain knowledge lecturer resulted in a quality material, in terms of students' learning, that is the same as a review by domain knowledge student.
- It has been shown that a review by a discipline knowledge lecturer resulted in a quality material, in terms of students' satisfaction and learning, that is the same as a review by discipline knowledge student.

To confirm the results of hypotheses that deal with students' satisfaction, the test (Mann-Whitney) was repeated on independent data. The related data was removed and the size of the evaluations for each group was reduced to 14 instead of 16. This was done by removing the first evaluation of the related data. For example, to test version A evaluations against version B, shown in **Table 6.17**, the related data was removed in the following way:

Subject	1st evaluation version	2nd evaluation version
1	A	B
2	B	A
3	A	B
4	B	A

Table 6.17: Removing the related data when testing A against B

The first evaluation was removed from each subject leaving only the second. As a result, version A evaluations were independent of B (in terms of the evaluator). Two evaluations were removed from each version. The results of the tests, shown in **Appendix H.12,** confirms the previous results with the exception of H8 with p = 0.085. Although the results were weakened when removing such data, there remains a high level of significance.

6.4 Frequency Analysis

In the experiment each subject evaluated two versions of the material. The last questions of Part IV of the questionnaire were designed to compare the two versions in terms of 9 categories (See **Appendix F.5**). The purpose of these questions was to support hypothesis results through frequency analysis of the preferred categories of each version. The frequencies of each category preferred for each version is presented in **Figure 6.3.** More than 30% of the subjects found that there was no difference in the audio, animation and the presentation categories in all versions[Ψ]. Categories of versions C, E and B were all preferred more than versions A and D. Also version C and E were almost equally preferred and, similarly, were versions A and D. This

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

result supports the results of the hypotheses test that the quality of versions B, C and E, as perceived by subjects, were better than versions A and D.

Figure 6.4, shows the frequency analysis of question 5-A that was designed to let the subject choose the preferred version overall. The figure shows that the highest frequencies were for versions C and E, where 60% of the subjects chose them equally, then version B where 22.5 % of the subjects chose it and 20% of subjects equally chose versions A and D. This result also supports the previous results of the hypotheses that versions C, E and B were more satisfactory than versions A and D.

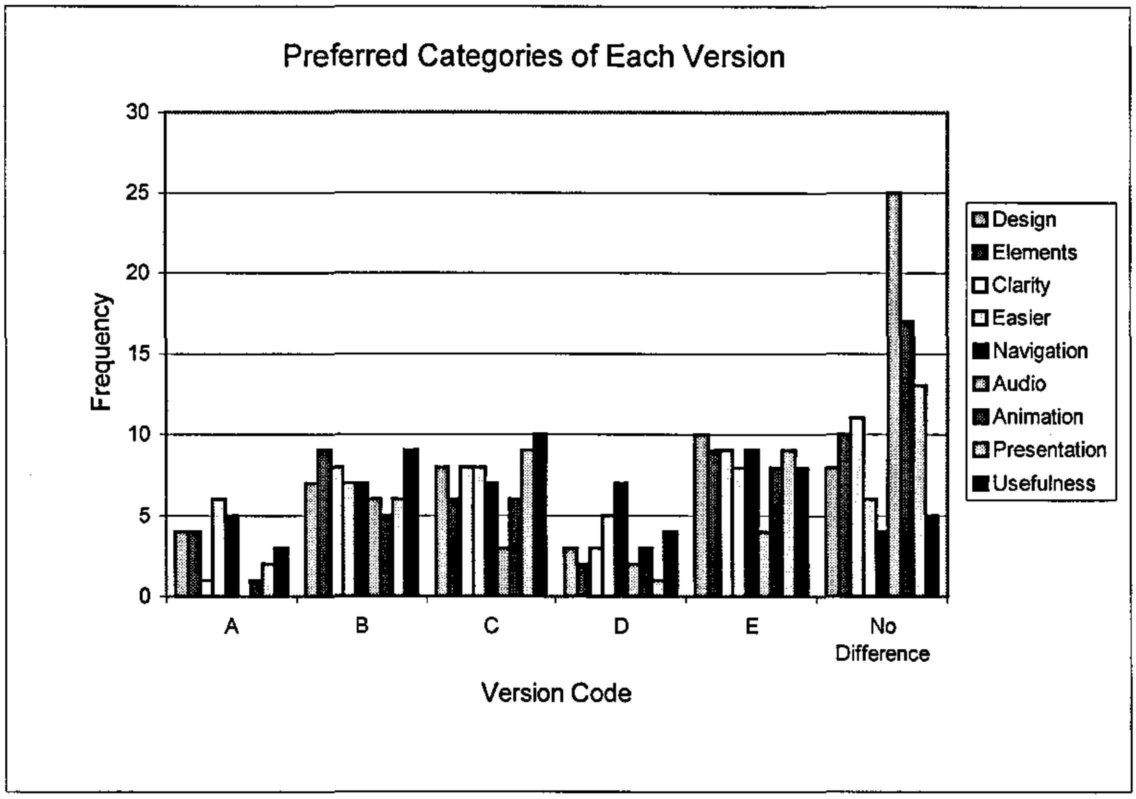

Figure 6.3: The frequency of each category preferred in each version (N=40)

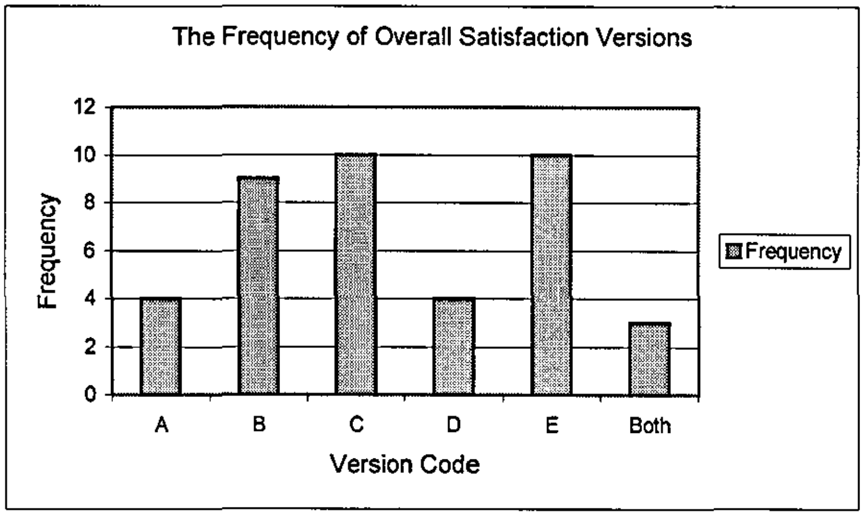

Figure 6.4: The frequency of each version chosen as the most satisfactory version (N=40)

The second part of question 5 was designed to investigate whether the revisions recommended by the reviewers were the reason for the subject to choose one version over the others (See **Appendix F.5**). The main modifications suggested by each reviewer were listed as reasons for choosing a particular version in the evaluation. Some modifications, shown in **Table 6.18**, were suggested by more than one reviewer. For example, reasons 1 and 2 were suggested by both reviewers B$^{\Psi}$ and C. Other modifications, such as 4, 6, 7, 8 and 9 were uniquely proposed by individual reviewers.

Version	Modifications listed as Reason(s) in Part IV									
	1	2	3	4	5	6	7	8	9	10
A										✓
B	✓	✓		✓	✓					
C	✓	✓	✓		✓					
D					✓	✓				
E			✓				✓	✓	✓	

Table 6.18: Some modifications which were suggested by more than one reviewer

As explained in Chapter 4, the Methodology Chapter, 16 subjects tested each version. For example in the case of version A, 8 tested it as the first version and 8 as the second. **Table 6.19** is a summary of a table shown in **Appendix H.11** that shows the

$^{\Psi}$ The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student frequency of subjects, out of 16, who agree with the listed reasons for the chosen version. The table presents each version chosen and whether that is related to the modifications (transactions) made by the reviewer. After analysing the data of the table the following could be summarised for each version:

- Version A: Only 25% (4) of the subjects preferred this version. Three of these subjects chose A when compared with version D. These subjects did not like the layout of version D. One subject preferred it because of the presentation features used in version A.
- Version B: 56% (9) of the subjects preferred this version. 8 of these subjects chose B for the modifications suggested by the reviewer (Domain Lecturer modifications - reasons 2 and 4).
- Version C: 63% (10) of the subjects preferred this version. Most of these subjects chose C for the modifications suggested by the reviewer (Discipline reviewer - reasons 3, 2 and 5).
- Version D: as with version A, 25% (4) of the subjects chose this version for the modifications suggested by reviewer D, especially, modification listed as reason 6.
- Version E: As with version C, it was chosen by 63% (10) of the subjects mainly because of the modifications suggested by reviewer E and listed as reasons 7, 8 and 9 (see **Appendix H.11**).

It can be concluded that subjects choose a particular version[Ψ] because of the modifications suggested by the reviewers.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

The main modifications suggested by each reviewer were listed as reasons for choosing a particular version over the other	A	B	C	D	E
1. Sound quality		3	3		
2. Sound summary		8	7		
3. Slide show with the sound file (animated bullets)			10		7
4. Big sound files were broken to small files showing the sound as bullets		8			
5. Navigation buttons in the bottom of the screen (e.g. Index, Back)		6	7	1	3
6. The pages were broken vertically into index on the left and the body of the material on the right, which shows the content of the active point of the index				4	
7. The graph index on the left of the screen and the content on the right, which shows the active index graphically					9
8. The status bar on the bottom of the screen, which acts as an index, shows all visited sections of the material					5
9. The audio at the beginning of the lecture and in the beginning of each section vertebra), which highlights the content of the lecture and the content of the current section (vertebra).					8
10. Others. Please specify	3				

Table 6.19: Frequency of listed reasons for choosing a particular version over the other (N=40)

6.5 Test Objectives Analysis

As part of the evaluation, a test was given to measure subjects' accomplishments in learning the material objectives (See **Appendix F.4**). The objectives were represented in the test as follows:

- Objective 1: Why Microcontrollers were developed? - represented by test questions 1 and 2;
- Objective 2: The Otto Cycle - represented by test questions 3 and 4;
- Objective 3: The need to move from 8-bit to 16-bit Microcontrollers - represented by test questions 5;
- Objective 4: How the 8096 Microcontrollers controls the ignition in the Otto Cycle represented by test questions 6 and 7;
- Objective 5: How to calculate critical parameters - represented by test questions 8, 9, and 10.

Figure 6.5 shows the average score of each objective of each version. Subjects scored the highest in objectives 2 and 3 and scored the lowest in objectives 4 and 5. The reason for scoring low in objective 5 might be the calculation aspects of this objective. This can be seen in the comments of one subject who explained that "the calculation was hard to do ... need more clarification of how to do the calculation". Another subject suggested "more questions are needed in the assessment". As for objective 4, it was covered mainly by the slide show presentation and was not repeated in another form, such as text. Therefore, subjects might miss some parts of the presentation and not repeat it since it was more than 10 minutes long.

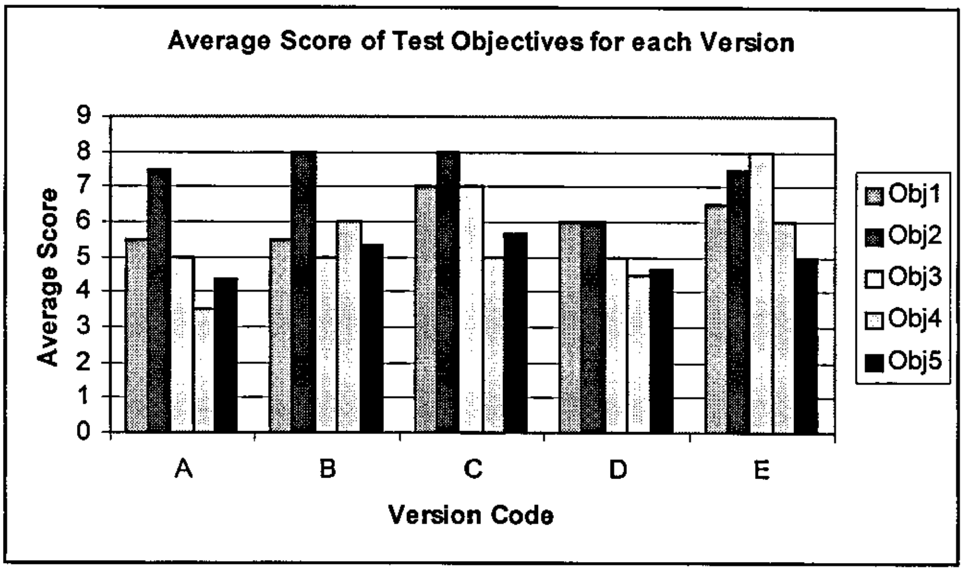

Figure 6.5: The average score of each objective for each version (N=40)

6.6 Analysis of Subjects Comments

About 80% of the total number of subjects made comments. These comments can be categorised into three main titles (Mason, 1996; Oppenheim,, 1992) :

- Attitude toward the material (positive and negative);
- Suggested features to control some media;
- Problems with the browser.

Examples of these comments are shown in **Table 6.20**. Overall, subjects commented positively in regard to the usefulness of the material. All subjects felt that the material could be used, at least, as an aid to traditional lectures. Some subjects were afraid, in the future, there would be no interaction with the lecturer and for that reason these subjects preferred the traditional lectures. They wanted to see how the interaction with the lecturer would be carried out. This let the evaluator explain to the subjects that a group e-mail system would be used for the interaction between students and lecturer and the intention of the experiment was not to investigate the interaction of students and lecturer.

Category	Frequency	Comments
Attitude toward the material	17 (12 +, 5-)	Example of Positive Attitude: - The material is of high quality and well designed - I enjoyed the experiment especially with the way it was developed - These lectures allow me to learn at my own pace. - Visual material was incredibly useful, interesting and well presented. I would thoroughly enjoy learning in this manner - This material in my opinion is very useful for making the learning process more fun and easy. Example of Negative Attitude: - The material cannot replace classroom lecture - CBL disadvantage: no interaction, important points need highlight, no straightaway access to lecturer. - The material was very interesting but cannot substitute for the classroom lecture
Suggested features	11	Features such as: - An auto return to previous page after the end of the presentation - I would like to see more control on presentation and video files - Speed of presentation should be adjustable - Pop up box for glossary
Problems	3	Some visited pages were not highlighted

Table 6.20: Examples of subject's comments

6.7 Conclusion

The analysis of preference questions, using crosstabulation, shows that the majority of subjects were willing to study in mixed mode – traditional and web-based lectures. Only 10% of the cases were extreme, toward either traditional or non-traditional class setting. What might explain the readiness of the subjects to study Web-based material is the use of the World Wide Web (WWW) and multimedia technology in presenting the material.

The second part of the analysis dealt with the quality of the media used and how subjects perceived its usefulness. The results of the tests showed that, across a broad spectrum of media, the quality of media was significantly rated different than its usefulness and there was a positive correlation between the two variables for all media used. In other words, the higher subjects rated the quality of media, the higher they rated its usefulness, which implies that the media was more useful when the quality of the media was perceived high. The mean rank of the quality of all media was more than 4 and the mean rank of the usefulness of media was more than 5, out of 7.

The three main research hypotheses were divided into 20 sub-hypotheses: 8 sub-hypotheses were derived from the first, another 8 were derived from the second, and 4 were derived from the third. Since the first hypothesis investigated the quality of the four revised versions against the unrevised one, in terms of student's satisfaction and learning, it was represented in the alternative form by H1 through H8 as follows:

1. **Any review by a domain (versions B[Ψ] and D) or a discipline knowledge person (versions C and E) will result in a higher quality material than the unreviewed version (version A).**

- H1: Students are satisfied with version B more than version A;

  Result: Not significant and the hypothesis was rejected.
- H2. Students are satisfied with version C more than version A.

  Result: Significant and the hypothesis was accepted.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student;

- H3: Students are satisfied with version D more than version A;
  Result: Not significant and the hypothesis was rejected.
- H4. Students are satisfied with version E more than version A;
  Result: Significant and the hypothesis was accepted.
- H5. Students studying version B score more in the test than students who studied version A;
  Result: Significant and the hypothesis were accepted.
- H6. Students studying version C score more in the test than students who studied version A
  Result: Significant and the hypothesis was accepted.
- H7. Students studying version D score more in the test than students who studied version A;
  Result: Not significant and the hypothesis was rejected.
- H8. Students studying version E score more in the test than students who studied version A;
  Result: Significant and the hypothesis was accepted.

As a result of the tests, the quality of the revised versions was higher than the unrevised material, version A[Ψ]. Except for version D where it was found as satisfactory as version A. Version A was chosen 3 out of 4 times when it was compared with version D. The reason for that might be the layout of D was less satisfactory as commented by some subjects (see **Appendix H.11**). In terms of learning outcome, version D was almost as same as version A. The reason for this might be that the reviewer concentrated more on the content and the layout of the material, as SME, more than as a learner. This agrees with Saroyan (92/93), to some degree, where reviewer D acted as an expert and focused on the content, and in this case the material layout, while other reviewers, especially C and E, acted as learners and seemed to perceive the material as a means to learning that invokes effective strategies for revision.

E - Reviewed by Discipline Knowledge Student

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

In contribution the results show the following about the first hypothesis:

- It has been evidenced that review by discipline knowledge reviewers resulted in a higher quality material, in terms of students' satisfaction and learning, than the unrevised material.
- It has been evidenced that a review by a domain lecturer resulted in a higher quality material, in terms of students' learning, than the unrevised material.
- It has been evidenced that a review by a domain lecturer resulted in quality of material, in terms of students' satisfaction, not significantly more than the unrevised material.
- It has been evidenced that a review by a domain student resulted in quality of material, in terms of students' satisfaction and learning, that is the same as the unrevised material.

The second hypothesis was also represented in the alternative form by 8 sub-hypothesis:

2. Discipline[Ψ] knowledge reviewers will provide a higher quality material than domain knowledge reviewers.

- H9 Students are satisfied with version C more than version B;
  Result: Not significant and the hypothesis was rejected.
- H10 Students are satisfied with version C more than version D;
  Result: Significant and the hypothesis was accepted.
- H11 Students are satisfied with version E more than version B;
  Result: Not significant and the hypothesis was rejected.
- H12 Students are satisfied with version E more than version D;
  Result: Significant and the hypothesis was Accepted.
- H13 Students studying version C score more in the test than students who studied version B;
  Result: Not significant and the hypothesis was rejected.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer;
C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student;
E - Reviewed by Discipline Knowledge Student

- H14 Students studying version C score more in the test than students who studied version D;

  Result: Significant and the hypothesis was accepted.
- H15. Students studying version E score more in the test than students who studied version B;

  Result: Not significant and the hypothesis was rejected.
- H16. Students studying version E score more in the test than students who studied version D;

  Result: Significant and the hypothesis was accepted.

Although the mean average of test score of C and E was higher than B, the hypotheses H13 and H15 were rejected since the result was not significant. The reason for that might be the use of summary file with each sound file and the presentation of big sound file as bullets as explained in **Appendix H.11** which seemed to improve learning.

The above results show the following about the second hypothesis:

- It has been evidenced that review by discipline knowledge reviewers resulted in a higher quality material, in terms of students' satisfaction and learning, than a review by a domain knowledge student.
- It has been evidenced that review by discipline knowledge reviewers resulted in a quality material, in terms of students' satisfaction and learning, that is the same as a review conducted by a domain knowledge lecturer.

Third hypotheses was investigated as 4-subhypotheses represented in the null form:

3. **Lecturers and students, as reviewers, produce the same quality of material in terms of students' satisfaction and learning.**

- H17 Students are satisfied with version B more than version D;

  Result: Significant and the hypothesis was accepted.
- H18 Students are satisfied with version C more than version E;

  Result: Not Significant and the hypothesis was rejected.

- H19 Students studying version B score more in the test than students who studied version D;
  Result: Not Significant and the hypothesis was rejected.
- H20 Students studying version C score more in the test than students who studied version E;
  Result: Not Significant and the hypothesis was rejected

The result shows that there was no significant difference between versions C[Ψ] and E in terms of student's satisfaction and learning. But in the case of versions B and D, B was a higher quality in terms of subject's satisfaction but in terms of learning outcome they were the same.

The above results show that the discipline reviewers were same as a domain lecturer reviewer but better than a domain student. It can be concluded that reviewer selection could be broadened to include discipline reviewers, which in the case of students could be cost effective.

In summary the results of the investigations of the three hypotheses are as follow:

1. Any review by a domain or a discipline knowledge person will result in a higher quality material than the unreviewed version.

The evidence gained in the experiment suggests that these people, domain or discipline, when they review the material can make a significant difference to the quality of the material, in terms of students' satisfaction and learning. But there exists a possibility, especially if the reviewer is a student, that they might not make a significant improvement, therefore it seems more reliable to use a lecturer rather than a student.

2. Discipline knowledge reviewers will provide a higher quality material than domain knowledge reviewers.

[Ψ] The five versions code are: A - Unrevised; B - Reviewed by Domain Knowledge Lecturer; C - Reviewed by Discipline Knowledge Lecturer; D - Reviewed by Domain Knowledge Student; E - Reviewed by Discipline Knowledge Student

The evidence suggests that a discipline knowledge reviewers, student or lecturer, are significantly better than a domain student, in improving the quality of the material in terms of students' satisfaction and learning, but not significantly better than a domain lecturer.

3. *Lecturers and students, as reviewers, produced the same quality of material in terms of student's satisfaction and learning.*

There is evidence to support the fact that a discipline student is as good as a discipline lecturer as a reviewer, however, the evidence also suggests that a domain lecturer is better than a domain student.

The analysis of the last questions of Part IV of the questionnaire suggests the following:

- Subjects preferred the categories of versions C, E and B to versions A and D.
- Subjects chose versions C, E and B as an overall satisfactory version more than version A and D.
- Subjects chose a particular version because of the modifications suggested by reviewers.

These results confirm the hypotheses test results.

The analysis of the open-end part of the questionnaire showed that overall, subjects commented positively in regard to the usefulness of the material. All subjects felt that the material could be used at least as an aid to traditional class lectures.

From the above results it can be concluded that students' satisfaction is an important ingredient for student's learning.

Chapter Seven

Conclusion

7.0 Introduction

This chapter summarises the forgoing research. It brings together the elements discussed in previous chapters and shows how the research hypotheses posed at the beginning of the thesis are addressed. Further, it discusses some of the main findings and the contribution of this study. Finally it points the way for further research.

7.1 An Overview

It was identified in **Chapter 1** that with the recent developments in computer technologies and the World Wide Web, more effort has been made by educators to develop Web-based material, creating a learning environment that utilises the Web features. Many previous technologies, used to deliver educational material, have been evaluated and improved using formative evaluation methods such as expert review and it is postulated that using such methods may improve Web-based material as well. The research aimed to conduct the review process on Web-based material and hoped to add to or confirm the findings of many empirical studies that had shown that formative evaluation methods improved the developed material. Also, it is hoped the research would fill the gaps in the literature through a) investigating whether the use of domain students are effective in producing higher quality material and b) modify the experiment methodology of the previous studies allowing subjects to compare the reviewed material with the unreviewed one. Furthermore, the research introduced discipline reviewers and investigated whether the review process can be broadened to include them in producing higher quality material. Since domain students might cost less than SMEs and discipline reviewers should be available in greater number, using such reviewers might make the review cost less, more practical and easier to implement. These issues were presented as the main objectives of the study.

Chapter 2 presented a review of three areas related to the research: distance learning, Computer-Based Instruction and Web-Based Instruction, and formative evaluation.

It has been explained that the Web environment is gaining the attention of many educators as a promising learning environment. The interest of many of these educators is to develop Web-Based material that benefits from this environment's unique features. The literature showed that many previous technologies, used to deliver educational material, were evaluated using formative evaluation methods. The purpose of the evaluation was to review the quality of the delivered material. It has been found that formative evaluation methods, such as expert review, improved the quality of the material. There are two main approaches, depending on the source of feedback, to formative evaluation. The first is to use experts, such as SMEs, to evaluate the developed material and revise it accordingly. The second is to use learners and learners' data, such as their performance in the tests, to find the material weaknesses and revise it accordingly. Learners' data could be collected through, mainly, three methods: one-to-one, small group and field-test evaluation.
However, it is recommended that formative evaluators call upon experts, such as SMEs, to examine the developing material from their point of view. The problem of using SMEs is that they might not approach the material as learners. Thus, subject sophisticates (domain student) or discipline reviewers, who have less knowledge in the subject but at the same time are experts or lecturers in other areas of the discipline, might produce a higher quality material than the unreviewed one.

Chapter 3 reviewed work done in the area of formative evaluation focusing on expert review. The areas of work included were those that investigate the effectiveness of formative evaluation methods in improving the material, the comparisons of different methods, and the comparisons of using different experts in the expert review process. Further, this chapter justified why the proposed reviewers might also be effective in improving the material.
The hypotheses were discussed in **Chapter 4**. The research investigates three main hypotheses that have been divided into 20 sub-hypotheses. Also, presented in this chapter the case study material, the design of the experiment, the subjects of the experiment and the tools used to collect data. At the end, the chapter presented the tools to analyse the data and validate the hypotheses
Further, in **Chapter 5**, the development procedure for the Web-based lectures was presented and the major development phases were highlighted. This chapter also presented the development analysis of a one-hour production of a multimedia lecture

and measurement alongside other developers work. Furthermore, the data collected from each review session was highlighted and the revision data for each reviewer was discussed. The results of applying the revision data on the material were also shown as separate versions of the material.

Finally, **Chapter 6** presents the analysis of the data and the results of applying statistical tests on the collected data verifying the hypotheses put forward.

7.2 Research Contribution

The study extended the area of formative evaluation in general and expert review in particular in the following (these issues were the main objectives of the study):

1. Conducting formative evaluation, in particular expert review, on Web-based material;
2. Investigating the quality of the material produced by domain student review;
3. Applying a methodology in the experiment design to investigate student satisfaction with the material by allowing subjects to compare the revised material with the unrevised one;
4. Introducing new types of reviewers, in particular discipline reviewers.

The study also contributed to understanding the perception of quality of media in Web-based material through the following:

5. Investigating the relationship between the quality of media as perceived by the subjects and it usefulness.

Furthermore,

6. Investigating students' preference to study lectures through Web-Based lectures compared to traditional lectures.

7.3 Some Discussion on the Experiment Results

The first four points, of the contribution listed above, were reached through three main hypotheses that were divided into 20 sub-hypothesis using two tests to validate them, the t-test and the Mann-Whitney test. The fifth point was investigated through a separate hypothesis using Spearman's rho and Pearson *r* correlation tests. The last point was analysed through descriptive statistics.

The results for the first four points are as follows:

1.1 Domain lecturer (SME) review has been shown to produce a higher quality material than unreviewed material in terms of students' satisfaction and learning.

1.2 There was not enough evidence to show that domain student review was effective in producing higher quality material than unreviewed material in terms of students' satisfaction and learning.

1.3 Discipline lecturer review has been shown to produce a higher quality material than unreviewed material in terms of students' satisfaction and learning.

1.4 Discipline student review has been shown to produce a higher quality material than unreviewed material in terms of students' satisfaction and learning.

2.1 There was not enough evidence to show that discipline lecturer review was more effective in producing a higher quality material than domain lecturer review in terms of students' satisfaction and learning.

2.2 Discipline lecturer review has been shown to produce a higher quality material than domain student review in terms of students' satisfaction and learning.

2.3 There was not enough evidence to show that discipline student review was more effective in producing a higher quality material than domain lecturer review in terms of students' satisfaction and learning.

2.4 Discipline student review has been shown to produce a higher quality material than domain student review in terms of students' satisfaction and learning.

3.1 There was not enough evidence to show that domain lecturer review was more effective in producing a higher quality material than domain student review in terms of students' satisfaction and learning.

3.2 There was not enough evidence to show that discipline lecturer review was more effective in producing a higher quality material than discipline student review in terms of students' satisfaction and learning.

In total, the first and the second main hypotheses can not be accepted since the results did not support the hypotheses that investigate domain student effectiveness in producing high quality material. However, the null hypotheses of the first main hypotheses can not be accepted either since 3 sub-hypotheses out of 4, merging satisfaction and learning hypotheses, were proven. Hence, it is safe to say that in most cases *Any review by a domain or a discipline knowledge person will result in a higher quality material than the unreviewed version.* As for the second main hypothesis the same thing applies. That is 2 sub-hypotheses out of 4 could not be proven which means that the null hypotheses can not be accepted also. Therefore, it is also safe to say that there is 50% chance that *Discipline knowledge reviewers will provide a higher quality material than domain knowledge reviewers.* In the third main hypothesis there was enough evidence to show that there was *no significant difference between lecturers and students, as reviewers, in producing high quality of material in terms of student's satisfaction and learning.*

The other findings of the research, regarding multimedia issues and students' preference, are as follows:

- There was a positive correlation between rating the quality of the media and the rating of its usefulness. In other words, the higher the quality (of media) rated by the subjects, the higher they rated its usefulness. That implies that *the media was more useful when the quality of the media was perceived high.*
- The majority of subjects, 90%, were willing to study Web-Based lectures for part of the course.

7.4 Some Limitations of This Study

Although the findings of this study were encouraging, some limitations of this study have to be acknowledged. Among these limitations are those pertaining to the following aspects:

- The pre-test: the background knowledge of the subjects was not measured through a pre-test due to the experiment time limits. Instead, a filtration question was used to exclude subjects with strong backgrounds.
- The location of multimedia files: the developed material with all of its multimedia files was located on the same server. Putting the files on separate servers might

create longer times for accessing big files, and hence might effect subject's satisfaction with the material.

- The Web: it is accepted that the learners in this study already had a high familiarity with computer workstation use, Web-browsers and PowerPoint presentations in particular, although none had witnessed the navigational format of the material before.
- The subjects: whilst all of the experiment learners were volunteers and took the role seriously, it must be noted that the learning was not a requirement of any given lecture course at the time, nor were the assessment results of any contributory value to their studies.
- The subjects: all of the experiment subjects had an interest in learning this experiment material.

The material was developed as Web-based lectures that could be use for distance students. Therefore, the timing of each student was ignored since the material was designed as open material that allows students to control the learning process.

7.5 Suggestions for Future Research

Given the encouraging findings in this research, future work could replicate such an experiment to investigate further the individual hypotheses that were not successfully proven. These were the hypotheses that deal mainly with domain student as a reviewer to produce a higher quality material than unreviewed material since such review may reduce the cost of the evaluation. Future work could also determine the generalisability of reviewing the material to improve its quality.

Many factors contributed to the necessity of only using one reviewer of each type in this study:

- Availability of qualified personnel in each category;
- Their willingness to contribute the time to the review process;
- The complex proliferation of reviewed versions of the material if more reviewers of the same types had been used;

- The number of evaluations and the time required by the sample learners in evaluating all reviewed and unreviewed versions against at least one other in deferring orders.

As a consequence and without any pre-selection other than their volunteering, it is possible and probable that the effectiveness of the individual as a reviewer cannot be guaranteed to be the best (as was witnessed by the domain student test subject reviewer). However to restate the research findings in most cases *any review by a domain or a discipline knowledge person will result in a higher quality material than the unreviewed version.*

It is possible for future work to use more than one reviewer of each type and then revise the material according to them. However it must be accepted that this will add additional cost to the process of developing Web-based material. One of the significant benefits of Web-based material is that it is an inherently more dynamic entity than the printed word and as such continuous feedback is solicited from learners. This research was primarily concerned with justifying the use of and finding the most cost-effective reviewer for the material prior to its inception date.

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Appendix A - Timing Sheet

This sheet was used to collect the time of each task involved in development of the material.

Date	Task No.	Task Name	Units	Comments

1 unit = 15 minutes.

Appendix B - Reviewer's Recommendation Sheet

Thank you for being a reviewer in this experiment. Part of my experiment is to implement your suggestion and recommendations on the first version of the multimedia distance learning lectures. It would help me organise the changes needed if you fill the following table. Thank you

.

Reviewer Name	Reviewer Code

Time Start	Time Stop

Lecture	Location	Transaction Code	Classification Code	Comments

Please use the following codes in order to organise the changes you make.

Reviewer Code	Reviewer Category
B	Domain Lecturer
C	Discipline Lecturer
D	Domain Student
E	Discipline Student

Transaction Code	Transaction Name
1	ADD
2	MODIFY
3	DELETE

Classification Code	Classification Name
10	Animation
20	Appearance/Order
30	Audio
40	Design
50	Grammar
60	Graphs
70	References/Pointers
80	Self Assessment
90	Solve Ambiguity
100	Test
110	Text/Content
120	Video
130	Link
140	Clarity
150	Icons
160	Navigation

Appendix C - Reviewer's Questionnaire

Thank for being a reviewer in this experiment. This questionnaire was designed to evaluate the reviewed material. Please take your time.

Thank you.

1) I give the integration of the material in a scale of 5 to 1, where 5 is excellent, a rate of:

⑤ ④ ③ ② ①

2. I give the clarity of concepts of the material a rate of:

⑤ ④ ③ ② ①

3. I give the design of the material a rate of:

⑤ ④ ③ ② ①

4. I give the navigation of the material a rate of:

⑤ ④ ③ ② ①

5. I give the multimedia used in the material a rate of:

⑤ ④ ③ ② ①

6. I give the presentation of the material a rate of:

⑤ ④ ③ ② ①

7. In the review, I found that:

❑No changes required ❑less than 20% of changes required ❑20%-40% of changes required ❑more than 50%

8. Most of the changes that I found needed are in

❑Text ❑Sound ❑Animation ❑diagrams ❑Pictures ❑Mix

9. Most of the changes that I recommend to improve the

❑Concepts ❑Level of understanding ❑Friendliness ❑Solve ambiguity ❑Others

10. The best thing I found in this material was

❑The design ❑The mix of media ❑The presentation of the material ❑The navigation ❑Others......................

11 The worse thing I found in this material was

❑The design ❑the mix of media ❑The presentation of the material ❑The navigation ❑Others......................

12.Please give any comments that you feel are important as feedback for future work

Appendix D - Technical Author's Questionnaire

Thank you for your time. Answering this questionnaire would help me in my work. Please take your time. Thank you.

1) In the process of producing multimedia material, the following software was used: Please rate them on a scale starting from 1(most often used/important) to N (least/never used)

❑ MS Office ❑ AuthorWare ❑ Lotus Notes ❑ Mac HyperCard ❑ Animator

❑ Video Editor Software ❑ Sound Editor Software ❑ Picture Editor Software

❑ Drawing Software ❑ Others (please specify)..........

2) In the process of producing multimedia material, the following platforms were used: Please rate them on a scale of 1 (most often used/important) to N (least/never used)

❑ PC ❑ Mac ❑ Sun ❑ Others (please specify)..........

3) How frequently do you think that the TA needs to review the authored material with the material originator?

❑ Weekly ❑ Every two weeks ❑ Every 3 weeks ❑ Monthly

❑ Other (please specify)..

4) In my experience I have found that producing a one hour's worth of <u>good</u> quality distance learning multimedia material would need

❑ less than 50 hours ❑ 50-75 hours ❑ 75-100 hours
❑ More than 100 hours

5) In producing DL material, which task(s) consumed most of the time in producing the first hour? Is it

❑ Transcription of the lectures ❑ Producing animation ❑Learning the packages ❑ Producing and editing sound files ❑ Producing and editing video files ❑ Reviews with the material originator ❑ Others (please specify).......

6) In producing DL material, write your estimate time percentage for each task. (For example if animation takes 20% of the time you write 20% in animation cell)

Task Name	Task time Percentage
Learning the packages	
Transcription of the lectures	
Producing animation files	
Producing and editing sound files	
Producing and editing video files	
Review with the material originator	
Others (please specify).	

7) In producing DL material, rate the following tasks (in order of perceived difficulty) starting from 1 as the most difficult.

Task Name	Difficulty Order
Learning the packages	
Transcription of the lectures	
Producing animation files	
Producing and editing sound files	
Producing and editing video files	
Review with the material originator	
Others (please specify).	

8) It is very important that TAs have a background knowledge of the material that are producing.

❑ Strongly Agree ❑ Agree ❑ Don't know ❑ Disagree ❑ Strongly Disagree

9) If you disagree that a background knowledge of the material is important, how significantly did you feel that learning or understanding the material to be presented in DL extended the production phase.

❑ 25 % of more time in the production phase

❑ 50% of more time in the production phase

❑ 75% of more time in the production phase

❑ 100% of more time in the production phase

❑ More- please state.......................................

10) If you have any technical comments or authoring comments that you like to share please do.

Appendix E - Pilot Student's Questionnaire

First I would like to thank you for conducting this experiment. Your response to this questionnaire would help us determine the future work in using multimedia in distance learning. It is very important that we have your feedback about the material. Please feel free to comment about the material with respect to the media used and how it could be used better. If you would like to give more comments by E-mail, please send your E-mail to: k.al-haddad@lboro.ac.uk.
Thank you.

Personality Preference.

1) I prefer to study :

☐ Solely in traditional lectures

☐ Solely in distance mode if it possible

☐ Mix of the two (traditional for some, and distance for some)

2) Distance lectures would not be as effective as traditional lectures with or without multimedia.

☐ Strongly agree ☐ Agree ☐ Acceptable ☐ Disagree ☐ Strongly disagree

3) I strongly recommend the use of multimedia technology to replace traditional lectures if possible.

☐ Strongly agree ☐ Agree ☐ Acceptable ☐ Disagree ☐ Strongly disagree

Quality of the Material.

4) How do you rate the design of the material?

☐ Excellent ☐ good ☐ Satisfactory ☐ Poor ☐ Very Poor

5) I found the elements of the Microcontrollers lectures fitted well together.

☐ Strongly agree ☐ Agree ☐ Acceptable ☐ Disagree ☐ Strongly disagree

6) The aims and objectives of the lectures were clear.

❒ Strongly agree ❒ Agree ❒ Acceptable ❒ Disagree ❒ Strongly disagree

7) It is clear to me now that I really can learn through a distance learning multimedia course.

❒ Strongly agree ❒ Agree ❒ Acceptable ❒ Disagree ❒ Strongly disagree

8) I think distance learning lectures might replace the traditional lectures.

❒ Strongly agree ❒ Agree ❒ Acceptable ❒ Disagree ❒ Strongly disagree

9) How did you find the use each media in the material? Was it:
(for each media, tick one box)

	Too Much	Just right	Too little
TEXT			
GRAPHS			
PICTURES			
SOUND			
ANIMATION			
VIDEO			

10) I rate each media used in the material as follows:

	Excellent	Good	Satisfactory	Poor	Very Poor
TEXT					
GRAPHS					
PICTURES					
SOUND					
ANIMATION					
VIDEO					

11) The best media (or combination of media) used in the material was

	TEXT	GRAPHS	PICTURES	SOUND	ANIMATION	VIDEO
TEXT						
GRAPHS						
PICTURES						
SOUND						
ANIMATION						
VIDEO						

12) The worse media (or combination of media) used in the material was

	TEXT	GRAPHS	PICTURES	SOUND	ANIMATION	VIDEO
TEXT						
GRAPHS						
PICTURES						
SOUND						
ANIMATION						
VIDEO						

Concepts

13) My background knowledge of the material is

❐ Excellent ❐ Good ❐ Satisfactory ❐ Poor ❐ Very Poor

14) The concepts of the Microcontrollers lectures were

❐ Very Clear ❐ Clear enough ❐ Satisfactory ❐ Poor ❐ Very Poor

15) After studying the material in distance mode, my level of understanding of the Microcontrollers lectures was

❐ Excellent ❐ Good ❐ Satisfactory ❐ Poor ❐ Very Poor

16) On balance, do you think that you would recommend taking the material in distance for other students? ❐ Yes ❐ No

17) My overall impression of the complete package (material & lectures)

❐ Excellent ❐ Good ❐ Satisfactory ❐ Poor ❐ Very Poor

18) Important points of the material are highlighted.

❐ Strongly agree ❐ Agree ❐ Acceptable ❐ Disagree ❐ Strongly disagree

19) The material was easy to follow.

❐ Strongly agree ❐ Agree ❐ Acceptable ❐ Disagree ❐ Strongly disagree

20) Please, give any comments that you feel are important as feedback for future work.

21) What changes do you recommend that we have to make in order improve the material.

Appendix F.1 - Student's Evaluation Instructions Page

Your code for this evaluation is ___________.

Thank you for your participation in this evaluation. To start the evaluation, Please read the following instructions:

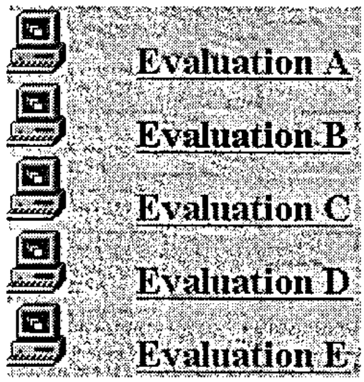
1) Answer Part I of the questionnaire.

2) From 

choose 

then 

3) Double click 

4) The file shows a menu like this 

5) Depending on the code given to you, choose the evaluation that the code starts with. For example, if your code is B-C this means that you should start with Evaluation B.

6 After going through the first evaluation, please answer Part II of the questionnaire and the questions of Part III, then you may take a break for 15 minutes.

7) Go back to the above menu and choose the second evaluation from the code given to you. For example, if the code was B-C, this time you should choose Evaluation C.

8) After going through the second evaluation, please answer Part IV of the questionnaire.

9) Please do not discuss your evaluation of this material with other students. Thank you.

Appendix F.2 - Student's Evaluation-Part I

Thank you for your participation in this evaluation. Before you start, please tick only one answer to each of the following questions.

1) **How would you prefer to study your courses?**
   - ☐ Solely in traditional class room lectures.
   - ☐ Solely in non-traditional computer based lectures.
   - ☐ Mix of the two methods (Class lectures + computer base learning).

2) **Do you think that you could learn using computer based lectures?**
   ☐ Yes ☐ No ☐ I don't know

3) **How do you rate your background knowledge of the developed material (The developed material is about the working of the automotive internal combustion engine and the use of microcontrollers in the modern engine management)?**
   ☐ Excellent ☐ Good ☐ Satisfactory ☐ Poor ☐ Very Poor

3) **Have you discussed any aspects of this evaluation with other students who have evaluated the material before?**
   ☐ Yes ☐ No

Now please undertake the first evaluation as directed on the previous page.

Appendix F.3 - Student's Evaluation-Part II

1) After going through the material, I think that

- ☐ Computer lectures are **better** than traditional class lectures.
- ☐ Computer lectures are the **same** as traditional class lectures.
- ☐ Computer lectures are **worse** than traditional class lectures.

2) I would prefer to study computer lectures , such as these,

- ☐ For the whole course.
- ☐ For some lectures of the course.
- ☐ I prefer traditional classroom lectures.

3) How do you rate the *quality* and the *usefulness* (in terms of learning) of each of the following media used in the material: (using a scale of 1 to 7, where 1 is very poor and 7 is excellent)

	Quality Of Media								Usefulness Of Media						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
1. Animation															
2. Audio															
3. Text															
4. Video															
5. Icons															
6. Pictures															
7. Presentations (slide show)															

4) How do you rate the navigation of the material? (tick one box of the following scale, where 1 is very poor and 7 is excellent)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

P. T. O.

5) Using the following continuum:

1	2	3	4	5	6	7
Strongly Disagree	**←**	**Increasing disagreement**	**Neutral**	**Increasing agreement**	**→**	**Strongly agree**

Please indicate, by ticking for each statement, to what extent you agree or disagree with the following statements:

	1	2	3 ←	4	5 →	6	7
1. The lectures were easy to follow.							
2. Human skeleton metaphor used in the design helped me to understand the structure of the material easily.							
3. There were many times when I did not know where to go next.							
4. I would suggest the use of these computer lectures as an alternative to classroom lectures.							
5. While going through the lectures, I found it hard to know which parts I had finished.							
6. I am satisfied with the overall presentation of the material.							
7. I do not think that these computer lectures could be used to substitute classroom lectures.							
8. I found the elements of the developed material fitted together well.							
9. After going through these computer lectures, I found these lectures were unsatisfactory.							
10. I found the material useful in understanding the need for and the role of a microcontroller in the car engine.							
11. It is clear to me now that I can not learn through these kinds of computer lectures.							
12. While going through the lectures, I always knew where I was.							
13. I would not recommend the use of these lectures.							

Please now turn over the page and attempt a few sample questions.

Appendix F.4 - Student's Evaluation-Part III

Please answer all the following questions. The purpose of these questions is to measure the quality of the material. For each question, tick just one answer that you understand from this material *best fits* the question.

1. **Why were Microcontrollers originally developed?**
   a) To further miniaturise the existing computer systems.
   b) To facilitate a move from centralised computer control to distributed process control.
   c) To enable the automotive industry to build better engines.

2. **Microcontrollers are used for Engine Management in the Car Engine primarily to**
   a) Accurately control the ignition of the fuel and thereby minimise pollutants caused by incorrect ignition.
   b) Accurately measure and control the operation (rotational speed) of the engine.
   c) Satisfy Government and Consumers, because Government and Consumers alike preferred electronic control to mechanical control (distributor).

3. **Nicholas Otto pioneered the development of the Internal Combustion Engine. Which one of the following correctly describes the Otto Cycle?**
   1. A four cylinder engine that uses petrol as a fuel.
   2. A four wheel cycle driven by a petrol engine.
   3. A four stroke cycle where gaseous fuel is compressed before ignition.

4. **Why is it necessary to have at least four cylinders in an automotive engine?**
   a) Because the Otto Cycle only delivers power for one quarter of its duration and four cylinders therefore can provide continuous power.
   b) In order to get four times the power out of the Otto Cycle.
   c) In order to keep the microcontroller fully occupied - otherwise it would only be required for one quarter of the time.

5. **Why was it necessary to move from an 8-bit microcontroller to a 16-bit microcontroller?**
   a) Government pollution regulations required the use of a 16-bit microcontroller in engine management systems.
   b) The process algorithms required arithmetic that included multiplication and division.
   c) Because the miniaturisation of the computer components on the silicon left enough space to produce 16-bit components.

6. **The Intel 8096 controls the ignition in the Otto Cycle by**
   a) Interacting with the engine to tell it how many times to ignite the fuel.
   b) Calculating and determining the exact time to ignite the fuel based upon input parameters.
   c) Igniting the fuel at the end of the compression stroke.

P.T.O

7. **The Intel 8096 uses an internal clock/counter to measure time. Such measurement is accurate**
   a) In absolute terms.
   b) Relative to the interrupt.
   c) Only if relative to some recent input event.

8. **If the clock is being incremented at the rate of one count per two microseconds and a difference of 10,000 counts is measured between successive passing of Bottom Dead Centre (one revolution), what rotational speed does this indicate that the engine is going at?**
   a) 300 Revs per minute.
   b) 3,000 Revs per minute.
   c) 10,000 Revs per minute.

9. **If the 16-bit clock is being incremented at the rate of one count per two microseconds, it will wrap around after approximately 130 ms. If the engine is rotating very slowly, at idle speed, how many revolutions can be allowed to occur before the clock wraps around based upon the Otto Cycle and a Bottom Dead Centre reference point**
   a) One quarter of a revolution.
   b) One half a revolution.
   c) One revolution.

10. **At full speed the ignition advancement will be at a maximum, typically 90 degrees. Which of the following most accurately describes this condition? The maximum engine speed would be limited by ...**
    a) The time that it takes to calculate the ignition time.
    b) The rate at which the clock/counter increments.
    c) The interrupt response time of the processor.

Please now feel free to take a short break and then undertake the second evaluation as directed in point 5 on the front page before completing the next page.

Appendix F.5 - Student's Evaluation-Part IV

Your code for this evaluation is __________.

Thank you again. After going through the second version of the material, please, answer the following:

1) How do you rate the *quality* and the *usefulness* (in terms of learning) of each of the following media used in the *second version* of the material:
(using a scale of 1 to 7, where 1 is very poor and 7 is excellent)

	Quality Of Media								Usefulness Of Media						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
1. Animation															
2. Audio															
3. Text															
4. Video															
5. Icons															
6. Pictures															
7. Presentations (slide show)															

2) How do you rate the navigation in the *second version* of the material?
(Tick one box of the following scale, where 1 is very poor and 7 is excellent)

1   **2**   **3**   **4**   **5**   **6**   **7**

P. T. O.

3) Using the following continuum:

1	2	3	4	5	6	7
Strongly Disagree	**←**	**Increasing disagreement**	**Neutral**	**Increasing agreement**	**→**	**Strongly agree**

Please indicate, by ticking for each statement, to what extent you agree or disagree with the following statements:

	1	2	3 ←	4	5 →	6	7
1. The lectures were easy to follow.							
2. Human skeleton metaphor used in the design helped me to understand the structure of the material easily.							
3. There were many times when I did not know where to go next.							
4. I would suggest the use of these computer lectures as an alternative to classroom lectures.							
5. While going through the lectures, I found it hard to know which parts I had finished.							
I am satisfied with the overall presentation of the material.							
6. I do not think that these computer lectures could be used to substitute classroom lectures.							
7. I found the elements of the developed material fitted together well.							
8. After going through these computer lectures, I found these lectures were unsatisfactory.							
9. I found the material useful in understanding the need for and the role of a microcontroller in the car engine.							
10. It is clear to me now that I can not learn through these kind of computer lectures.							
11. While going through the lectures, I always knew where I was.							
12. I would not recommend the use of these lectures.							

P. T. O

4) Choose the Version that satisfies you most according to the following categories:

	First Version	Second Version	No Difference	None
1. The design of the material was better in the ……				
2. The elements of the lectures fitted better together in the ……				
3. The concepts of the material were clearer in the ……				
4. The lectures were easier to follow in the ……				
5. The navigation of the material was better in the ……				
6. The audio part of the material was better in the ……				
7. The animation part of the material was better in the ……				
8. The presentation (slide show) was better in the ……				
9. As an alternative to classroom lectures I would recommend the use of the ….				

P. T. O.

5) **A. Which of the two versions you saw satisfied you most over all?**
☐ The first ☐ The second ☐ Neither ☐ Both

Please answer either B or C as applicable.

B. The reasons I chose one version over the other were:
(tick N.A. if the aspect is not applicable to the versions you saw)

	Yes	No	N. A.
1. Sound quality			
2. Sound summary			
3. Slide show with the sound file (animated bullet)			
4. Big sound files were broken to small files showing the sound as bullets			
5. Navigation buttons in the bottom of the screen (e.g. Index, Back)			
6. The pages were broken vertically into index on the left and the body of the material on the right, which shows the content of the active point of the index			
7. The graph index on the left of the screen and the content on the right, which shows the active index graphically			
8. The status bar on the bottom of the screen, which acts as an index, shows all visited sections of the material			
9. The audio at the beginning of the lecture and in the beginning of each section (vertebra), which highlights the content of the lecture and the content of the current section (vertebra).			
10. Other. Please specify			

C. Neither versions was individually preferable because

....

....

Please write anything you want to say as a feedback about the developed material. (Use the back of this paper for more space)

....

....

Thank you again.

Appendix G - Results of Reviewer's Sheet

	Animation-10			Appearance/Order-20			Audio-30		
	Add	Modify	Delete	Add	Modify	Delete	Add	Modify	Delete
B	X							X	
C	XX				XXX			6X	
D									
E	X						XX	XX	

	Design-40			Grammar/Spelling-50			Graphs-60		
	Add	Modify	Delete	Add	Modify	Delete	Add	Modify	Delete
B					6X				
C					10X			X	
D		XX			X				
E		XX							

	Reference/Pointers-70			Self Assessment-80			Solve Ambiguity-90		
	Add	Modify	Delete	Add	Modify	Delete	Add	Modify	Delete
B									
C								X	
D					X				
E									

	Text/Content-100			Test-110			Video-120		
	Add	Modify	Delete	Add	Modify	Delete	Add	Modify	Delete
B	X	6X							
C	X	5X							
D		X						X	
E									

	Link-130			Clarity-140			Icon/Icon Text-150		
	Add	Modify	Delete	Add	Modify	Delete	Add	Modify	Delete
B	XX	XX					X	XXX	
C					X			XX	
D		X						X	
E	X	XX							

	Navigation-160			Software Issues/Problems-170			Presentation-180		
	Add	Modify	Add	Add	Modify	Delete	Add	Modify	Delete
B		X							
C		X			X				
D					X			X	
E					X		X	X	

	Pictures-190		
	Add	Modify	Add
B			
C			
D			
E		X	

Appendix H.1 - Crosstabulation Analysis

Crosstabulation and frequency tables of preference questions of Part I and Part II of the questionnaire.

How would you prefer to study? * Learn through CBL Crosstabulation

			Learn through CBL			Total
			Yes	No	I don't know	
How would you prefer to study?	Solely-Traditional	Count		1	1	**2**
		% within Learn through CBL		100.0%	12.5%	**5.0%**
	Solely-Non traditiona	Count	2			**2**
		% within Learn through CBL	6.5%			**5.0%**
	Mix	Count	29		7	**36**
		% within Learn through CBL	93.5%		87.5%	**90.0%**
Total		Count	31	1	8	40
		% within Learn through CBL	100.0%	100.0%	100.0%	100.0%

Table 1: The results of cross-tabulation of Q1 and Q2 of Part I

Comparing Computer-Based Lecture to Traditonal Lectures

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Better	18	45.0	45.0	45.0
	Same	19	47.5	47.5	92.5
	Worse	3	7.5	7.5	100.0
	Total	40	100.0	100.0	

Table 2: Frequency of Rating CBL Material

Preference of Studying CBL Material

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Whole Course	5	12.5	12.5	12.5
	Some Lectures	30	75.0	75.0	87.5
	Traditional	5	12.5	12.5	100.0
	Total	40	100.0	100.0	

Table 3: Answers of question 2 of Part II

After CBL * Preference After CBL * How would you prefer to study? Crosstabulation

How would you prefer t study?				Preference After CBL: Whole Course	Some Lectures	Traditional	Total
Solely-Traditional	After CBL	Same	Count			1	1
			% within After CBL			100.0%	100.0%
			% within Preference Af CBL			50.0%	50.0%
		Worse	Count			1	1
			% within After CBL			100.0%	100.0%
			% within Preference Af CBL			50.0%	50.0%
	Total		Count			2	2
			% within After CBL			100.0%	100.0%
			% within Preference Af CBL			100.0%	100.0%
Solely-Non traditional	After CBL	Better	Count	1	1		2
			% within After CBL	50.0%	50.0%		100.0%
			% within Preference Af CBL	100.0%	100.0%		100.0%
	Total		Count	1	1		2
			% within After CBL	50.0%	50.0%		100.0%
			% within Preference Af CBL	100.0%	100.0%		100.0%
Mix	After CBL	Better	Count	4	12		16
			% within After CBL	25.0%	75.0%		100.0%
			% within Preference Af CBL	100.0%	41.4%		44.4%
		Same	Count		16	2	18
			% within After CBL		88.9%	11.1%	100.0%
			% within Preference Af CBL		55.2%	66.7%	50.0%
		Worse	Count		1	1	2
			% within After CBL		50.0%	50.0%	100.0%
			% within Preference Af CBL		3.4%	33.3%	5.6%
	Total		Count	4	29	3	36
			% within After CBL	11.1%	80.6%	8.3%	100.0%
			% within Preference Af CBL	100.0%	100.0%	100.0%	100.0%

Table 4: The results of cross-tabulation of Q1 of Part I with Q1 and Q2 of Part II

Appendix H.2 - Wilcoxon and Sign Test

Non-parametric tests, Wilcoxon Signed Ranks Test and Sign Test, to assess whether the subjects rated the quality of the media different than it's usefulness.

Ranks

		N	Mean Rank	Sum of Ranks
Animation Useful - Quality of Anim	Negative Ranks	10[a]	16.30	163.00
	Positive Ranks	30[b]	21.90	657.00
	Ties	40[c]		
	Total	80		
Audio Useful - Audio Quality	Negative Ranks	9[d]	23.50	211.50
	Positive Ranks	48[e]	30.03	1441.50
	Ties	23[f]		
	Total	80		
Text Useful - Text Quality	Negative Ranks	13[g]	19.69	256.00
	Positive Ranks	27[h]	20.89	564.00
	Ties	40[i]		
	Total	80		
Video Useful - Video Quality	Negative Ranks	9[j]	17.28	155.50
	Positive Ranks	41[k]	27.30	1119.50
	Ties	30[l]		
	Total	80		
Icon Useful - Icons Quality	Negative Ranks	25[m]	18.66	466.50
	Positive Ranks	14[n]	22.39	313.50
	Ties	41[o]		
	Total	80		
Pict. Useful - Pict. Quality	Negative Ranks	17[p]	21.41	364.00
	Positive Ranks	27[q]	23.19	626.00
	Ties	36[r]		
	Total	80		
Pres. Useful - Presentation Quality	Negative Ranks	7[s]	11.00	77.00
	Positive Ranks	24[t]	17.46	419.00
	Ties	49[u]		
	Total	80		

a. Animation Useful < Quality of Anim
b. Animation Useful > Quality of Anim
c. Quality of Anim = Animation Useful
d. Audio Useful < Audio Quality
e. Audio Useful > Audio Quality
f. Audio Quality = Audio Useful
g. Text Useful < Text Quality
h. Text Useful > Text Quality
i. Text Quality = Text Useful
j. Video Useful < Video Quality
k. Video Useful > Video Quality
l. Video Quality = Video Useful
m. Icon Useful < Icons Quality
n. Icon Useful > Icons Quality
o. Icons Quality = Icon Useful
p. Pict. Useful < Pict. Quality
q. Pict. Useful > Pict. Quality
r. Pict. Quality = Pict. Useful
s. Pres. Useful < Presentation Quality
t. Pres. Useful > Presentation Quality
u. Presentation Quality = Pres. Useful

Test Statistics [c]

	Animation Useful - Quality of Anim	Audio Useful - Audio Quality	Text Useful - Text Quality	Video Useful - Video Quality	Icon Useful - Icons Quality	Pict. Useful - Pict. Quality	Pres. Useful - Presentation Quality
Z	-3.470[a]	-4.998[a]	-2.211[a]	-4.727[a]	-1.125[b]	-1.576[a]	-3.465[a]
Asymp. Sig. (2-tailed)	.001	.000	.027	.000	.261	.115	.000

a. Based on negative ranks.
b. Based on positive ranks.
c. Wilcoxon Signed Ranks Test

Sign Test Results

Frequencies

		N
Animation Useful - Quality of Anim	Negative Differences[a,b]	10
	Positive Differences[h,i,j]	30
	Ties[o,p,q,r,s,t,u]	40
	Total	80
Audio Useful - Audio Quality	Negative Differences[a,b]	9
	Positive Differences[h,i,j]	48
	Ties[o,p,q,r,s,t,u]	23
	Total	80
Text Useful - Text Quality	Negative Differences[a,b]	13
	Positive Differences[h,i,j]	27
	Ties[o,p,q,r,s,t,u]	40
	Total	80
Video Useful - Video Quality	Negative Differences[a,b]	9
	Positive Differences[h,i,j]	41
	Ties[o,p,q,r,s,t,u]	30
	Total	80
Icon Useful - Icons Quality	Negative Differences[a,b]	25
	Positive Differences[h,i,j]	14
	Ties[o,p,q,r,s,t,u]	41
	Total	80
Pict. Useful - Pict. Quality	Negative Differences[a,b]	17
	Positive Differences[h,i,j]	27
	Ties[o,p,q,r,s,t,u]	36
	Total	80
Pres. Useful - Presentation Quality	Negative Differences[a,b]	7
	Positive Differences[h,i,j]	24
	Ties[o,p,q,r,s,t,u]	49
	Total	80

a. Animation Useful < Quality of Anim
b. Audio Useful < Audio Quality
c. Text Useful < Text Quality
d. Video Useful < Video Quality
e. Icon Useful < Icons Quality
f. Pict. Useful < Pict. Quality
g. Pres. Useful < Presentation Quality
h. Animation Useful > Quality of Anim
i. Audio Useful > Audio Quality
j. Text Useful > Text Quality
k. Video Useful > Video Quality
l. Icon Useful > Icons Quality
m. Pict. Useful > Pict. Quality
n. Pres. Useful > Presentation Quality
o. Quality of Anim = Animation Useful
p. Audio Quality = Audio Useful
q. Text Quality = Text Useful
r. Video Quality = Video Useful
s. Icons Quality = Icon Useful
t. Pict. Quality = Pict. Useful
u. Presentation Quality = Pres. Useful

Test Statistics[a]

	Animation Useful - Quality of Anim	Audio Useful - Audio Quality	Text Useful - Text Quality	Video Useful - Video Quality	Icon Useful - Icons Quality	Pict. Useful - Pict. Quality	Pres. Useful - Presentation Quality
Z	-3.004	-5.033	-2.055	-4.384	-1.601	-1.357	-2.874
Asymp. Sig. (2-tailed)	.003	.000	.040	.000	.109	.175	.004

a. Sign Test

Appendix H.3 - Correlation Tests

Correlation test results between the quality and the usefulness of the media.

Correlation - Animation

Correlations

		Quality of Anim	Animation Useful
Quality of Anim	Pearson Correlation	1.000	.545**
	Sig. (2-tailed)	.	.000
	N	80	80
Animation Useful	Pearson Correlation	.545**	1.000
	Sig. (2-tailed)	.000	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Quality of Anim	Animation Useful
Spearman's rho	Quality of Anim	Correlation Coefficient	1.000	.528**
		Sig. (2-tailed)	.	.000
		N	80	80
	Animation Useful	Correlation Coefficient	.528**	1.000
		Sig. (2-tailed)	.000	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Correlation - Audio

Correlations

		Audio Quality	Audio Useful
Audio Quality	Pearson Correlation	1.000	.316**
	Sig. (2-tailed)	.	.004
	N	80	80
Audio Useful	Pearson Correlation	.316**	1.000
	Sig. (2-tailed)	.004	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Audio Quality	Audio Useful
Spearman's rho	Audio Quality	Correlation Coefficient	1.000	.306**
		Sig. (2-tailed)	.	.006
		N	80	80
	Audio Useful	Correlation Coefficient	.306**	1.000
		Sig. (2-tailed)	.006	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Correlation - Text

Correlations

		Text Quality	Text Useful
Text Quality	Pearson Correlation	1.000	.579**
	Sig. (2-tailed)	.	.000
	N	80	80
Text Useful	Pearson Correlation	.579**	1.000
	Sig. (2-tailed)	.000	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Text Quality	Text Useful
Spearman's rho	Text Quality	Correlation Coefficient	1.000	.636**
		Sig. (2-tailed)	.	.000
		N	80	80
	Text Useful	Correlation Coefficient	.636**	1.000
		Sig. (2-tailed)	.000	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Correlation - Video

Correlations

		Video Quality	Video Useful
Video Quality	Pearson Correlation	1.000	.527**
	Sig. (2-tailed)	.	.000
	N	80	80
Video Useful	Pearson Correlation	.527**	1.000
	Sig. (2-tailed)	.000	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Video Quality	Video Useful
Spearman's rho	Video Quality	Correlation Coefficient	1.000	.413**
		Sig. (2-tailed)	.	.000
		N	80	80
	Video Useful	Correlation Coefficient	.413**	1.000
		Sig. (2-tailed)	.000	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Correlation - Icons

Correlations

		Icons Quality	Icon Useful
Icons Quality	Pearson Correlation	1.000	.575**
	Sig. (2-tailed)	.	.000
	N	80	80
Icon Useful	Pearson Correlation	.575**	1.000
	Sig. (2-tailed)	.000	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Icons Quality	Icon Useful
Spearman's rho	Icons Quality	Correlation Coefficient	1.000	.634**
		Sig. (2-tailed)	.	.000
		N	80	80
	Icon Useful	Correlation Coefficient	.634**	1.000
		Sig. (2-tailed)	.000	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Correlation - Pictures

Correlations

		Pict. Quality	Pict. Useful
Pict. Quality	Pearson Correlation	1.000	.400**
	Sig. (2-tailed)	.	.000
	N	80	80
Pict. Useful	Pearson Correlation	.400**	1.000
	Sig. (2-tailed)	.000	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Pict. Quality	Pict. Useful
Spearman's rho	Pict. Quality	Correlation Coefficient	1.000	.443**
		Sig. (2-tailed)	.	.000
		N	80	80
	Pict. Useful	Correlation Coefficient	.443**	1.000
		Sig. (2-tailed)	.000	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Correlation - Presentations

Correlations

		Presentation Quality	Pres. Useful
Presentation Quality	Pearson Correlation	1.000	.592**
	Sig. (2-tailed)	.	.000
	N	80	80
Pres. Useful	Pearson Correlation	.592**	1.000
	Sig. (2-tailed)	.000	.
	N	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Presentation Quality	Pres. Useful
Spearman's rho	Presentation Quality	Correlation Coefficient	1.000	.693**
		Sig. (2-tailed)	.	.000
		N	80	80
	Pres. Useful	Correlation Coefficient	.693**	1.000
		Sig. (2-tailed)	.000	.
		N	80	80

**. Correlation is significant at the .01 level (2-tailed).

Appendix H.4 - Tests Results of H1-H4

The results of comparing the satisfaction variable for the four version B, C, D, E against version A using the Mann-Whitney test (Testing H1 through H4).

Test H1 – Mann-Whitney (A – B)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	A	16	14.34	229.50
	B	16	18.66	298.50
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	93.500
Wilcoxon W	229.500
Z	-1.304
Asymp. Sig. (2-tailed)	.192
Exact Sig. [2*(1-tailed Sig.)]	.196[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Test H2 – Mann-Whitney (A – C)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	A	16	12.81	205.00
	C	16	20.19	323.00
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	69.000
Wilcoxon W	205.000
Z	-2.228
Asymp. Sig. (2-tailed)	.026
Exact Sig. [2*(1-tailed Sig.)]	.026[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Test H3 – Mann-Whitney (A – D)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	A	16	17.50	280.00
	D	16	15.50	248.00
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	112.000
Wilcoxon W	248.000
Z	-.605
Asymp. Sig. (2-tailed)	.545
Exact Sig. [2*(1-tailed Sig.)]	.564[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Test H4 – Mann-Whitney (A – E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	A	16	13.78	220.50
	E	16	19.22	307.50
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	84.500
Wilcoxon W	220.500
Z	-1.643
Asymp. Sig. (2-tailed)	.100
Exact Sig. [2*(1-tailed Sig.)]	.102[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix H.5 - Normal Distribution Test

Test the normal distribution of test score variable for all versions.

Descriptives

	Version Code			Statistic	Std. Error
TESTSUM	A	Mean		6.1250	.3981
		95% Confidence Interval for Mean	Lower Bound	5.1836	
			Upper Bound	7.0664	
		5% Trimmed Mean		6.0833	
		Median		6.0000	
		Variance		1.268	
		Std. Deviation		1.1260	
		Minimum		5.00	
		Maximum		8.00	
		Range		3.00	
		Interquartile Range		2.0000	
		Skewness		.488	.752
		Kurtosis		-.989	1.481
	B	Mean		7.3750	.4978
		95% Confidence Interval for Mean	Lower Bound	6.1980	
			Upper Bound	8.5520	
		5% Trimmed Mean		7.3611	
		Median		7.0000	
		Variance		1.982	
		Std. Deviation		1.4079	
		Minimum		5.00	
		Maximum		10.00	
		Range		5.00	
		Interquartile Range		1.0000	
		Skewness		.339	.752
		Kurtosis		2.053	1.481
	C	Mean		8.0000	.2673
		95% Confidence Interval for Mean	Lower Bound	7.3680	
			Upper Bound	8.6320	
		5% Trimmed Mean		8.0000	
		Median		8.0000	
		Variance		.571	
		Std. Deviation		.7559	
		Minimum		7.00	
		Maximum		9.00	
		Range		2.00	
		Interquartile Range		1.5000	
		Skewness		.000	.752
		Kurtosis		-.700	1.481
	D	Mean		6.5000	.5000
		95% Confidence Interval for Mean	Lower Bound	5.3177	
			Upper Bound	7.6823	
		5% Trimmed Mean		6.5556	
		Median		7.0000	
		Variance		2.000	
		Std. Deviation		1.4142	
		Minimum		4.00	
		Maximum		8.00	
		Range		4.00	
		Interquartile Range		2.5000	
		Skewness		-.808	.752
		Kurtosis		-.229	1.481
	E	Mean		7.8750	.3504
		95% Confidence Interval for Mean	Lower Bound	7.0465	
			Upper Bound	8.7035	
		5% Trimmed Mean		7.9167	
		Median		8.0000	
		Variance		.982	
		Std. Deviation		.9910	
		Minimum		6.00	
		Maximum		9.00	
		Range		3.00	
		Interquartile Range		1.5000	
		Skewness		-.862	.752
		Kurtosis		.840	1.481

Tests of Normality

	Version Code	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TESTSUM	A	.216	8	.200*	.883	8	.259
	B	.270	8	.089	.890	8	.292
	C	.250	8	.150	.849	8	.098
	D	.263	8	.109	.898	8	.331
	E	.300	8	.032	.871	8	.199

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix H.6 - Tests Results of H1-H8

The results of testing the hypotheses H5 through H8 by using t-test and Mann-Whitney test to compare the mean of test score for version A against the other four versions.

Testing H5 (A – B) t-Test

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	A	8	6.1250	1.1260	.3981
	B	8	7.3750	1.4079	.4978

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	.025	.876	-1.961	14	.070	-1.2500	.6374	-2.6170	.1170
	Equal variances not assumed			-1.961	13.355	.071	-1.2500	.6374	-2.6233	.1233

Testing H5 (A – B) Mann-Whitney Test

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	A	8	6.44	51.50
	B	8	10.56	84.50
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	15.500
Wilcoxon W	51.500
Z	-1.800
Asymp. Sig. (2-tailed)	.072
Exact Sig. [2*(1-tailed Sig.)]	.083[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Testing H6 (A – C) t-Test

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	A	8	6.1250	1.1260	.3981
	C	8	8.0000	.7559	.2673

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	2.147	.165	-3.910	14	.002	-1.8750	.4795	-2.9034	-.8466
	Equal variances not assumed			-3.910	12.245	.002	-1.8750	.4795	-2.9174	-.8326

Testing H6 (A – C) Mann-Whitney Test

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	A	8	5.25	42.00
	C	8	11.75	94.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	6.000
Wilcoxon W	42.000
Z	-2.806
Asymp. Sig. (2-tailed)	.005
Exact Sig. [2*(1-tailed Sig.)]	.005[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Testing H7 (A – D) t-Test

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	A	8	6.1250	1.1260	.3981
	D	8	6.5000	1.4142	.5000

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	.434	.521	-.587	14	.567	-.3750	.6391	-1.7458	.9958
	Equal variances not assumed			-.587	13.331	.567	-.3750	.6391	-1.7523	1.0023

Testing H7 (A – D) Mann-Whitney Test

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	A	8	7.69	61.50
	D	8	9.31	74.50
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	25.500
Wilcoxon W	61.500
Z	-.703
Asymp. Sig. (2-tailed)	.482
Exact Sig. [2*(1-tailed Sig.)]	.505[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Testing H8 (A – E) t-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	.496	.493	-3.300	14	.005	-1.7500	.5303	-2.8874	-.6126
	Equal variances not assumed			-3.300	13.778	.005	-1.7500	.5303	-2.8892	-.6108

Testing H8 (A – E) Mann-Whitney Test

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	A	8	5.50	44.00
	E	8	11.50	92.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	8.000
Wilcoxon W	44.000
Z	-2.584
Asymp. Sig. (2-tailed)	.010
Exact Sig. [2*(1-tailed Sig.)]	.010[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix H.7 - Tests Results of H9-H12

Testing H9 through H12 hypotheses that test the quality of the material in terms of student's satisfaction. The Mann-Whitney was applied to test these hypotheses.

H9 - Testing the Overall Satisfaction Using Mann-Whitney Test (B – C)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	B	16	14.47	231.50
	C	16	18.53	296.50
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	95.500
Wilcoxon W	231.500
Z	-1.227
Asymp. Sig. (2-tailed)	.220
Exact Sig. [2*(1-tailed Sig.)]	.224[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H10 - Testing the Overall Satisfaction Using Mann-Whitney Test (C – D)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	C	16	20.44	327.00
	D	16	12.56	201.00
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	65.000
Wilcoxon W	201.000
Z	-2.380
Asymp. Sig. (2-tailed)	.017
Exact Sig. [2*(1-tailed Sig.)]	.017[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H11 - Testing the Overall Satisfaction Using Mann-Whitney Test (B - E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	B	16	15.59	249.50
	E	16	17.41	278.50
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	113.500
Wilcoxon W	249.500
Z	-.547
Asymp. Sig. (2-tailed)	.584
Exact Sig. [2*(1-tailed Sig.)]	.590[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H12 - Testing the Overall Satisfaction Using Mann-Whitney Test (D - E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	D	16	13.56	217.00
	E	16	19.44	311.00
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	81.000
Wilcoxon W	217.000
Z	-1.777
Asymp. Sig. (2-tailed)	.076
Exact Sig. [2*(1-tailed Sig.)]	.080[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix H.8 - Test Results of H13-H16

Testing H13 - H16 hypotheses that test the quality of the material in terms of student's learning. The t-test and the Mann-Whitney were applied to test these hypotheses.

H13 - Testing the Learning Outcome - The t-Test (B – C)

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	B	8	7.3750	1.4079	.4978
	C	8	8.0000	.7559	.2673

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	1.471	.245	-1.106	14	.287	-.6250	.5650	-1.8368	.5868
	Equal variances not assumed			-1.106	10.726	.293	-.6250	.5650	-1.8724	.6224

H13 - Testing the Learning Outcome - The Mann-Whitney Test (B – C)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	B	8	7.00	56.00
	C	8	10.00	80.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	20.000
Wilcoxon W	56.000
Z	-1.332
Asymp. Sig. (2-tailed)	.183
Exact Sig. [2*(1-tailed Sig.)]	.234[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H14 - Testing the Learning Outcome - The t-Test (C - D)

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	C	8	8.0000	.7559	.2673
	D	8	6.5000	1.4142	.5000

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	3.723	.074	2.646	14	.019	1.5000	.5669	.2840	2.7160
	Equal variances not assumed			2.646	10.698	.023	1.5000	.5669	.2478	2.7522

H14 - Testing the Learning Outcome - The Mann-Whitney Test (C - D)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	C	8	11.13	89.00
	D	8	5.88	47.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	11.000
Wilcoxon W	47.000
Z	-2.302
Asymp. Sig. (2-tailed)	.021
Exact Sig. [2*(1-tailed Sig.)]	.028[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H15 - Testing the Learning Outcome - The t-Test (B – E)

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	B	8	7.3750	1.4079	.4978
	E	8	7.8750	.9910	.3504

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	.468	.505	-.821	14	.425	-.5000	.6087	-1.8056	.8056
	Equal variances not assumed			-.821	12.570	.427	-.5000	.6087	-1.8196	.8196

H15 - Testing the Learning Outcome - The Mann-Whitney Test (B – E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	B	8	7.25	58.00
	E	8	9.75	78.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	22.000
Wilcoxon W	58.000
Z	-1.096
Asymp. Sig. (2-tailed)	.273
Exact Sig. [2*(1-tailed Sig.)]	.328[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H16 - Testing the Learning Outcome - The t-Test (D – E)

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	D	8	6.5000	1.4142	.5000
	E	8	7.8750	.9910	.3504

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	1.538	.235	-2.252	14	.041	-1.3750	.6105	-2.6845	-6.6E-02
	Equal variances not assumed			-2.252	12.539	.043	-1.3750	.6105	-2.6990	-5.1E-02

H16 - Testing the Learning Outcome - The Mann-Whitney Test (D – E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	D	8	6.13	49.00
	E	8	10.88	87.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	13.000
Wilcoxon W	49.000
Z	-2.068
Asymp. Sig. (2-tailed)	.039
Exact Sig. [2*(1-tailed Sig.)]	.050[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix H.9 - Tests Results of H17-H18

Testing H17 and H18 hypotheses that test the quality of the material in terms of student's satisfaction. The Mann-Whitney was applied to test these hypotheses.

H17 - Testing the Overall Satisfaction Using Mann-Whitney Test (B – D)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	B	16	19.44	311.00
	D	16	13.56	217.00
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	81.000
Wilcoxon W	217.000
Z	-1.775
Asymp. Sig. (2-tailed)	.076
Exact Sig. [2*(1-tailed Sig.)]	.080[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H18 - Testing the Overall Satisfaction Using Mann-Whitney Test (C – E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
Overall Satisfaction	C	16	16.72	267.50
	E	16	16.28	260.50
	Total	32		

Test Statistics[b]

	Overall Satisfaction
Mann-Whitney U	124.500
Wilcoxon W	260.500
Z	-.132
Asymp. Sig. (2-tailed)	.895
Exact Sig. [2*(1-tailed Sig.)]	.897[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix H.10 - Tests Results of H19-H20

Testing H19 and H20 hypotheses that test the quality of the material in terms of student's learning. The t-test and the Mann-Whitney were applied to test these hypotheses.

H19 - Testing the Learning Outcome - The t-Test (B – D)

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	B	8	7.3750	1.4079	.4978
	D	8	6.5000	1.4142	.5000

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	.133	.720	1.240	14	.235	.8750	.7055	-.6382	2.3882
	Equal variances not assumed			1.240	14.000	.235	.8750	.7055	-.6382	2.3882

H19 - Testing the Learning Outcome - The Mann-Whitney Test (B – D)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	B	8	9.69	77.50
	D	8	7.31	58.50
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	22.500
Wilcoxon W	58.500
Z	-1.051
Asymp. Sig. (2-tailed)	.293
Exact Sig. [2*(1-tailed Sig.)]	.328[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H20 - Testing the Learning Outcome - The t-Test (C – E)

Group Statistics

	Version Code	N	Mean	Std. Deviation	Std. Error Mean
TESTSUM	C	8	8.0000	.7559	.2673
	E	8	7.8750	.9910	.3504

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TESTSUM	Equal variances assumed	.387	.544	.284	14	.781	.1250	.4407	-.8202	1.0702
	Equal variances not assumed			.284	13.085	.781	.1250	.4407	-.8264	1.0764

H20 - Testing the Learning Outcome - The Mann-Whitney Test (C – E)

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
TESTSUM	C	8	8.63	69.00
	E	8	8.38	67.00
	Total	16		

Test Statistics[b]

	TESTSUM
Mann-Whitney U	31.000
Wilcoxon W	67.000
Z	-.114
Asymp. Sig. (2-tailed)	.910
Exact Sig. [2*(1-tailed Sig.)]	.959[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix H.11 - Results of Question 5

Subjects' responses of the last question in the questionnaire that deal with reviewers' main modifications and whether that effects their choice of a particular version.

Reviewers' Main Modifications

				Subject Code	Sound Quality	Sound Summary	Animated Bullets	Sound Bullets	Navg. Buttons	Index and body	Graph Index	Status Bar	Audio Title
Overall Satisfaction version	A	1		D-A	No	N.A.*	N.A.	N.A.	N.A.	No	N.A.	N.A.	N.A.
		2		A-D	No	N.A.	N.A.	N.A.	No	No	N.A.	N.A.	N.A.
		3		B-A	No	No	No	No	No	N.A.	N.A.	N.A.	N.A.
		4		D-A	No	No	No	N.A.	No	No	N.A.	N.A.	N.A.
		Total	N	4	4	4	4	4	4	4	4	4	4
	B	1		D-B	No	Yes	N.A.	Yes	No	No	N.A.	N.A.	N.A.
		2		A-B	Yes	Yes	N.A.	Yes	Yes	N.A.	N.A.	N.A.	N.A.
		3		C-B	No	Yes	No	Yes	No	N.A.	N.A.	N.A.	N.A.
		4		E-B	No	Yes	No	Yes	Yes	N.A.	No	No	No
		5		B-E	No	Yes	No	Yes	Yes	N.A.	No	No	No
		6		D-B	No	Yes	No	Yes	Yes	N.A.	N.A.	N.A.	N.A.
		7		A-B	No	No	N.A.	No	Yes	N.A.	N.A.	N.A.	N.A.
		8		C-B	Yes	Yes	No	Yes	No	N.A.	N.A.	N.A.	N.A.
		9		B-A	Yes	Yes	N.A.	Yes	Yes	N.A.	N.A.	N.A.	N.A.
		Total	N	9	9	9	9	9	9	9	9	9	9
	C	1		B-C	No	No	Yes	No	No	N.A.	N.A.	N.A.	N.A.
		2		C-D	Yes	Yes	Yes	N.A.	No	N.A.	N.A.	N.A.	N.A.
		3		C-A	No	Yes	Yes	N.A.	Yes	N.A.	N.A.	N.A.	N.A.
		4		A-C	Yes	Yes	Yes	N.A.	Yes	N.A.	N.A.	N.A.	N.A.
		5		B-C	No	No	Yes	No	No	N.A.	N.A.	N.A.	N.A.
		6		C-D	No	Yes	Yes	N.A.	Yes	No	N.A.	N.A.	N.A.
		7		E-C	No	Yes	Yes	No	Yes	N.A.	No	No	No
		8		C-A	Yes	Yes	Yes	N.A.	Yes	N.A.	N.A.	N.A.	N.A.
		9		D-C	No	No	Yes	N.A.	Yes	No	N.A.	N.A.	N.A.
		10		A-C	No	Yes	Yes	N.A.	Yes	N.A.	N.A.	N.A.	N.A.
		Total	N	10	10	10	10	10	10	10	10	10	10
	D	1		D-C	No	No	No	No	No	Yes	N.A.	N.A.	N.A.
		2		B-D	No	No	N.A.	No	No	Yes	N.A.	N.A.	N.A.
		3		D-E	No	N.A.	No	N.A.	No	Yes	No	No	No
		4		A-D	No	N.A.	N.A.	N.A.	Yes	Yes	N.A.	N.A.	N.A.
		Total	N	4	4	4	4	4	4	4	4	4	4
	E	1		C-E	No	No	No	No	Yes	No	Yes	No	Yes
		2		A-E	Yes	N.A.	Yes	N.A.	Yes	N.A.	Yes	Yes	Yes
		3		B-E	No	No	No	No	No	N.A.	Yes	No	Yes
		4		E-C	Yes	No	Yes	N.A.	No	N.A.	Yes	Yes	Yes
		5		D-E	No	N.A.	Yes	N.A.	Yes	No	Yes	Yes	Yes
		6		E-A	No	N.A.	Yes	N.A.	No	N.A.	Yes	No	Yes
		7		C-E	No	No	No	No	No	No	N.A.	Yes	No
		8		E-D	No	No	Yes	N.A.	No	No	Yes	No	Yes
		9		A-E	No	N.A.	Yes	N.A.	No	No	Yes	Yes	Yes
		10		E-A	No	N.A.	Yes	N.A.	No	N.A.	Yes	No	No
		Total	N	10	10	10	10	10	10	10	10	10	10
	Both	1		E-B	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
		2		B-D	Yes	Yes	N.A.	Yes	Yes	Yes	N.A.	N.A.	N.A.
		3		E-D	No	N.A.	No	N.A.	No	Yes	Yes	Yes	Yes
		Total	N	3	3	3	3	3	3	3	3	3	3
	Total	N		40	40	40	40	40	40	40	40	40	40

Table 1: Subjects' Answers of Q5. of Part IV

*. Not Applied

Subjects' main comments

Subjects' Comments For Choosing A Particular Version

			Subject Code	Others
Overall Satisfaction version	A	1	D-A	Layout of the 2nd was better. Can access what is required faster.
		2	A-D	The arrangement of the buttons was better in the first.
		3	B-A	
		4	D-A	The presentation was not automatic which makes it more like lecture.
	B	1	D-B	
		2	A-B	
		3	C-B	
		4	E-B	
		5	B-E	
		6	D-B	More Details in terms of navigation through it
		7	A-B	
		8	C-B	
		9	B-A	
	C	1	B-C	
		2	C-D	
		3	C-A	
		4	A-C	
		5	B-C	The information was presented in different format (sound, sound summay, silde show).
		6	C-D	
		7	E-C	Glossary helps a new students in better understanding. Navig. improve better
		8	C-A	
		9	D-C	Better presentation
		10	A-C	Video (avi) presentation, which allowed more control.
	D	1	D-C	The layout in the first was better (more readable)
		2	B-D	
		3	D-E	
		4	A-D	
	E	1	C-E	
		2	A-E	
		3	B-E	
		4	E-C	Back and Prev Buttom. Some sound file is not clear. Vedio is not clear.
		5	D-E	More presentable
		6	E-A	
		7	C-E	
		8	E-D	
		9	A-E	
		10	E-A	
	Both	1	E-B	
		2	B-D	
		3	E-D	V1 provide better structure in terms of understanding, v2 is easier to follow in term of the arrangement of the material

Table 2: (Cont.) Subjects' Answers of Q5. of Part IV

Appendix H.12 - Repeated Tests

Repeating the test, Mann-Whitney Test, for the satisfactions' hypotheses after removing the related data.

H1 - Testing A against B

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	A	14	13.04	182.50
	B	14	15.96	223.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	77.500
Wilcoxon W	182.500
Z	-.945
Asymp. Sig. (2-tailed)	.344
Exact Sig. [2*(1-tailed Sig.)]	.352[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H2 - Testing A against C

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	A	14	11.14	156.00
	C	14	17.86	250.00
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	51.000
Wilcoxon W	156.000
Z	-2.165
Asymp. Sig. (2-tailed)	.030
Exact Sig. [2*(1-tailed Sig.)]	.031[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H3 - Testing A against D

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	A	14	14.36	201.00
	D	14	14.64	205.00
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	96.000
Wilcoxon W	201.000
Z	-.092
Asymp. Sig. (2-tailed)	.926
Exact Sig. [2*(1-tailed Sig.)]	.946[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H4 - Testing A against E

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	A	14	12.39	173.50
	E	14	16.61	232.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	68.500
Wilcoxon W	173.500
Z	-1.359
Asymp. Sig. (2-tailed)	.174
Exact Sig. [2*(1-tailed Sig.)]	.178[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H9 - Testing B against C

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	B	14	12.25	171.50
	C	14	16.75	234.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	66.500
Wilcoxon W	171.500
Z	-1.450
Asymp. Sig. (2-tailed)	.147
Exact Sig. [2*(1-tailed Sig.)]	.150[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H11 - Testing B against E

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	B	14	14.46	202.50
	E	14	14.54	203.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	97.500
Wilcoxon W	202.500
Z	-.023
Asymp. Sig. (2-tailed)	.982
Exact Sig. [2*(1-tailed Sig.)]	.982[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H10 - Testing C against D

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	C	14	18.25	255.50
	D	14	10.75	150.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	45.500
Wilcoxon W	150.500
Z	-2.418
Asymp. Sig. (2-tailed)	.016
Exact Sig. [2*(1-tailed Sig.)]	.014[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H12 - Testing D against E

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	D	14	11.57	162.00
	E	14	17.43	244.00
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	57.000
Wilcoxon W	162.000
Z	-1.888
Asymp. Sig. (2-tailed)	.059
Exact Sig. [2*(1-tailed Sig.)]	.062[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H17 - Testing B against D

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	B	14	17.04	238.50
	D	14	11.96	167.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	62.500
Wilcoxon W	167.500
Z	-1.634
Asymp. Sig. (2-tailed)	.102
Exact Sig. [2*(1-tailed Sig.)]	.104[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

H18 - Testing C against E

Ranks

	Version Code	N	Mean Rank	Sum of Ranks
SATEASUF	C	14	14.25	199.50
	E	14	14.75	206.50
	Total	28		

Test Statistics[b]

	SATEASUF
Mann-Whitney U	94.500
Wilcoxon W	199.500
Z	-.161
Asymp. Sig. (2-tailed)	.872
Exact Sig. [2*(1-tailed Sig.)]	.874[a]

a. Not corrected for ties.

b. Grouping Variable: Version Code

Appendix K - The Evaluated Material

This appendix presents the evaluated material by showing all the five versions as segments of the whole material.

Student's Evaluation

Thank you for your participation in this evaluation. Please follow the code given to you for this evaluation. Each evaluation is given a letter A, B, C, D and E. For example, if your code is E-D then you start with evaluation E then, later when you return, evaluation D.

Thank you.

Evaluation A

Evaluation B

Evaluation C

Evaluation D

Evaluation E

Software Environment
Advance Computer Architecture

Previous Next
Unit 0: The Design of the Material
Index Help

File No: 700

Advanced Computer Architecture

Advanced Computer Architecture course is divided into the following lectures:

Software Environment
Unit 0: The Design of the Material

Previous
Advance Computer Architecture

Next
Unit 7: Introduction To Microcontroller

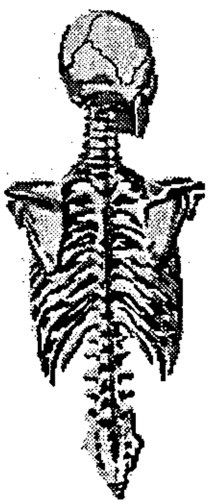
Index

Help

The design of the material

Frames and Icons used in the material

The design of the material

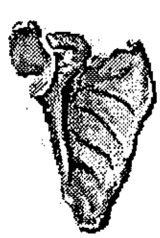


The authors and the students need a referential framework with which to both approach and view the learning material. For the present, most of the material to be converted to or created in distance learning format will be of a technical nature and, with the exception of referential access, is often best viewed in a guided manner. The lecturer has traditionally organised the presentation of material in a structured sequence and it is useful to allow this approach to be carried through to the distant learner (although students who do not favour or need this approach will not be constrained to using it).

A good metaphor for the body of material to be taught is to view an entire topic as being represented by the human skeleton - upper torso.

Each and every Topic presented in this manner would have its head. This section will contain all of the usual introductory material together with adjuncts such as:

- a rational for its inclusion
- a (hyperlinked) map or guide through the material together with brief notes on each Unit
- information on the coursework or assessment procedures, if any
- any references that the material draws upon
- an outline of any tools or techniques that will be required for the following units.



Moving on down it is useful to consider the shoulder blades, these may be thought of as providing both Help information (specifically for using the system) and specifying the prerequisite Units or knowledge required.

Software Environment
Unit 0: The Design of the Material

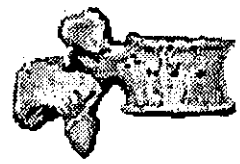
Previous
Advance Computer Architecture

Next
Unit 7: Introduction To Microcontroller

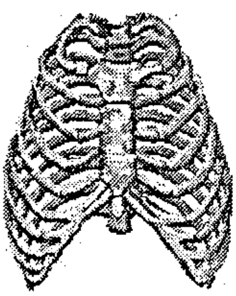
Index

Help

The main thread of the learning material may be viewed as the spine of this model, with each Unit being represented by a vertebra and its associated ribs. It is useful for both author and student to know that, if trying to learn such material from scratch, then there exists a recommended path through the material as prescribed by following the vertebrae down the spine from head to tail. This is facilitated in the delivery system by means of clear indications of both how to proceed and how to backtrack.



Each vertebrae can be considered to contain the minimum set of nuggets - elements of the Unit consisting of lecture notes, multimedia material, self-assessment material etc., such that a student who is proceeding well will only need to work with this core material. The spinal vertebrae thus can be considered to represent the terse route.
However, the inclusions of 'Tristram Shandies' (interesting digressions) is to be encouraged to satisfy the learner who would wish to know all that there is to know.



It will often be the case that the student may struggle at this level, at which point the ribs provide a range of additional material to supplement or reinforce the learning process.

The formative self-assessment in both the vertebrae and the ribs serves to provide a level of diagnostic aid to the learner such that they could be guided or linked back to an appropriate Unit that could represent the cause of their difficulties.

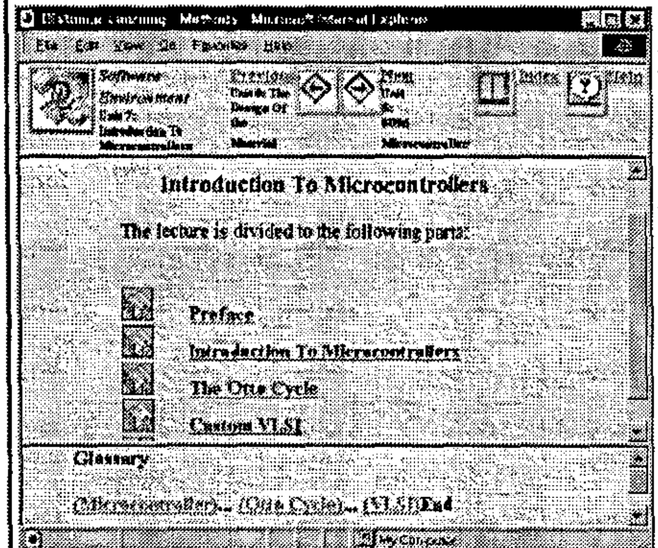
The tail (vestigial) of the spine thus represents the completion of the Topic. It would contain not only the summaries for all of the units covered but may also provide both all encompassing formative self-assessment and summative assessment.

Tristram Shandy - "The Life and Opinions of Tristram Shandy (Gentleman)" Laurence Sterne 1760

Software Environment
Unit 0: The Design of the Material

Previous Advance Computer Architecture | **Next** Unit 7: Introduction To Microcontroller | **Index** | **Help**

Frames and Icons used in the material



The screen is divided into 3 frames: header, body and footer. The **header frame** contains information to navigate the material. At the top level, the header is used to navigate through the lectures or units. At the bottom level, when the user want to explore one of the lectures (units), the header is used to navigate the lecture's sections (Vertebrae). Text, hypertext and icons are used to show the present lectures navigation information. For this evaluation, we developed two lectures of Advance Computer Architectures. These are "Introduction to Microcontrollers" (Unit 7) and as a Microcontroller example, the "Intel 8096 Microcontroller" (Unit 8). The following table shows the icons used in the header frame.

	Aims and objective of the Distance Learning initiative.
	No back link.
	At the upper level, returns to the previous lecture. At the lower level, returns to the previous section (vertebra)
	At the upper level, moves to the next lecture. At the lower level, moves to the next section (vertebra)
	Returns to the upper index.
	Load the help page (this page)

The **body frame** used as menu in the upper level and as text page in the lower level. At the top level, the body frame contains lectures menu. At a lower level, the body frame shows a menu of the lectures sections (vertebra). At the bottom level, the body frame contains the text of the lecture. The following table shows the icons used in the body frame.

	Represents a a link to one of the lecture's sections (vertebra).

Software Environment
Unit 0: The Design of the Material

Previous
Advance Computer Architecture

Next
Unit 7: Introduction To Microcontroller

Index

Help

	Represents a a link to one of the lecture's sections (vertebra).
	Click this to play a sound file.
	Click this to play an animation file.
	Used in the upper index menu to load the lecture notes.
	This represents additional information (a Rib). This is used to indicate the user choice to read this extra information.
	Represents a preset bookmark within the lecture text.
	Click this to play a slide show.
	Click this to play a video file.
	Click this to go to the top of the page.
	Back to the main index.

The **footer frame** is used as a glossary page and as a summary page of the sound file. In the glossary page, a menu of terms are written as a hypertext. The user can click any of the terms to find the explanation. On other hand, if the user clicks for a summary file of a sound file, a summary page is loaded in the footer frame. The user can go back to the glossary page by clicking the browser's back button, or by clicking the right mouse button and then choose back.

File No: 700

Introduction To Microcontrollers

The lecture is divided into the following parts:

Glossary

(Microcontroller)... (Otto Cycle)... (VLSI)End

Software Environment
Microcontrollers
Preface

Previous
Introduction To Microcontroller
(Index)

Next
Introduction To Microcontroller

Index

Help

File No: 701

Preface

In the 80's, computing industry was sponsored by big companies to develop a microprocessor that can accurately control specific tasks required by their line of production. Automotive industry, for example, sponsored a development of a single chip microprocessor that can manage and control engine efficiency, engine performance, engine safety and engine pollution. In this lecture, Vertebra 1 with its Ribs cover the introduction of microcontrollers, Vertebra 2 explain the basic components of a microcontrollers. The usage and limitation that led to the 16-bit microprocessor is given in Vertebra 3. The Otto cycle as a theory of the engine, is presented in Vertebra 4. Finally the idea of custom VLSI and IC's development tools is highlighted in Vertebra 5.
This lecture is the seventh lecture in the course. The lecture is broken to five sections, as mentioned above, but for the purpose of this evaluation, only three sections would be visible. These sections are: Introduction to Microcontroller, The Otto Cycle and Custom VLSI. The Introduction section contains a sound file and one Rib (extra information). The Otto Cycle section explains the Otto Cycle concept and the need for a Microcontroller to control the Otto Cycle. This section contains sound files, presentations, and three Ribs. The first Rib summarises the Automobile Ignition System. The second Rib is an animation of the Otto Cycle summary and the third Rib is a self-assessment Rib. The last section in this lecture is on Custom VLSI. This section explains how we could use ASIC libraries to build custom components. It contains two sound files.

Glossary

Software Environment
Microcontrollers
Introduction

Previous
Preface

Next
Otto
Cycle

Index

Help

File No: 710

Introduction

Introduction To Microcontrollers

Industry and Microcontrollers

Introduction To Microcontrollers

By the early 80's there was sufficient Silicon space with the advent of VLSI to consider two prime directives:

- **The design and development of the first 32-bit microprocessors (CPUs) or**
- **The design and development of a range of single chip microcomputers (complete computer systems on a single piece of silicon) .** ***It is clear that if the silicon real-estate is used in this way, then only a small CPU can be incorporated and in the first instance these were 8-bit.***
  Examples include:Intel 8035 and 8048

Glossary

CPU... Microprocessor... Silcon Real State... Silcon Space...End

Software Environment
Microcontrollers
Introduction
Why and What for?

Previous
Introduction

Next
Otto
Cycle

Index

Help

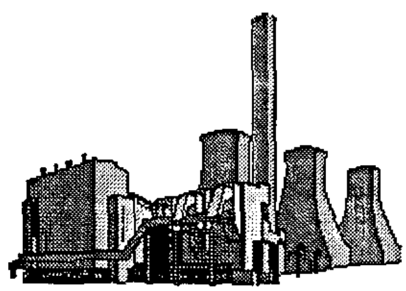
File No: 711

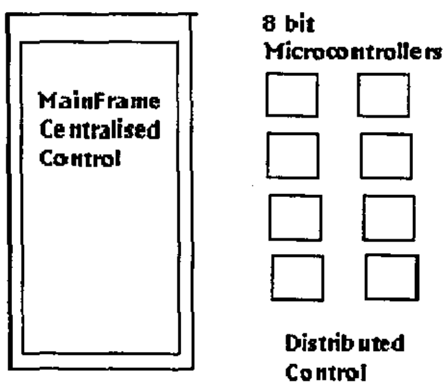
Microcontrollers

Why and What for?

Industry and Microcontrollers

8-bit Microcomputers were not foreseen as being relevant to the computing industry, but rather the industrial and process control industry, where the problems of centralised control, in the form of a single large computer, were being devolved down to *distributed* control.





Glossary

Software
Environment
Microcontrollers
Otto Cycle

Previous
Introduction To
Microcontroller

Next
Custom
VLSI

Index

Help

File No: 740

Otto Cycle

Introduction To The Otto Cycle

The Four Stroke Cycle Inlet, Compression, *Ignition,* Expansion, Exhaust

The Otto Cycle applied to Four Cylinders

Combustion

Timing - Correct Ignition , Late Ignition , Early Ignition

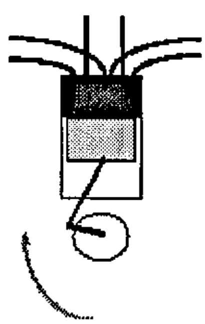
Critical Reference Point

An Automobile Ignition System , Animation

Assessment

Introduction Summary of sound

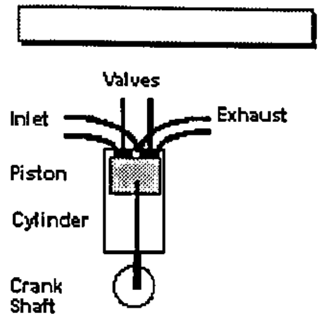
The Otto Cycle



The Internal Combustion (Petrol) Engine is based upon a four

Glossary

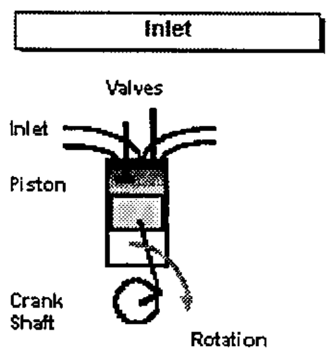
Crankshaft... Flywheel... Bottom Dead Centre... Piston... Reciprocating Cycle... Top Dead Centre...End



Start Cycle Summary of sound

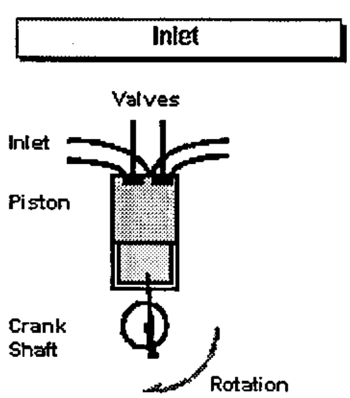
Inlet Summary of sound

During the first revolution of the crankshaft, the piston is drawn down the Cylinder. Fuel/Air mix is *sucked* into the chamber. (Rotation is dependent upon stored energy in the Flywheel)



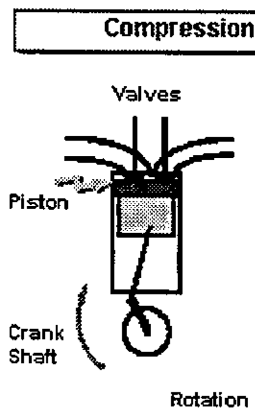
Inlet

At the *bottom* of the inlet stroke the valves are closed.



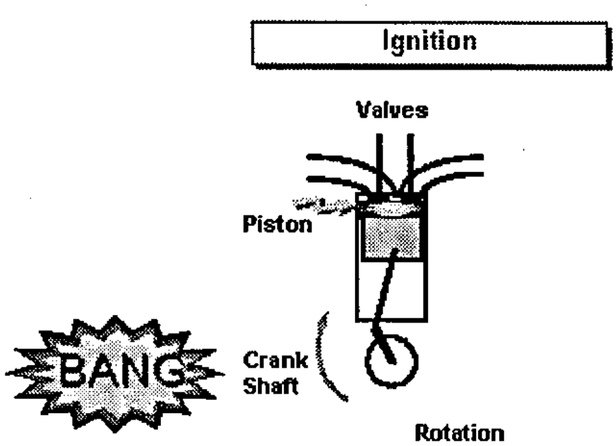
Compression Summary of sound

When almost fully compressed the fuel/air mix becomes explosive and a short spark from the spark plug ignites the gas and....



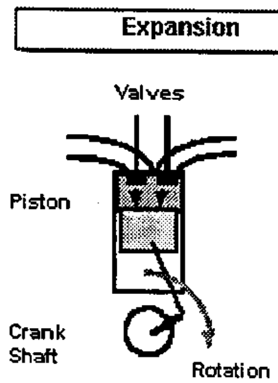
Ignition

When almost fully compressed the fuel/air mix becomes explosive and a short spark from the spark plug ignites the gas and....



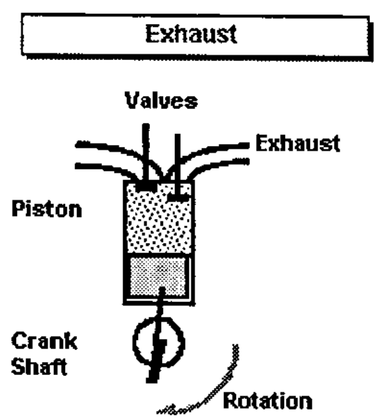
Expansion

The expanding hot gas pushes the piston back down the cylinder. This is the Power stroke delivering energy to the Flywheel. Note that this is the third stroke and the second revolution.



Exhaust

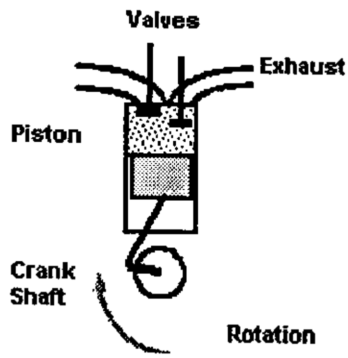
At the bottom of the stroke, the Exhaust Valve is opened and....



Exhaust

At the bottom of the stroke, the Exhaust Valve is opened and in the fourth stroke the waste gasses are blown out through the exhaust system.

Exhaust



The Otto Cycle applied to Four Cylinders
Summary of sound

- **Each cylinder requires two revolutions to complete the four strokes:**
  Suck Squeeze Bang Blow

  Suck Squeeze Bang Blow

The Otto Cycle - 4 Cylinder

In a four cylinder engine there is a continuous power stroke by virtue of distributed cycles:
Cylinder

1 Suck Squeeze Bang Blow

3 Blow Suck Squeeze Bang

2 Bang Blow Suck Squeeze

4 Squeeze Bang Blow Suck

Combustion

Despite what it may seem, explosions are not instantaneous. It takes about 2 ms for the flame to propagate through the combustion chamber. For this reason the ignition must be *advanced* in time to a precise point before the top of the compression stroke, know as Top, Dead Centre (TDC) such

that the fuel is fully combusted by TDC and the maximum power can be extracted from it.

Please note that you have the choice to play the following file, either as full presentation or as segments of the presentation.

Timing of the ignition(full presentation, need 2 minutes to load)

or

Timing (Play the segment as sound) Timing (Play the segment as a slide show presentation)

(play each point in the segment as sound.)

- **The principles outlined in the Otto Cycle work fine up to a point......**
- **If the spark does not come at the correct time.....**
- **If the ignition occurs much to early....**
- **If the ignition occurs too late....**
- **These things do not necessarily mean that a microcomputer is required.....**
- **However, early and late ignition also significantly affect the amount of pollution...**
- **...look at the range of times that might be needed in a modern engine.....**
- **Generally speaking we cannot look inside a working engine....**
- **6000 RPM is incredible when turned into seconds.....**

A typical engine idles at 600 revs per minute (rpm), i.e. 10 revs per second.
Thus 1 rev takes 100 ms.
Each degree of revolution takes about 300 microseconds.

- **At maximum, the engine is turning at 6000 rpm.**
  Thus 1 rev takes 10 ms.
  Each degree of revolution takes about 30 microseconds.

Correct Ignition (Play the segment as sound) Correct Ignition (Play the segment as a slide show presentation)

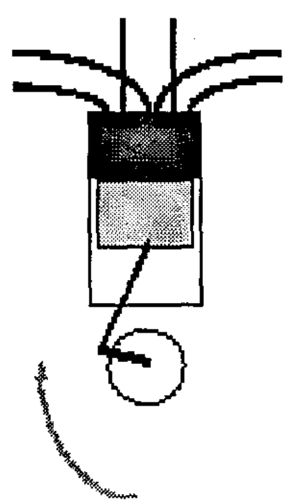
(play each point in the segment as sound.)

- **If we take a typical engine running at 3000 RPM....**
- **An engine running at 3000 RPM is equivalent to.....**
- **If the four stroke Otto cycle requires 2 ignitions per revolution....**
- **In order to provide a reference point for this ignition....**
- **Timing of the ignition just before TDC is reached is critical....**
- **In order to discuss when the ignition should occur...**
- **Correct ignition for an engine rotating at....**

The trouble is, if ignition occurs a few degrees too early or too late(Play the segment as a sound)

The trouble is, if ignition occurs a few degrees too early or too late(Play the segment as a slide show presentation)

If the gas is ignited precisely 2 ms before TDC the gas will start to expand right at the start of the power stroke, and hence deliver maximum power and fuel efficiency. 2ms corresponds to about 8 degrees before TDC at idle and about 80 degrees at maximum revs.



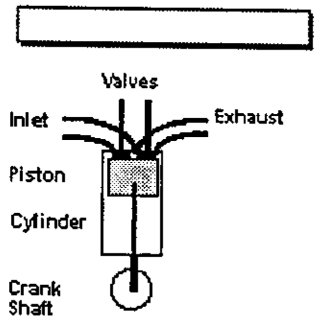
Late Ignition (Play the segment as sound) Late Ignition (Play the segment as animation)

(play each point in the segment as sound.)

- **If the ignition is late.....**

- <u>**Such an engine will also never fully burn all of the fuel.**</u>

If the gas is ignited too late, i.e. only about 20 usec later than optimal, the fuel is not completely burnt and less power is delivered. It also exhausts unspent fuel and doesn't meet international regulations on emissions.

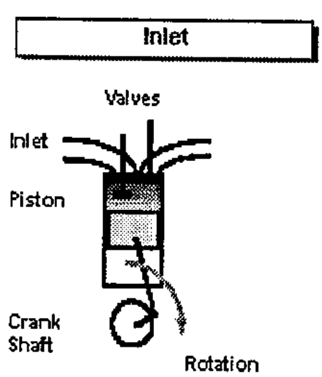


Early Ignition (Play the segment as sound) Early Ignition (Play the segment as a slide show presentation)

(play each point in the segment as sound.)

- <u>**If the ignition comes too early...**</u>
- <u>**Although this cannot stop or reverse an engine...**</u>

If the gas is ignited too early, i.e. only about 20 usec earlier than optimal, the fuel burns and starts to expand. As the piston has not yet reached TDC it is forced *backwards* in the opposite rotational direction. This effect can be heard as a *knocking* sound.



Critical Reference Point (Play the segment as sound)

Critical Reference Point (Play the segment as a slide show presentation)

Critical Reference Point (play each point in the segment as sound.)

- **The question therefore is just how critical are these timings?**
- **In the worst case we would have only ¼ of a revolution....**
- **Although only 2 ms may be sufficient to calculate the degree of advancement...**
- **....ignition to an accuracy of less than 20us for efficient combution.**
- **In order to stage this ignition at exactly the right time...**
- **If we measure everything from BDC....**
- **In processing terms, at 1 Mips, ...**

If a reference point in time can be found at Bottom, Dead Centre, a processor would have at least 90 degrees of revolution (2.5 ms minimum at maximum revs) to calculate the ignition firing time w.r.t. BDC and should fire the ignition with a relative accuracy of less than 10 microseconds. 2.5 ms is an adequate amount of time in which the calculate (or look up) the firing point delay, but the 10 microsecond accuracy is virtually impossible to achieve with traditional interrupt systems and comparatively slow microprocessors.

Enter the Intel 8096.(Play the segment as sound)
Enter the Intel 8096. (Play the segment as a slide show presentation)

(play each point in the segment as sound.)

- **So calculation time is not important....**
- **And there in lies the problem. If an ordinary microprocessor were used....**
- **Having completed the calculation, such a processor...**
- **What is needed is some device or processor that is dedicated to the task...**

An Automobile Ignition System , Animation

Assessment

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Software Environment Previous Otto Cycle | Next Custom VLSI | Index | Help

Microcontrollers

Otto Cycle

An Automobile Ignition System

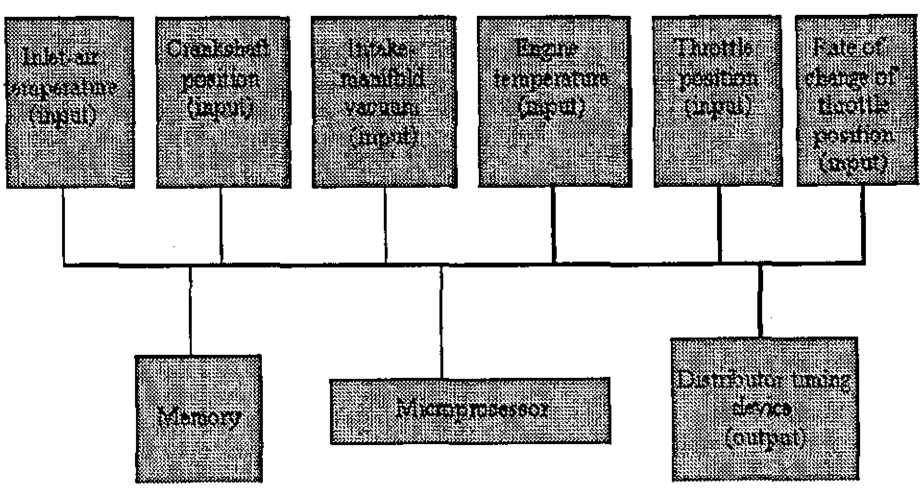
File No: 743

An Automobile Ignition System

Automobile industry realised the need to use a microprocessor in the engine to maximise engine output and minimise engine pollution. To reach the optimal time to ignite the fuel mixture, six values need to be controlled. These values were:

- Inlet-air temperature.
- Crankshaft position.
- Intake manifold vacuum.
- Engine temperature.
- Throttle position.
- Rate of change of throttle position.

The optimisation criterion for an engine would be some weighted combination that would tend to minimise fuel consumption and exhaust pollutants and maximise performance. Once the criterion is established, optimal control theory could be used to produce an algorithm for determining the output timing from the input variables listed above. Microcontroller is used to read the input variables periodically and , by using optimisation algorithm , to predict the precise time to ignite the fuel mixture. The memory not only can be used to store the current information, but, depending on the complexity of the algorithm, could also store past readings of the input variables.



Inputs of Microcontroller

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File No: 741

Summary in Animation

Otto Cycle Animation (Need 2 minutes to load)

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File No: 742

Assessments

Timings

A typical engine idles at 600 revs per minute (rpm), i.e. 10 revs per second.
Thus 1 rev takes 100 ms.
Each degree of revolution takes about 300 microseconds.

- **At maximum, the engine is turning at 6000 rpm.**
  Thus 1 rev takes 10 ms.
  Each degree of revolution takes about 30 microseconds.

Questions

Q1) If a 4-cylinder engine is turning at 3000 revolutions per minute, approximately how long would a single processor have between successive ignitions to calculate the ignition advancement for each cylinder?

a) less than 20 ms
b) less than 10 ms
c) less than 2 ms
d) less than 1 ms
Answer Q1

Q2) Why is it necessary to ignite the fuel-air mixture whilst the compression stroke is not yet complete, i.e, before Top Dead Centre?
Answer Q2

Q3) Why can knocking sound sometimes be heard from the engine?
Answer Q3

Q4) Why does late ignition result in unburnt fuel and pollution?
Answer Q4

Glossary

Software Environment Previous Next Index Help
Microcontrollers Otto Cycle Summary
Custom VLSI

File No: 750

Custom VLSI

IC's Specific Applications
Custom VLSI
8096 Microcontroller

IC's Specific Applications

(Please note that you have the choice to play the file as a presentation, sound or/and a text in the summary.)

Or From Intel 8096 To ASIC Summary of sound

Companies such as:
Sony
Yamaha
Philips
led the field in this
utilisation of the
technology.

Or Custom VLSI Summary of sound

Towards the end of the 80's, the processes involved with VLSI design were sufficiently automated that the user (especially the bulk consumer item manufacturer) could begin to purchase ICs custom designed to their requirements.

Glossary

ASIC... IC...End

Software Environment
Microcontrollers
Summary

Previous Custom VLSI | **Next** Unit 8: 8096 Microcontroller | **Index** | **Help**

Summary

The effect of pollution is felt over the whole earth. Advanced countries forced laws to reduce the pollution on any line of production that causes air pollution in particular . The Automotive industries were very much involved with such causes. The car engine needed some advanced control to burn fuel efficiently. The kind of control required by the new laws was impossible with the primitive controllers they had inherited from the mechanical era. A change was needed in the controller to satisfy the laws and to control the ignition of the Otto cycle. This led big companies, such as Ford, to work with Intel so they could develop a Microcontroller to manage the engine's combustion processes. The Intel 8096 was the Microcontroller chip that was developed from this partnership.

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Advance Computer Architecture

Unit 0: The Design of the Material

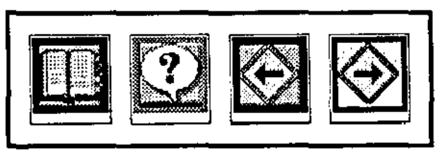
L7:Introduction To Microcontroller Overview

L8: Intel 8096 Microcontroller Lecture

Intel 8096 Microcontroller

Overview

This lecture (unit) is the eighth lecture in the course. The lecture is broken into eight sections (vertebrae), but, for the purpose of this evaluation, only three sections would be visible and an assessment section. These sections are: Introduction to the 8096 Microcontroller, Intel 8096 Temporal Control and How the Intel 8096 controls the Otto Cycle. The Introduction section contains a sound file, a video file and one Rib (extra information). The second section explains the need for an interrupt system. The last section is a slide show presentation which explains through a worked example how the Intel 8096 controls the ignition of the Otto Cycle. This section also contains a video clip of the real class lecture. Finally, an assessment is provided to help students solve a very important questions.



Intel 8096 Microcontrollers

The lecture is divided into the following parts:

File No: 801

Preface

The Ford company, as a big automotive industry, needed a better microcontroller. This led the computing industry to build a 16 bit microcontroller. As an example of a 16 bit microcontroller, the Intel 8096 microcontrollers will be explained in more detail. First, Vertebra 1 and Vertebra 2, explain why a better microprocessor is needed. Vertebra 3 presents the sections of the 8096 microcontroller. CPU operation is clarified in Vertebra 4. Vertebra 5 introduces the architectural overview of the 8096 microcontroller. The interrupt structure and the hardware timers of 8096 are covered in vertebrae 6 and 7 respectively. A presentation of how 8096 microcontoller function is showed in Vertebra 8. Finally, program development issues is briefed in Vertebra 9.

Intel 8096 Microcontrollers

The lecture is divided into the following parts:

File No: 810

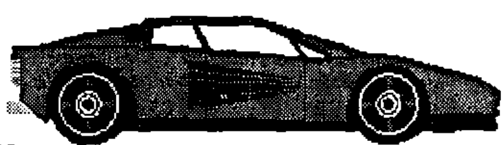
Introduction

Introduction To Microcontrollers

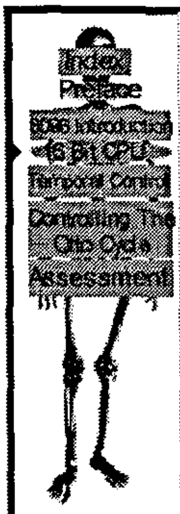
16 Bit CPU

The Intel MCS-96 Microcontroller

- The Ford Motor company was the direct sponsor for the development of the Intel 8096.
- There were requirements for discrete, embedded microcontrollers in:
  - **Engine Management (Ignition and Fuel Injection)**
  - Anti-lock Braking Systems
  - Traction Control



Glossary



File No: 811

Or **16-bit CPU**

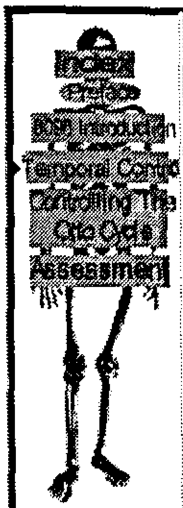
Paramount in the new design was the incorporation of a 16-bit processor/ALU with native multiplication instructions.

The requirements of fuel efficiency and emission control dictated the use of complex 6 to 8 parameter algorithms to control the ignition spark and fuel injection systems in real time.

Such levels of control cannot be implemented successfully using look-up table driven software and must resort to direct calculation based upon input parameter sampling.

Index	Preface	8096 Introduction 16 Bit CPU	Temporal Control	Controlling The Otto Cycle	Assessment

Glossary



File No: 820

Vertebra 2: Temporal Control

Temporal Control

Temporal Control

A second, but equally important feature, is the requirement to divorce the temporal control of both input and output events from the main processor cycle and, in particular, the interrupt system.

- This is best achieved by using additional, self-contained hardware on-chip that associates closely with the system bus.

This is a traditional technique, where hardware I/O co-processors have been used in conjunction with the main processor to manage time-critical functions,
e.g. Disc Controllers

Index	Preface	8096 Introduction 16 Bit CPU	Temporal Control	Controlling The Otto Cycle	Assessment

Glossary

Disc Controllers... I/O Coprocessor...End

File No: 880

Vertebra 8: 8096 Controlling The Otto Cycle

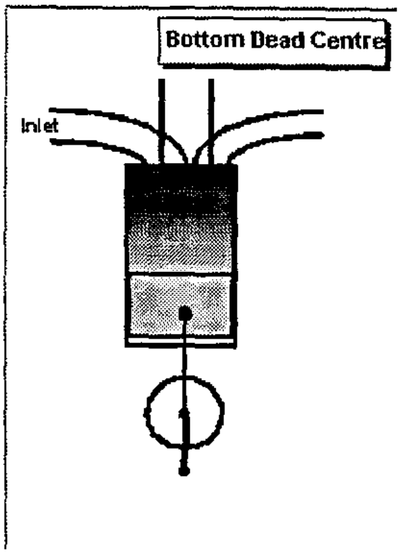
8096 Controlling The Otto Cycle

Controlling The Otto Cycle (need 2 minutes to load)

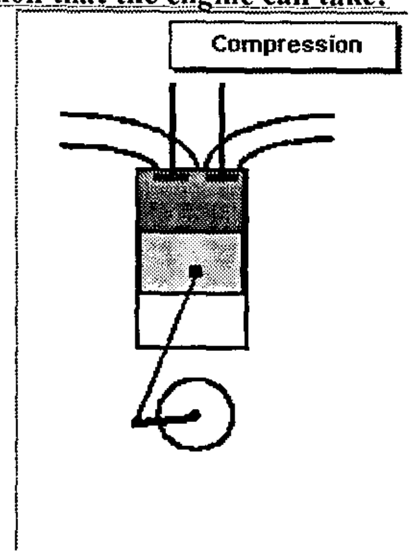
Controlling The Otto Cycle

Index	Preface	8096 Introduction 16 Bit CPU	Temporal Control	Controlling The Otto Cycle	Assessment

Assessment



OR Calculating the Minimum Revolution that the engine can take?



OR What is the Maximum Revolution that the engine can take?

Calculating the Maximum Revolution that the engine can take?

Index	Preface	8096 Introduction 16 Bit CPU	Temporal Control	Controlling The Otto Cycle	Assessment

Appendix L – The Collected Data

The data collected from students' evaluations. This data was processed by the statistical package SPSS© to test the research hypotheses.

A:\fw6.sav

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12	2	4	2	7	2	2	2	2	1	3	1	2	2
13	5	5	7	7	5	5	5	2	3	1	3	1	2
14	4	4	7	7	7	4	4	2	2	2	2	2	1
15	2	2	2	2	2	2	2	1	1	3	1	1	3
16	7	2	7	7	7	2	2	2	1	2	1	2	3
17	1	1	7	7	7	1	1	2	3	3	3	2	2
18	1	1	5	5	5	5	5	2	3	1	3	2	3
19	1	1	7	7	7	1	1	2	2	2	2	2	3
20	7	3	7	3	3	3	3	1	1	1	3	1	3

	reason7	reason8	reason9	reason10	noprefer	comments	testsum	sateasuf
1	1	2	1			Left frame should inclu	8.00	6.08
2	1	1	1			I think this was very goo	8.00	4.92
3	3	3	3			Very interesting, but ca	8.00	5.00
4	3	3	3	Layout of the 2nd was		CBL is good to go back	5.00	3.83
5	3	3	3				7.00	5.00
6	1	1	1	V1 provide better struct			6.00	4.58
7	3	3	3				7.00	5.25
8	1	1	1			More control on presen	5.00	4.17
9	1	2	1			A better use of back bu	7.00	4.00
10	1	1	1	Back and Prev Buttom.			8.00	5.83
11	3	3	3				9.00	5.83
12	3	3	3			CBL disadvantages: no	6.00	4.75
13	1	1	1	more presentable		good for learning purpo	8.00	4.83
14	3	3	3	The layout in the first w		the presentation of the l	7.00	6.25
15	3	3	3			The lecture was excelle	7.00	5.50
16	3	3	3				7.00	4.92
17	3	3	3	The arrangement of th		the material is of high q	5.00	5.75
18	1	2	1			This material could be	9.00	4.67
19	3	3	3			At the end of the power	5.00	5.42
20	3	3	3			Back button in the glos	8.00	4.33

	sub_no	sub_code	vcode1	b_prefer	b_learn	b_knowlg	b_discus	a_cbl	a_prefer	animq1	audioq1	textq1
21	21	35	3	3	1	5	2	2	2	5	4	6
22	22	52	5	3	1	3	2	1	2	5	6	6
23	23	24	2	2	1	4	2	1	1	5	7	5
24	24	41	4	3	1	4	2	2	3	3	7	6
25	25	23	2	3	3	3	2	1	2	6	5	6
26	26	54	5	3	1	4	2	2	2	6	5	5
27	27	34	3	3	1	5	2	2	2	6	6	6
28	28	15	1	3	1	5	2	1	1	6	5	7
29	29	25	2	3	1	5	2	1	2	7	6	7
30	30	53	5	3	3	4	2	3	3	4	4	5
31	31	31	3	2	1	4	2	1	2	7	5	2
32	32	42	4	3	1	5	2	2	2	7	4	7
33	33	45	4	3	3	4	2	2	2	4	5	5
34	34	43	4	3	3	3	2	2	2	5	4	4
35	35	12	1	3	1	4	2	2	2	6	4	3
36	36	32	3	3	1	3	2	1	2	3	3	4
37	37	14	1	3	3	3	2	2	2	5	4	5
38	38	51	5	3	1	5	2	1	1	4	3	6
39	39	21	2	3	1	4	2	1	1	4	6	6
40	40	13	1	3	1	4	2	2	2	5	6	7

	videoq1	iconsq1	pictq1	prestq1	animu1	audiou1	textu1	videou1	iconsu1	pictu1	prestu1	navg1	eas111
21	2	6	6	6	5	6	5	4	3	3	6	5	5
22	5	5	6	7	6	7	6	5	6	5	7	6	6
23	1	2	2	6	5	7	6	1	6	6	7	3	3
24	7	6	7	5	6	7	6	7	6	7	5	5	3
25	5	6	6	7	6	6	5	6	5	6	7	6	4
26	4	3	5	6	7	6	6	3	3	5	6	5	6
27	6	6	4	4	6	7	7	6	6	6	6	6	7
28	2	7	7	5	7	7	7	7	7	7	7	5	6
29	4	7	7	6	5	7	7	4	6	6	6	4	3
30	5	5	4	5	5	5	5	5	5	5	5	3	3
31	5	4	4	3	7	7	5	4	4	4	4	5	4
32	1	7	7	7	7	7	7	4	7	7	7	5	5
33	3	6	6	4	4	7	6	5	5	7	4	5	4
34	5	4	4	6	4	5	4	4	3	4	6	3	4
35	4	4	6	4	6	6	4	6	6	7	4	4	4
36	4	5	4	5	4	4	5	4	5	4	4	4	4
37	4	6	6	6	4	5	6	5	5	7	5	5	5
38	3	6	5	6	7	6	6	5	4	7	7	7	7
39	4	7	5	7	7	5	7	4	7	7	7	6	7
40	3	6	5	5	6	6	7	4	5	5	6	6	6

	eas213n	eas315n	eas4111	design1	useb114	useb217n	useb3110	use4113n	sat116	sat218	sat319n	sat4112n
21	5	6	5	2	4	4	6	6	5	5	6	6
22	5	5	5	5	5	6	6	7	6	5	7	7
23	3	3	3	1	6	5	7	7	4	4	6	7
24	2	3	1	7	5	1	7	6	6	5	7	4
25	4	3	4	3	7	5	7	5	5	5	6	7
26	5	3	3	4	2	5	6	7	5	5	5	7
27	4	4	4	5	5	4	7	7	6	7	7	7
28	5	3	3	4	4	4	5	5	6	5	6	6
29	2	3	3	3	6	4	3	7	6	5	5	6
30	2	2	4	3	4	2	5	4	3	4	3	3
31	3	3	3	4	3	6	6	7	6	3	7	7
32	7	5	5	1	4	5	5	5	4	4	5	5
33	7	5	1	3	5	5	6	5	6	5	5	5
34	3	5	5	4	5	5	4	6	4	5	4	4
35	6	5	4	4	1	1	5	4	4	4	5	5
36	5	5	4	5	4	4	4	5	5	4	5	5
37	4	4	5	3	4	4	5	5	5	6	5	5
38	7	7	6	3	7	5	6	7	7	6	7	7
39	7	6	6	3	7	6	7	7	6	7	5	5
40	4	3	3	6	6	7	6	6	5	6	6	7

	test1	test2	test3	test4	test5	test6	test7	test8	test9	test10	vcode2	p_design	p_elmnts	p_clear
21	0	1	1	1	1	1	0	1	1	1	5	7	7	7
22	1	1	1	1	1	1	0	1	0	1	2	2	2	7
23	0	1	1	1	1	1	1	1	1	0	4	4	4	4
24	1	1	1	0	0	0	0	1	0	0	1	1	1	7
25	1	1	1	1	1	1	1	1	1	1	3	3	3	3
26	0	1	1	1	1	1	0	1	1	0	4	5	5	5
27	1	1	1	1	1	1	0	1	0	1	4	3	3	3
28	1	0	1	0	1	1	0	1	0	0	5	5	5	5
29	0	1	1	1	1	1	1	1	0	0	5	7	2	7
30	1	1	1	1	1	1	1	1	0	1	3	3	3	3
31	1	1	1	1	1	1	1	1	1	0	1	3	3	3
32	1	1	1	0	1	1	1	1	0	1	2	2	7	2
33	0	1	1	1	1	1	0	1	1	0	5	4	5	4
34	1	1	1	1	1	1	0	1	0	0	3	3	7	3
35	0	1	1	1	0	1	0	1	0	1	2	7	2	2
36	1	1	1	1	1	1	0	1	1	0	2	2	2	2
37	0	1	1	1	1	0	1	1	1	0	4	7	7	7
38	0	1	1	1	1	1	1	1	0	1	1	5	7	5
39	0	1	1	1	0	1	0	1	1	1	1	2	2	2
40	0	1	1	1	0	1	0	1	0	1	3	7	7	3

	p_easy	p_navig	p_audio	p_anim	p_presnt	p_use	v_satis	reason1	reason2	reason3	reason4	reason5	reason6
21	7	5	7	7	7	7	5	2	2	2	2	2	2
22	7	2	5	5	7	2	2	2	1	2	1	1	3
23	4	4	7	7	7	4	4	2	2	3	2	2	1
24	1	1	7	7	1	8	1	2	2	2	3	2	2
25	7	3	7	7	3	3	3	2	2	1	2	2	3
26	5	4	7	5	5	5	5	2	2	1	3	2	2
27	3	4	7	7	3	3	3	2	1	1	3	1	2
28	5	5	7	5	5	5	5	2	3	1	3	2	2
29	7	2	2	7	5	2	2	2	1	2	1	1	3
30	3	3	7	7	7	3	3	2	1	1	2	1	3
31	3	3	3	3	3	3	3	1	1	1	3	1	3
32	2	2	7	2	7	2	2	2	1	2	1	1	3
33	4	5	4	4	4	4	4	2	3	2	3	2	1
34	3	3	7	4	3	3	3	2	2	1	3	1	2
35	2	7	7	2	2	2	2	2	2	3	2	1	3
36	3	7	2	2	2	7	2	1	1	2	1	2	3
37	4	4	7	7	7	4	4	2	3	3	3	1	1
38	5	5	7	5	5	5	5	2	3	1	3	2	3
39	2	2	2	2	2	2	2	1	1	3	1	1	3
40	3	7	7	3	3	3	3	2	1	1	3	1	3

	reason7	reason8	reason9	reason10	noprefer	comments	testsum	sateasuf
21	3	1	2			The status bar was use	8.00	5.25
22	2	2	2				8.00	5.83
23	3	3	3			I like the idea, but there	8.00	4.83
24	3	3	3	The presentation was n		I enjoyed the experime	4.00	4.17
25	3	3	3	The information was pr		This material in my ope	10.00	5.17
26	1	2	1			Slide show with audio &	7.00	4.92
27	3	3	3			Version C was easier to	8.00	5.75
28	1	1	1			V2. showed a more str	5.00	4.83
29	2	2	2			First Version was most	7.00	4.42
30	2	2	2	Glossary helps a new s		Navigation can be impr	9.00	3.25
31	3	3	3			Visted pages should be	9.00	4.83
32	3	3	3	More Details in terms of		some sound file record	8.00	4.92
33	2	2	2			The video file can be i	7.00	4.92
34	3	3	3	Better presentation		Some audio files were	7.00	4.50
35	3	3	3			More pictures (slides or	6.00	4.00
36	3	3	3				8.00	4.50
37	3	3	3			Some sound files, from	7.00	4.75
38	1	2	2			It needs just some impr	8.00	6.58
39	3	3	3			These lectures allowed	7.00	6.33
40	3	3	3	Video (avi) presentation		I would like to see more	6.00	5.42

	sub_no	sub_code	vcode1	b_prefer	b_learn	b_knowlg	b_discus	a_cbl	a_prefer	animq1	audioq1	textq1
41	41	.	5	.	.	.	.	.	.	6	4	5
42	42	.	2	.	.	.	.	.	.	5	5	4
43	43	.	4	.	.	.	.	.	.	5	5	4
44	44	.	1	.	.	.	.	.	.	7	5	6
45	45	.	3	.	.	.	.	.	.	5	4	6
46	46	.	4	.	.	.	.	.	.	5	4	5
47	47	.	4	.	.	.	.	.	.	3	6	6
48	48	.	5	.	.	.	.	.	.	7	7	7
49	49	.	5	.	.	.	.	.	.	4	5	4
50	50	.	3	.	.	.	.	.	.	6	5	5
51	51	.	1	.	.	.	.	.	.	5	4	5
52	52	.	2	.	.	.	.	.	.	5	6	6
53	53	.	5	.	.	.	.	.	.	6	6	6
54	54	.	3	.	.	.	.	.	.	6	4	5
55	55	.	2	.	.	.	.	.	.	7	6	6
56	56	.	2	.	.	.	.	.	.	7	6	5
57	57	.	4	.	.	.	.	.	.	6	5	6
58	58	.	1	.	.	.	.	.	.	5	4	5
59	59	.	1	.	.	.	.	.	.	6	5	6
60	60	.	3	.	.	.	.	.	.	7	5	6

	videoq1	iconsq1	pictq1	prestq1	animu1	audiou1	textu1	videou1	iconsu1	pictu1	prestu1	navg1	eas111
41	6	6	5	5	7	4	5	7	6	5	5	6	7
42	4	4	5	5	5	5	4	5	5	5	5	6	5
43	5	4	4	5	5	5	4	5	3	4	5	6	5
44	2	5	5	4	6	6	6	4	4	6	6	6	5
45	4	5	5	6	5	4	6	4	5	5	6	5	5
46	3	2	6	7	7	7	7	6	5	7	7	4	5
47	2	5	3	4	3	6	6	2	4	3	4	2	3
48	7	7	7	7	7	6	7	7	7	7	7	7	7
49	5	4	4	5	5	5	4	5	4	5	5	6	6
50	4	4	4	6	5	7	7	6	5	7	7	6	5
51	4	5	6	6	7	7	5	7	5	3	7	4	6
52	5	7	7	6	6	5	5	2	5	6	5	5	4
53	4	5	5	6	7	7	6	7	6	6	7	6	5
54	3	6	5	6	6	5	4	4	6	5	6	3	5
55	6	6	6	7	7	7	7	6	5	6	7	6	6
56	6	5	6	7	7	6	5	6	5	6	7	7	7
57	5	6	6	7	7	6	5	5	5	6	7	5	6
58	5	4	5	3	5	4	4	5	4	4	4	5	5
59	3	5	5	7	6	6	6	4	5	6	7	6	6
60	7	7	7	7	7	7	5	6	7	7	7	6	5

	eas213n	eas315n	eas4111	design1	useb114	useb217n	useb3110	use4113n	sat116	sat218	sat319n	sat4112n
41	4	3	5	5	7	7	7	7	6	6	7	7
42	6	5	4	5	5	5	5	6	5	5	5	6
43	5	4	4	4	5	3	6	6	6	5	6	6
44	5	6	5	4	2	1	6	7	6	4	5	6
45	6	6	6	4	5	4	5	6	6	6	6	6
46	4	3	5	5	4	3	5	4	5	5	6	5
47	5	5	4	4	3	3	6	4	4	4	4	3
48	4	7	6	7	5	5	7	5	7	7	5	4
49	5	3	5	6	4	3	5	5	5	5	5	5
50	3	4	3	4	5	7	5	7	5	5	7	7
51	5	7	5	1	2	1	6	6	4	5	6	6
52	3	6	7	6	3	4	7	5	6	6	3	6
53	3	5	5	5	6	6	6	6	5	6	6	6
54	6	6	5	5	6	6	6	6	5	6	6	6
55	4	6	6	2	6	3	7	7	7	6	7	6
56	6	5	6	6	6	5	6	5	6	6	5	5
57	7	6	6	4	6	6	6	7	6	6	6	7
58	6	5	5	4	4	3	4	4	4	4	5	4
59	5	6	5	4	5	6	5	6	5	5	6	6
60	5	2	3	7	6	6	6	7	6	5	6	7

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	test1	test2	test3	test4	test5	test6	test7	test8	test9	test10	vcode2	p_design	p_elmnts	p_clear
41	.	.	.	.	.	.	.	.	.	.	.	.	.	.
42	.	.	.	.	.	.	.	.	.	.	.	.	.	.
43	.	.	.	.	.	.	.	.	.	.	.	.	.	.
44	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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3-4

	p_easy	p_navig	p_audio	p_anim	p_presnt	p_use	v_satis	reason1	reason2	reason3	reason4	reason5	reason6
41	.	.	.	.	.	.	.	.	.	.	.	.	.
42	.	.	.	.	.	.	.	.	.	.	.	.	.
43	.	.	.	.	.	.	.	.	.	.	.	.	.
44	.	.	.	.	.	.	.	.	.	.	.	.	.
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59	.	.	.	.	.	.	.	.	.	.	.	.	.
60	.	.	.	.	.	.	.	.	.	.	.	.	.

	reason7	reason8	reason9	reason10	noprefer	comments	testsum	sateasuf
41	.	.	.				.	6.08
42	.	.	.				.	5.17
43	.	.	.				.	5.08
44	.	.	.				.	4.83
45	.	.	.				.	5.58
46	.	.	.				.	4.50
47	.	.	.				.	4.00
48	.	.	.				.	5.75
49	.	.	.				.	4.67
50	.	.	.				.	5.25
51	.	.	.				.	4.92
52	.	.	.				.	5.00
53	.	.	.				.	5.42
54	.	.	.				.	5.75
55	.	.	.				.	5.92
56	.	.	.				.	5.67
57	.	.	.				.	6.25
58	.	.	.				.	4.42
59	.	.	.				.	5.50
60	.	.	.				.	5.33

	sub_no	sub_code	vcode1	b_prefer	b_learn	b_knowlg	b_discus	a_cbl	a_prefer	animq1	audioq1	textq1
61	61	.	5	.	.	.	.	.	.	6	6	6
62	62	.	2	.	.	.	.	.	.	5	7	6
63	63	.	4	.	.	.	.	.	.	5	7	6
64	64	.	1	.	.	.	.	.	.	4	7	6
65	65	.	3	.	.	.	.	.	.	6	6	6
66	66	.	4	.	.	.	.	.	.	5	3	3
67	67	.	4	.	.	.	.	.	.	6	6	6
68	68	.	5	.	.	.	.	.	.	7	5	7
69	69	.	5	.	.	.	.	.	.	7	7	7
70	70	.	3	.	.	.	.	.	.	4	4	5
71	71	.	1	.	.	.	.	.	.	5	4	4
72	72	.	2	.	.	.	.	.	.	7	4	7
73	73	.	5	.	.	.	.	.	.	5	4	4
74	74	.	3	.	.	.	.	.	.	5	5	4
75	75	.	2	.	.	.	.	.	.	6	4	4
76	76	.	2	.	.	.	.	.	.	5	4	5
77	77	.	4	.	.	.	.	.	.	4	4	5
78	78	.	1	.	.	.	.	.	.	4	4	5
79	79	.	1	.	.	.	.	.	.	3	2	7
80	80	.	3	.	.	.	.	.	.	6	5	7

	videoq1	iconsq1	pictq1	prestq1	animu1	audiou1	textu1	videou1	iconsu1	pictu1	prestu1	navg1	eas111
61	3	5	6	6	6	6	6	5	4	4	6	6	5
62	5	5	6	7	5	6	6	5	6	5	7	6	6
63	1	3	2	5	5	7	7	1	6	6	7	5	5
64	7	6	7	7	6	7	6	7	6	7	7	6	5
65	5	7	6	7	6	7	6	4	6	5	7	7	5
66	3	3	6	6	7	7	6	6	3	7	7	6	4
67	6	6	4	2	6	7	7	6	6	6	6	7	5
68	2	7	7	7	7	7	7	6	7	7	7	7	7
69	5	6	6	7	7	5	6	4	6	6	7	4	3
70	4	5	4	5	5	5	5	5	5	5	5	5	4
71	3	4	3	3	5	5	5	5	5	6	6	3	4
72	1	7	7	7	7	7	7	4	7	7	7	6	6
73	3	6	6	3	5	7	5	6	7	6	4	6	5
74	4	5	4	5	5	5	5	5	5	4	6	6	5
75	4	6	4	6	5	4	4	5	5	5	5	5	5
76	5	4	4	4	4	4	5	4	5	4	4	5	4
77	4	6	6	6	5	4	6	6	5	6	7	4	5
78	4	5	3	1	7	6	6	4	5	6	7	5	6
79	4	7	5	4	5	5	7	4	7	7	6	4	6
80	7	6	5	5	7	6	6	7	5	5	6	7	7

	eas213n	eas315n	eas4111	design1	useb114	useb217n	useb3110	use4113n	sat116	sat218	sat319n	sat4112n
61	6	6	5	4	5	6	6	5	6	6	6	6
62	6	7	6	5	5	7	6	7	6	6	7	7
63	5	3	3	1	6	6	7	7	5	4	6	7
64	5	5	5	7	6	1	7	6	6	5	7	2
65	5	5	5	3	7	7	7	7	6	5	6	7
66	6	6	6	4	3	3	3	4	3	4	4	4
67	7	7	7	5	5	3	6	3	3	5	4	4
68	7	7	7	5	7	7	7	7	7	7	7	7
69	3	3	3	2	5	6	5	7	5	4	5	5
70	4	3	3	4	4	3	5	5	5	5	5	3
71	3	2	3	5	3	6	5	5	5	3	6	6
72	7	5	5	1	4	5	5	5	4	4	6	5
73	5	5	7	5	4	5	5	5	6	4	7	7
74	5	5	5	5	5	6	4	6	6	4	5	5
75	5	5	4	4	5	4	5	5	5	5	5	5
76	5	5	4	5	4	4	5	4	4	5	4	5
77	5	4	5	4	5	4	5	4	5	5	4	5
78	4	4	4	3	5	5	6	7	5	5	3	5
79	5	5	4	3	6	6	6	6	4	4	7	7
80	6	6	6	6	6	7	7	7	6	7	7	7

	test1	test2	test3	test4	test5	test6	test7	test8	test9	test10	vcode2	p_design	p_elmnts	p_clear
61	.	.	.	.	.	.	.	.	.	.	.	.	.	.
62	.	.	.	.	.	.	.	.	.	.	.	.	.	.
63	.	.	.	.	.	.	.	.	.	.	.	.	.	.
64	.	.	.	.	.	.	.	.	.	.	.	.	.	.
65	.	.	.	.	.	.	.	.	.	.	.	.	.	.
66	.	.	.	.	.	.	.	.	.	.	.	.	.	.
67	.	.	.	.	.	.	.	.	.	.	.	.	.	.
68	.	.	.	.	.	.	.	.	.	.	.	.	.	.
69	.	.	.	.	.	.	.	.	.	.	.	.	.	.
70	.	.	.	.	.	.	.	.	.	.	.	.	.	.
71	.	.	.	.	.	.	.	.	.	.	.	.	.	.
72	.	.	.	.	.	.	.	.	.	.	.	.	.	.
73	.	.	.	.	.	.	.	.	.	.	.	.	.	.
74	.	.	.	.	.	.	.	.	.	.	.	.	.	.
75	.	.	.	.	.	.	.	.	.	.	.	.	.	.
76	.	.	.	.	.	.	.	.	.	.	.	.	.	.
77	.	.	.	.	.	.	.	.	.	.	.	.	.	.
78	.	.	.	.	.	.	.	.	.	.	.	.	.	.
79	.	.	.	.	.	.	.	.	.	.	.	.	.	.
80	.	.	.	.	.	.	.	.	.	.	.	.	.	.

	p_easy	p_navig	p_audio	p_anim	p_presnt	p_use	v_satis	reason1	reason2	reason3	reason4	reason5	reason6
61	.	.	.	.	.	.	.	.	.	.	.	.	.
62	.	.	.	.	.	.	.	.	.	.	.	.	.
63	.	.	.	.	.	.	.	.	.	.	.	.	.
64	.	.	.	.	.	.	.	.	.	.	.	.	.
65	.	.	.	.	.	.	.	.	.	.	.	.	.
66	.	.	.	.	.	.	.	.	.	.	.	.	.
67	.	.	.	.	.	.	.	.	.	.	.	.	.
68	.	.	.	.	.	.	.	.	.	.	.	.	.
69	.	.	.	.	.	.	.	.	.	.	.	.	.
70	.	.	.	.	.	.	.	.	.	.	.	.	.
71	.	.	.	.	.	.	.	.	.	.	.	.	.
72	.	.	.	.	.	.	.	.	.	.	.	.	.
73	.	.	.	.	.	.	.	.	.	.	.	.	.
74	.	.	.	.	.	.	.	.	.	.	.	.	.
75	.	.	.	.	.	.	.	.	.	.	.	.	.
76	.	.	.	.	.	.	.	.	.	.	.	.	.
77	.	.	.	.	.	.	.	.	.	.	.	.	.
78	.	.	.	.	.	.	.	.	.	.	.	.	.
79	.	.	.	.	.	.	.	.	.	.	.	.	.
80	.	.	.	.	.	.	.	.	.	.	.	.	.

	reason7	reason8	reason9	reason10	noprefer	comments	testsum	sateasuf
61	.	.	.				.	5.67
62	.	.	.				.	6.33
63	.	.	.				.	5.33
64	.	.	.				.	5.00
65	.	.	.				.	6.00
66	.	.	.				.	4.17
67	.	.	.				.	4.92
68	.	.	.				.	7.00
69	.	.	.				.	4.50
70	.	.	.				.	4.08
71	.	.	.				.	4.25
72	.	.	.				.	5.08
73	.	.	.				.	5.42
74	.	.	.				.	5.08
75	.	.	.				.	4.83
76	.	.	.				.	4.42
77	.	.	.				.	4.67
78	.	.	.				.	4.92
79	.	.	.				.	5.50
80	.	.	.				.	6.58