non-supported areas. In the next section of the project, these ideas will be applied to the development and evaluation of a multimedia application that may be configured to support individual learners.

Chapter 6

A study into the use of a student model in a multimedia application: Introduction

6.1 Introduction

The overall aim of this project was to integrate the power and richness of multimedia with the 'intelligent' use of AI (Connell, 1997) to produce an individually configurable learning environment that could deliver learning effectively.

In previous chapters, exploratory studies were undertaken to provide information on how best to create and evaluate constructivist, task-based multimedia learning applications, configured for individual learners. It was intended in the next and final stage of the project to investigate and establish the overall benefit of an approach based on individual configuration in a multimedia learning application.

In addition to these exploratory studies, two experiments were described which investigated the effect of language and cognitive style on performance in multimedia learning applications. The results of these studies suggested that language and cognitive style were important in influencing performance in multimedia learning applications. Learners with poor language skills were found to benefit most from the provision of additional language support. Learners at the extremes of the Verbaliser/Imager cognitive scale performed significantly better in areas of a multimedia application where the presentation mode matched their preferred cognitive style.

6.1.1 Aim of the final study

The aim of the final study was to develop a multimedia application based on a student model which could be configured according to learners' individual needs. It was then intended to perform an investigation to answer the principal question, *'has the multimedia application configured in this way been beneficial to users in the delivery of effective learning?'* In the next section, an overview of the final study is presented.

6.1.2 Overview of the final study

In the following three chapters, the design, implementation and evaluation of a study involving learners and tutors at 6 FE colleges following an individually configured multimedia learning application is described.

In this chapter, two areas important to the background of the study are introduced. The first of these is the student model. The background and reasons for the use of a student model in the study are explained here. Different types of student model are compared and reasons for choosing and constructing the particular form of model used in this study are given. In the final section of the chapter, the methodological approach used in the final study is explained. This

approach is based upon Grounded Theory and uses a combination of qualitative and quantitative data. Grounded Theory is described in outline and the justification for its adoption is presented.

In Chapter 7, the materials and methods section of the investigation is presented. The chapter describes the development of the multimedia learning application used in the study and presents details of how the student model was developed and used to configure learning for individual learners. The methods used in the study are next presented. These include methods used in the implementation of the study, data collection methods and evaluation methods. Chapter 8 presents the results of the study in detail and Chapter 9 is a discussion of how the results obtained relate to the overall aims of the work described in this thesis.

6.2 A collaborative student model

The use of a student model is central to the individual configuration of learning in this project. Student modelling may be of benefit in the delivery of learning for several reasons. A student model may hold a great deal of information about a learner which can be used to configure a computer application optimally for an individual. This information may relate to knowledge held by a user, personality, preference, individual skills and in fact any information about the user that may be useful to the application. Measures of performance may also be used to check on progress as the user interacts with the application, and the model may be adapted automatically to reflect any changes. Benefits, then, include the ability to hold lots of information about the user, the ability to configure applications based on this information and the ability to adapt the model according to performance. The range of student modelling approaches available is surveyed by Ragnemalm (1996) who distinguishes between models that contain students' actual domain knowledge to those that contain student characteristics.

The term, 'student model', as explained previously, is used in this study to mean the representation of characteristics of a student in a form which can be used within a computer application to configure the presentation of a multimedia course. This usage is referred to as a 'global description' of a student (Ohlson, 1993). The term 'student model' has also been used in the *'hard'* AI context to describe how learners may be represented within intelligent systems (Vassileva, 1996). Vassileva describes a student model as an example of a general user model, but where a representation of student knowledge (i.e. what the system infers the student knows), held by the system, is overlaid on (compared with) a representation of the domain and a representation of an expert or desired state. The aim of such systems is to compare the student, domain and expert models and to attempt to configure presentation of information based in some way upon differences between them. Such models are often referred to as overlay models and are important in knowledge-based systems where automatic configuration of presentation modes may be accomplished by their use.

An important difference between global descriptions of a learner and the overlay modelling approach is in the kinds of decisions that may be made by using the models. Overlay models are used to configure how material is presented based upon a learner's performance within the domain, compared to standard measures of performance and are often used for automatic adaptation. Global description models however, configure the presentation of learning based upon assumptions about how individual characteristics influence learning. It is more difficult to adapt such models automatically, as they are less directly related to performance within the domain. In the work described in this thesis, a student model based upon a global description of a learner was developed. In the next section, the collaborative or co-operative method of establishing and adapting the values of the global descriptors used in the student model is explained. The terms collaborative and co-operative student models are used interchangeably within the literature.

Brusilovsky states that some components of the student model cannot be deduced by the system and must be provided by the user (Brusilovsky 1996). User's characteristics such as cognitive style are difficult to imply from user interaction in the domain alone. In the study described in the following chapters, diagnostic tests were used to establish cognitive style and language level variables in the student model. A collaborative approach was adopted to establish the levels of variables relating to the difficulty of tasks and questions to be undertaken, based upon collaborative student modelling. Collaborative student models have been described by several authors, (Rich 1983; Vassileva 1996; Milne et al 1996; 1997) as one of the many ways that user models may be established, configured and applied. Collaborative methods represent an alternative to fully automatic configuration of the presentation of information and involve user input into the system. In such models, users co-operate or collaborate with the computer system to establish optimum configuration of the student model. In the study described in the following work, the users of the system were tutors and learners.

Collaboration is often based upon user's input and may take place at one or more of the three main stages in user modelling, at the data collection, application or presentation stage (Vassileva 1996). In the system employed in this project, collaboration was achieved initially at the data input stage in order to establish the parameters for the student model. Tutors initially configured levels of some of the global descriptors, based on their knowledge of the student and on diagnostic tests. Regularly throughout the use of the application, progress was checked by students and tutors together. The parameters for the student model could then be adapted, using tools provided within the application.

Perhaps the most important reason for use of the collaborative approach in this project was the requirement to maximise involvement of students and tutors in the modelling process. An important outcome of the exploratory studies described in chapter 3 of this work, was the positive influence that the direct

involvement of tutors in learning with multimedia had on tutors' attitudes. Constructivist theories also stress the importance of learners' involvement in controlling their own learning. The collaborative student model used in this study relied upon a significant input from tutors as well as learners. In this way tutors and learners were in control of the configuration of the learning process. Connell (1997) has stated that the *intelligent* use of AI necessitates human involvement. By using a collaborative student model approach involving the application of human intelligence, it was hoped that the benefits of student modelling could be had without the risks that accompany fully adaptive user modelling, i.e. lack of student/tutor involvement and feeling excluded.

The approach adopted in the final study then, was based on constructivist theories of learning which recommend that learners should have a significant personal input into their own learning. Decisions are made in collaboration with the learner and the tutor, and not by the application in isolation. The collaborative student model configures learning, based not just on a learner's understanding of the domain, but also on what support a learner's need in order to construct learning for themselves. This is different from the hard AI applications, where decisions are often based on an overlay model of the learners' knowledge in the domain. In hard AI, models are applied to correct perceived differences between a student's knowledge and an expert's knowledge in the domain. The student model in this study was concerned with individual learning style, language level and the representation of those cognitive skills needed to perform tasks and answer questions within the application.

An example of this type of student model is presented by Milne and colleagues (1996), who describe a composite user modelling approach. Their approach may be described as composite, as it employs an adaptive configuration of learning with some collaboration with users. Their student model combines a learner's attributes obtained from psychological questionnaires, in a simple overlay model of learners' domain knowledge states. The approach used in the

final study also drew on Bull and Smith's (1997) ideas where a fuller collaborative adaptation of the model involving tutors was employed. Bull and Smith's model did not involve automatic configuration of the student model at all, but involved collaboration with learners at all stages within the application. The approach adopted in this study then can be considered to be a composite of these two ideas. In this study, variables for the student model are configured based on diagnostic assessment of learner characteristics and an assessment of learners by tutors. This assessment involves a negotiation with learners, who must understand all the learning objectives and share them with the tutor. The level at which the application was configured for the individual was determined within this negotiation process. Motivational aspects of learning and the requirement for the learner to invest effort are handled in these negotiations. It was also important that tutors were involved in the multimedia learning approach. From experience, lack of motivation in learners with multimedia is often a reflection of dissatisfied tutors who feel marginalised by the process. This important issue is considered more fully in chapters 9 and 10 of this work. Details of the student model approach used in the final study and how it was used to configure a multimedia learning application are described in the next chapter.

6.3 Introduction to the evaluation approach used

In the previous experiments described in chapters 4 and 5 of this thesis, improvements in learning were implied from gains in performance between pre-test and post-test scores. Learning, however, has been described as being more than the difference between the pre-test and post-test scores obtained in an experiment, for example. Constructivist theories of learning see learning as the *'subjective construction of meaning from experience in specific contexts'* (Somekh 1996). In such theories, a teacher is seen as a negotiator or facilitator of shared understandings and not merely a transmitter of knowledge in the form of facts or rules. The question as to whether or not effective learning is taking place, then, is more complex than measuring test scores. In order to assess

whether or not the aim of the final study had been met, it was necessary to develop and apply a range of evaluation approaches and methods. The development of general evaluation methods used in the final study was described in chapter 3 of this work. In that chapter, an understanding of design, implementation and evaluation issues was obtained. It was necessary however, for reasons described below, to develop and implement a different research methodology to evaluate the final study. This section describes and justifies the underlying approach adopted in this evaluation.

Summative evaluation (Squires 1997), is performed in order to measure the benefit of an application after implementation and as it is being used in a real context. It is an attempt to measure whether or not the objectives of the application have been satisfied. The aim of the final study was to investigate the benefit of a student model approach to learning in a multimedia application. The simple experimental approach adopted in chapters 4 and 5 to explore the influence of independent variables on the differences in test scores is unlikely to be useful by itself, in assessing the benefit to learning. Reasons for this and a potential solution to the problem are discussed in the next section.

6.3.1 Qualitative and quantitative methodology

Research methods in the social sciences and related fields have centred around two main schools according to Denzin (1994), qualitative and quantitative methods. Denzin states that more traditional quantitative research involving experimental, statistical and survey methods is being 'overtaken' by the new school of qualitative research methods. Reasons for this change have been outlined in general by several authors (Denzin and Lincoln 1994; Straus and Corbin 1990; Hammersley 1992; Hamilton 1994) and are centred around the difficulty in using scientific methods to understand complex social phenomena. Qualitative methods of analysis are employed in circumstances involving multiple variables and complex relationships, in situations where it would be difficult to

impose the kinds of controls required in a scientific experiment. Best and Khan suggest that qualitative research is more open and responsive to the subject than quantitative methods, though they consider that both forms are useful, valid and not mutually exclusive (Best and Khan 1989).

Gortner and Schultz (1988) describe standards or canons that are applied to scientific research, including significance, precision, generalisability, consistency, reproducibility, verification and theory observation compatibility. The main criticism of qualitative methods centres around their failure to meet these standards. Scientific method (the hypothetico-deductive method) requires the systematic control of variables, use of control groups and relies on the condition that results are reproducible. The scientific method is concerned with the testing of hypothesis with data, in a process where results are used to regenerate the hypothesis iteratively. Scott (1996) emphasises many problems in the application of the scientific method in complex sociological and educational contexts. It is not always possible or indeed desirable to apply scientific methodology directly to social problems (Scott 1996). Rather than abandon Gortner and Schultz's standards, Scott suggests that the standards should be redefined to accommodate qualitative research. There were many features in the final study that prevented the application of a direct experiment. These are explained in the next section.

6.3.2 Features of the final study

The final study was an evaluation of an individually configured multimedia learning application used in real contexts. The necessity to evaluate learning applications in this way has been discussed by Squires (1996). The study involved staff and students using the application in a range of environments and educational contexts as part of their normal curriculum. The application also provided a complex, rich and differentiated environment. Each learner would have a different experience of the application, depending on how it was

configured for them personally. Grabinger and colleagues (1997) have emphasised the importance of extrinsic factors in learning, including motivational aspects, collaboration, meta-cognition and other factors leading to greater invested effort and dynamic generative learning. The control of these important external factors was impossible in an experiment.

In addition, the aim of the study involved assessing the benefit of the application to a user in the delivery of effective learning. The measurement of learning itself presents a challenge. Reeves (1992) cautions us against the direct and inappropriate use of science to answer such complex questions.

Thus, the complexity of the final study precluded a simple experimental approach, yet there was a great deal of useful data available that would facilitate qualitative analysis. It was therefore decided in the final study, to employ a combination of qualitative and quantitative research approaches. In the next section, reasons for the choice of the ethnographical method employed in the final study are presented.

6.3.3 Selection of a qualitative methodology

The general area of qualitative research includes several research methods, often referred to as 'ethnography'. These include Case Studies, Participant Observation, Phenomenology, Ethnomethodology, Grounded Theory, Biographical Methodology and Clinical Research Methods. Denzin and Lincoln (1994) describe many of the features and applications of qualitative research methods.

An important qualitative method that has regularly been employed in educational and social research is Grounded Theory (Glaser and Strauss 1967). It has several important advantages for this study over other ethnographical methods. Grounded Theory, for example, presents a single, unified, systematic method of

analysis. Other qualitative methods often rely upon the application of general principles rather than systematic method, making their application and interpretation more difficult. Methods for validating findings and can integrate well with quantitative methods are also provided by Grounded Theory, in fact, both forms of data are necessary in many instances (Glaser and Strauss 1967). Grounded Theory is also well documented and had been used systematically in studies since the 1960s (Strauss and Corbin, 1990). These factors assist the rapid application of the methods of Grounded Theory and also provide a framework for the interpretation of results. A rigorous methodology based on the canons of scientific research[3] is also employed by Grounded Theory (Scott, 1996). There have been other claims regarding the benefits of Grounded Theory. These are summarised by Strauss and Corbin (1994) and explained in the next section. Quantitative researchers are becoming less satisfied with purely quantified results and are turning increasingly to supplementary qualitative analyses according to Strauss and Corbin (1994). Grounded Theory was selected therefore, as the research method used in the final study. Features of the Grounded Theory method are described in the next section.

6.4 Grounded Theory

Grounded Theory is a research method developed by Glaser and Strauss (1967). It is a general methodology for developing theory that is grounded in data systematically gathered and analysed (Strauss and Corbin 1994). Theory develops and evolves during the research process due to the interplay between data collection and analysis phases. It is important to note that the result of a Grounded Theory study is the generation of a theory, consisting of a set of plausible relationships proposed among concepts and sets of concepts. This differs from other ethnographical methods where often the information is often presented with little comment from a researcher.

[3] These canons may be redefined however to allow for qualitative methodology. See later.

A Grounded Theory, it is claimed, is a theory which is inductively derived from the phenomenon it represents and meets four central criteria: fit, understanding, generality and control (Strauss and Corbin 1990). Fit entails that the theory fits the substantive data. Understanding entails that the theory be comprehensible to all involved in the area of study. Generality entails that the theory is applicable in a variety of contexts. Control implies that the theory should provide control with regard to action toward the phenomenon. Grounded theory provides a systematic method involving several stages which is used to 'ground' the theory, or relate it to the *reality* of the phenomenon under consideration (Scott 1996). A Grounded Theory is derived from the phenomenon under study. This contrasts with the hypothetico-deductive method, where theories are generated from cyclical testing and refining of a previously constructed hypothesis. In Grounded Theory studies, theory emerges from the systematic examination of the phenomenon.

An important feature of Grounded Theory is theoretical sensitivity, which refers to a personal quality of the researcher and relates to understanding the meaning and subtlety of data. Theoretical sensitivity has been described by Glaser (1978) as the process of developing the insight with which a researcher comes to the research situation. Such insight should be conceptual rather than concrete. It is often referred to as a creative aspect of Grounded Theory and involves the researcher working in the area to obtain experience and expertise. By gaining theoretical sensitivity the researcher will be able to recognise important data and formulate conceptually dense theory.

An important feature of the Grounded Theory method involves systematic methods of data collection and analysis. These methods are described by Strauss and Corbin (1990) and are summarised below.

6.4.1 Stages in Grounded Theory

An important feature of Grounded Theory is that it represents a systematic method that may be applied to research problems. The systematic nature of the method is useful in judging, generalising and comparing the results of Grounded Theory research. This is not always possible with alternative ethnographical methods where no clear system is involved. In the following sections, the stages of the Grounded Theory methodology are outlined.

6.4.1.1 Research question

The process starts with the selection of a suitably complex research question. In the context of this study, the research question related to the aims of the project, which were to develop a multimedia application based on a student model and to investigate the benefits of individual configuration of multimedia to learning within the application. As Grounded Theory is inductively developed from the phenomenon it represents and theories emerge from data obtained from the phenomenon under study, the research question will be re-stated in the next chapter in a form that can be tested by Grounded Theory.

6.4.1.2 Data acquisition

In Grounded Theory methodology, data is collected in the same ways, using the same techniques as in other research methodologies. Data may be qualitative or quantitative or combinations of both types. The analysis of data collected in research is often referred to as *'coding'*. Data is coded differently depending on the purpose of the data and the stage of the project. Three stages of data analysis are involved in Grounded Theory. These are open coding, axial coding

and selective coding. The features and uses of these methods are explained below.

a) Open coding

Open coding is the process of selecting and naming categories from the analysis of the data. It is the initial stage in data acquisition and relates to describing overall features of the phenomenon under study. Variables involved in the phenomenon are identified, labelled, categorised and related together in an outline form. The properties of a category are described or dimensionalised at this stage. This involves placing or locating the property along a continuum within a range of possible values.

b) Axial coding

Axial coding is the next stage after open coding. In axial coding, data are put together in new ways. This is achieved by utilising a 'coding paradigm', i.e. a system of coding that seeks to identify causal relationships between categories. The aim of the coding paradigm is to make explicit connections between categories and sub-categories. This process is often referred to as the *'paradigm model'* and involves explaining and understanding relationships between categories in order to understand the phenomenon to which they relate.

c) Selective coding

Selective coding involves the process of selecting and identifying the core category and systematically relating it to other categories. It involves validating those relationships, filling in, and refining and developing those categories. Categories are integrated together and a Grounded Theory is arrived at.

The process involves the following stages:

- Explication of the story line
- Relating subsidiary categories to the core category using the paradigm model
- Relating categories at the dimensional level. This involves understanding the range of values that categories may have. For example, the category 'motivation' may have a range of values between *not motivated* and *highly motivated*.
- Validation of relationships against data
- Further refinement of the storyline

The core category is the central phenomenon around which all other categories are based. Once this has been identified, the storyline is generated as a restatement of the project in a form that relates to the core category. Validation is done by generating hypothetical relationships between categories and using data from the field to test these hypotheses. Categories may be further refined and reclassified and the storyline may be further refined. This completes the grounding of the theory.

The following table summarises the relationship between the stages in the Grounded Theory methodology and the data collected in the final study

Table 6.1

Table showing the relationship between the data collection and analysis stages described in the following chapters and the Grounded Theory method

Stage in the final study	**Grounded theory stage**
Preliminary stage (Described in chapter 7) Involving Data collection Questionnaire Interviews	**Open coding starts** Producing a preliminary structure of categories, sub-categories and variables. Axial coding starts Modification of structure
Final study - Data collection stage (Described in chapter 8) Data collection methods • Video • Interviews • Pre-test and post-test • Data logging • Questionnaire • Tasks and questions • Focus groups • Staff evaluation • Staff diary • Staff interviews • Staff report • Expert evaluation	**Axial coding continues** Identification of causal relationships **Selective coding starts** Assigning values to variables from data Modification of structure based on data Identification of the core category Generation of theory Validation of theory with data
Final study - Data analysis stage (Described in chapter 9)	**Selective coding continues** **Grounding the theory** Core theme specified Emergence of the theory Production of narrative Presentation of theory Validation of theory with data

6.4.2 The relationship between theory and reality

A constant criticism of qualitative methods is their inability to relate to aspects of the real world (Hammersley 1992), although it is generally accepted that they have their own internal logic and validity. The relationship between theory and reality in a Grounded Theory study is a complex issue. Often the goal of experimental science is to discover laws and universal truths that may be generalised and widely applied. The goal of social research involving humans however, is often to describe and understand the rich and complex phenomena they engage in. Such descriptions and understandings are usually placed at a certain time and located in specific societies and social contexts. The goal then of such studies is to understand contemporary social relationships. In the rapidly changing world of multimedia, information technology and education, the fact that these relationships change equally rapidly ensures that any insight into such processes is likely to be temporary. This important issue will be discussed in the final chapter of this work.

6.5 Summary

In this chapter, an introduction to two important features of the final study have been presented. The collaborative student model used in the final study was described with reasons for the choice of this form. The Grounded Theory methodology used in the final study was explained and reasons for its selection as the research methodology employed in the final study were presented.

In the next chapter, the stages of the final study are described. These include the development and implementation of the multimedia application and the methods used in the collection and analysis of the qualitative and quantitative data relating to its use.

Chapter 7

A study into the use of a student model in a multimedia application: Materials and method

7.1 Introduction

This chapter presents the materials and methods section of the final study. The objective of the final study was to investigate the usefulness of a student model in the individual configuration of a multimedia learning application. The student model and the research approach adopted in the study were introduced and explained in the previous chapter. In this chapter, the development of the multimedia application and the use and configuration of the student model are presented in section 7.2. The methods section, (section 7.3), describes the development and application of the Grounded Theory research method used in the final study. The final section of the chapter explains how the final study was carried out.

7.2 Materials

In this section, the development of a multimedia application individually configurable to a student model is described.

7.2.1 Development of the application

In the following section, the development of the application is considered firstly, in terms of the systems development process, and secondly, in terms of the development and application of the underlying pedagogy upon which the application was based.

7.2.1.1 Description of the course

The application was designed to deliver units from the Application of Number level 1 key skills General National Vocational Qualification (GNVQ) course. GNVQ courses require learners to take a great deal of responsibility for their own learning, which includes that they provide a portfolio of evidence for assessment. Key skills courses are taken in a wide range of vocational and curriculum contexts and may be delivered by subject experts in the key skill, by vocational experts experienced in the key skills area, or flexibly in open access areas. Assessors have to decide if the evidence provided by a learner satisfies the requirements of the qualification. Assessment is subject to an internal and external verification process by qualified assessors and verifiers appointed by the examining body. Underpinning knowledge for GNVQ courses is provided in a variety of ways, including lectures, text books, the Internet and CD-ROM. Similarly, evidence of competence may be provided in several formats, but must include a specified number of assignments, some of which are externally marked. The course was designed to cover the four assignments required to obtain the

GNVQ qualification, though the study reported here was based upon students and tutors following material for assignment one.

7.2.1.2 Software development process

The requirements for the multimedia system were derived at meetings between multimedia designers, subject authors and the project manager. An iterative method was employed in the development process involving the creation of prototypes. The method has been described by several authors, for example, Preece et al (1994) and Dix et al (1998) outline variations of the method. In the method employed in this study, prototypes were developed based upon a software specification document agreed during early stages of the project. This document contained full technical and pedagogical specifications for the multimedia application as well as objectives for formative and summative evaluation of the application. The pedagogical specifications for the system are presented in the next section.

Evolutionary prototypes were created by the development team and evaluated by expert evaluators and small groups of users. Barker et al (1997c) describe details of the approach adopted in the development of prototypes.

7.2.1.3 Development and application of pedagogy

Boyle (1997) suggests that an important feature of multimedia learning applications is their underlying pedagogical structure. A specification for the pedagogical structure of materials was based on constructivist ideas about how learning should be delivered, as recommended by Boyle. Ideas were developed and tested in exploratory studies described in chapter 3 of this work. In the first exploratory study, design methods for multimedia materials were developed. Many of the pedagogical assumptions underlying the multimedia material produced for the final study were tested in the exploratory study and models of

implementation and delivery of multimedia courses in real situations were developed.

The results of the first exploratory study were applied directly to the development of materials for the final study. This was achieved by the software development team, who constructed a list of pedagogical features to be included in the application. This list was based upon ideas initially developed in the exploratory study described in chapter 3. For every pedagogical feature in the list, a corresponding set of features in the multimedia application were specified by the team and developed for the prototype. For example the requirement that the application should provide a hierarchical system of scaffolding and help, which could be individually configured, gave rise to a corresponding set of features in the prototype. These were identified in this case as:

- Differentiated glossary and help system to be available on demand.
- Help should only be provided when demanded.
- Layered help system with configurable entry point to be provided.
- Help to be available in different modes, sound, image, text and animation.

Once the features had been specified generally in this way, subject authors worked with multimedia designers and the project manager to implement these features within the prototype. Experts and user groups were then involved in formative evaluation of these specific features within the prototype. Small groups of learners worked with tutors and a design team members in order to implement each feature specified by the design team. The iterative method employed at this stage was important in ensuring that materials were usable and of high screen design quality as well as pedagogically sound. Implementation of a feature was completed when the specified pedagogical, usability, design and user satisfaction objectives presented in Appendix 3 were satisfied in the prototype to a level acceptable to the full project team. Barker et al (1997c) presents an account of the methods used in this process.

The main pedagogical features identified by the software development team for inclusion in the application were as follows:

- Language level and language support,
- Cognitive style differentiation
- Task level and type variation
- Question level and type variation
- Presentation of domain knowledge
- Help and support systems

Language and cognitive style differentiation were included in the specification in the light of results from the experimental investigations described in chapters 4 and 5. There were many other features included in the application, for example the ability for the individual to configure sound presentation according to preference, which was identified in the exploratory studies as a potential barrier to learning when omitted. Navigation, orientation and location tools were also provided which coupled with the simple hierarchical structure of the application made sure it was simple to use and avoided unnecessary cognitive overhead and memory overload (Molich and Nielsen 1990), which was considered to be an important pedagogical as well as usability consideration. Material was intended to be interesting to use with the highest graphical design quality and as far as possible to be constructivist in outlook. In the next chapter, the course to be delivered by the multimedia application is described.

7.2.1.4 Technical details and tools used

The multimedia application used in the final study was developed in Macromedia Authorware version 4.0. Adobe Premiere version 4.2 was used to for digital video editing and production. BYG TX Elite version 1.0, Microsoft Visual C++ version 2.0 and Borland Delphi version 2 were used to create the language testing modules for the application. Network applications for collecting and analysing user data were created using Visual Basic 3.0 Professional Edition. Statistical analysis was performed using Microsoft Excel 97 and SPSS version 7.5. Evaluation data was managed using QSR Nudist version 4. The learning materials were created on high specification computers connected to a Novel 3.1 network running Windows 95.

7.2.2 Development of the student model

The individual configuration of the multimedia learning material developed in this study was based upon the application of a co-operative student model. An explanation of the student model used in the final study was presented in the previous chapter. The user characteristics modelled were based upon the pedagogical features identified as being important, described in the previous section. These were language level and language support, cognitive style, task level and type, question level and type, presentation of domain knowledge and help and support systems.

Users' characteristics were modelled by assigning values to variables defining the level of each characteristic in the student model. The application was designed to present different versions of the application to learners depending on the values held in the student model, their global description. This approach is

sometimes classified as a 'stereotype' method, since stereotypical presentations are mapped onto stereotypes of users. A similar approach was used by Milne and colleagues (1997) where cluster analysis was used to assign stereotypical presentations to users based upon a student model.

Table 7.1 displays the range of each characteristic included in the model. Explanations are provided in the following paragraphs.

Table 7.1

Table of student characteristics and the range of values held in the student model

Student characteristic	**Student model variable**
Language level	0 Additional support/Low level 1 No additional support/Higher level (Barker et al 1999a)
Cognitive style	0 Verbaliser 1 Bi-modal 2 Imager (Riding 1991a; Barker et al 1999b)
Task level	0 Level 1 1 Level 2 2 Level 3 (Bloom 1956; Barker 1997b)
Question level	0 Level 1 1 Level 2 2 Level 3 (Felder and Brent 1994)
Help system	0 Low entry point 1 Standard entry point 2 Highest entry point

The values of the language and cognitive style variables held for each individual in the student model were established by means of diagnostic tests undertaken prior to learning. The values of the other variables used in the model were established co-operatively with the tutor. The co-operative method of establishing values for these variables is explained later.

7.2.2.1 Language level

Language ability was established using a multimedia language testing application based upon students' reading and listening skills. A value of the SMOG level was determined as described in chapter 4 of this work. Learners scoring less than 60% on the diagnostic were recorded as requiring additional support and had a value of the language variable set to 0. Those obtaining higher scores were assigned a value of 1, to the language variable.

All texts and spoken words in the application were implemented at these two language levels, using methods and software previously described. Presentation of all textual and spoken content was determined by the value of the language variable held in the student model. Users requiring additional support were presented with texts and spoken words at or below level 14 on the SMOG scale (see chapter 4). Learners not requiring such additional support had their level set to 15 to 17 on the SMOG scale. Where difficult words arose, irrespective of the language level set, additional glossary help was made available to all users.

7.2.2.2 Cognitive style

Cognitive style was determined along the Verbaliser – Imager (VI) dimension by means of the CSA test developed by Riding (1991a) and described in chapter 5

of this work. The student model was configured as follows. Learners with VI scores of less than 0.8 were assigned to be Verbalisers and the VI value in the student model was set to be 0. VI scores of above 1.2 were assigned as Imagers and the VI value set to be 2. Scores between these values (>0.8 <1.2) were assigned as Bi-modals and a VI score of 1 was assigned to their student model. Riding's (1991b) test also provided a score for the Wholist- Analyst (WA) dimension. These values were also held in the student model for use in future development of the system.

Learners who were assigned as Verbalisers had information presented predominantly in a textual form. (All images were provided with additional textual support.) This related to those areas of the course conveying information, not to motivational images. Learners assigned as Imagers, had information presented predominantly in the form of images and diagrams with explanation. Where text was important, additional support was available in the form of pictures, diagrams and additional explanations. Imagers might for example be presented with an image first, followed by a spoken or textual explanation. Verbalisers would perhaps have the same explanation, followed by an image if needed. Those learners classified as intermediates had both systems available and were able to select the presentation format for themselves.

7.2.2.3 Other variables

A simple pre-test was used to assess students' previous experience and knowledge in the subject area. Scores obtained on the pre-test, in conjunction with other information available, was used by the tutor to assign the values of the remaining variables, task level, question level and help level. In the next section, how these variables were set and the use of a co-operative student model is described.

7.2.3 The use of a co-operative student model

An important feature of the model developed here is the requirement that some characteristics of the model were established co-operatively. The level of tasks presented to the student, the level and types of question available, the possibility of fast tracking through material and the entry level of help and scaffolding systems were all established co-operatively. Learners were able to discuss their progress on the course with tutors. In a process of target setting and negotiation, the level of each of the above characteristics of the model was established. A simple tool was made available that allowed tutors to change the values of variables stored in the student model as required. For example students who felt they were not yet confident and able to attempt more challenging tasks and questions would have task and question level set to low values in the student model. Later, when they had gained experience and developed within the course, they would be able to accept greater challenge and the task and question levels could be increased.

The use of a co-operative student model was felt to be important for several reasons. Students would be involved in taking responsibility for their learning and tutors would have involvement in the process. This was important as it had been shown to increase motivation in students and tutors, in exploratory studies. There were also the benefits of a student modelling approach, in that learning was presented at the most appropriate level for the individual. In chapter 6 it was explained that within some adaptive AI systems, all decisions about changes in the values of variables held in the model are made by the system. In the co-operative student model used here, the system is used primarily to hold information about student characteristics and to control presentation based upon these values. The establishment of the values is controlled either by the tutor, or by diagnostic testing for language and cognitive style.

The use of a student model to control the presentation of a multimedia learning application is a rich and complex phenomenon. This is because students and tutors are able to use the application in a large number of different ways with a large number of presentation configurations. In order to test the effectiveness of the student modelling approach employed, the final study used a Grounded Theory method to study the phenomenon, as described in chapter 6. An important feature of this approach was the establishment of a storyline to describe the phenomenon under study. In the next section, the stages leading up to the development of the storyline is explained.

7.3 Grounded Theory research method

The evaluation of the system developed in the final study was based upon both qualitative and quantitative methods. The first stage of the study involved the isolation of the characteristics, features and variables involved in the phenomenon under study, the use of a student model and individual configuration in a multimedia course. This was referred to in chapter 6, as the open and axial coding stages of the method. By the use of this method, it was possible to establish relationships between the variables and to understand better the phenomenon. In the following sections, the stages involved in the process of identifying these characteristics and variables are described.

7.3.1 Establishment of the main categories

The theme of the study related to how individual configuration of the multimedia course was important in the teaching and learning process. In order to understand this phenomenon it was necessary to identify the issues that were important. This was achieved by the process of open coding as described by Strauss and Corbin (1990) and as outlined in chapter 6 of this work. Variables were identified in an initial pre -study at 7 FE Colleges. Early prototypes of the

learning materials were demonstrated to groups of tutors, learning centre managers and college middle/senior managers. Presentations were accompanied by discussion and question sessions. After the presentations, participants were asked to list features that they considered to be important in multimedia learning. A total of 82 lists were examined and summarised in order to prepare a questionnaire to be administered to workers in the area of multimedia and education. This questionnaire rated how important they considered the listed features to be in educational multimedia on a scale of 1 to 5. The instrument also recorded the position of the responder within their organisation. Questionnaires were distributed to 21 colleges of FE at meetings, training sessions, presentations and demonstrations for a range of college staff involved in multimedia and learning. Staff were also asked to list any features they considered important and not covered by the questionnaire. Results of this initial study and the instrument used are shown in Appendix 14.

The identification of the main categories involved the production of a hierarchical structure, which showed tentative relationships between factors identified from the work described above, that were consistently rated as being important to the phenomenon. This hierarchy is presented in Appendix 15. The production, refinement and modification of this hierarchy of categories and sub-categories is described in the following sections.

7.3.2 Related variables

Once the main categories relating to the individual configuration of multimedia had been identified as described above, it was important to understand how these categories were related. Relationships between the categories were identified as follows:

Key staff (i.e. those involved in the day to day delivery of open and flexible learning) at 8 colleges of FE were provided with final prototypes of the

application. These contained full instructions for their installation and use. They were asked to comment on features identified as being important in the previous stage from the questionnaire and lists. Each of the key staff provided a semi-structured written report on the use of the prototypes at their colleges. They were encouraged to show the prototype to others and elicit their responses. Key staff were also asked to provide additional comments on any aspect of the application they themselves considered to be important. The format of the report is shown in Appendix 16.

After the initial analysis of these data, interviews were conducted with volunteer experts from four of the colleges involved. These interviews were unstructured or semi-structured with the intention of exploring issues identified in written reports. Interviews took place between four and eight weeks after receipt of the written report. The objective of this was to identify how those variables identified in the report might be related one to another. For example, where pedagogy was identified as an important theme in the delivery of multimedia, issues related to pedagogy were discussed in the interview with the intention of identifying related variables, and issues and understanding features of the relationship between them.

Interviews were recorded on audio tape and were transcribed in full. An initial tentative logical structure for the phenomenon under study was generated. This structure attempted to clarify relationships between the categories or variables involved in the phenomenon. A main category, sub-categories and variables/features were identified. The hierarchical structure developed earlier and presented in Appendix 15 was modified based upon evidence from the interviews. The relationships identified in this exercise were a tentative representation of one view of the many possible ways these relationships could be presented. This particular view, however, had the advantage that it was derived from the phenomenon as it was understood by workers and experts in the area. The next stage involved refining the relationships described.

7.3.3 Refining relationships

In this section, the further elucidation and refinement of relationships between categories presented in section 7.3.2 is described. This was accomplished using the standard techniques of Grounded Theory as were described in the previous chapter.

An important feature in establishing relationships between categories and sub-categories is the identification of the dimensions of a category. For example the category 'student model' had several associated sub-categories, including 'language' that had the dimension 'level' that could take values of 'low level' or 'high level'. Once dimensions had been identified in this way, then the range of possible values were described for each category and sub-category. The result of this exercise was the production of a modified, detailed and extended structure to which could be attached code notes or memos pertaining to each of the categories and sub-categories, their dimensions and ranges of values, shown in Appendix 15. At the same time, a detailed and richer understanding of the research phenomenon was being developed.

Memos were obtained in several ways. For example, comments made by experts were recorded and attached to relevant nodes in the structure. Transcripts of interviews and the results of text searches were also related to categories and sub-categories. In this way an understanding of the phenomenon began to emerge in terms of the relationships between categories, sub-categories and their dimensions. Memos were also used in the early stages of the analysis, to record the context of relationships between categories. For example if a category was considered to be important, consistently, in several interviews, then this fact was recorded along with possible reasons for this. Where phenomena were consistently related, details were recorded in memos and attached to related nodes. It was hoped that ideas would emerge from this

phase of the study that would guide the main data acquisition stage of the project and the development of an understanding of the phenomenon. New categories were identified and added to the structure during this process and a phase of reorganisation of the structure was undertaken.

The aim of the stage of the work described above was to gain an understanding of the phenomenon in order that a core category could be identified. The core category was identified as *'the quality of learning'*. All other categories were then organised around this central theme, which was intended to allow an understanding or statement of the phenomenon in a form that could be tested against data later in the study. A full description of the core category and its relationship to the data obtained in the study are described in chapter 9 of this work.

The work described above was undertaken as a preliminary stage of the final study. It is presented here as a linear exercise in time, for the sake of clarity. The process of relating main categories, sub-categories and variables in a structure that could be tested against data was an iterative process. Indeed modifications to the structure presented in Appendix 15 were made throughout the whole study, including the data collection and analysis phase, As ideas became clearer about relationships, and as more data became available, the structure of categories and sub-categories was modified accordingly. The structure of ideas produced in the open and axial coding stages of the study was instrumental in organising the implementation of the final study, which is described in the next section.

7.4 Implementation of the study

The study reported here involved six small groups of learners and their tutors located at FE colleges in the UK. Learners were following vocational courses in a variety of subject areas, all having in common, the key skills programme, in General National Vocational Qualification (GNVQ) Application of Number, level one. Key skills also include Information Technology and Communication studies, and are compulsory components of all GNVQ courses followed. These courses were being followed in parallel to the Application of Number course by all students involved in the study.

According to Gunn (1998) the evaluation of CAL must involve the assessment of particular resource combinations. It was important therefore, in consideration of the variety of environments provided within the study to ensure that a minimum standard at least was provided. Callear and King (1997) describe 'crucial' features of the environment to support computer-based testing. Their guidelines cover staff and student support, technical support and other resources. As part of the selection procedure for the study locations, a set of guidelines similar to Callear and King's were provided for all locations employed in the study. In this way it was possible to exercise some small measure of control over the microenvironment.

7.4.1 Tutors

Prior to the study, tutors were trained to use the application in a series of short courses. This training involved the following stages:

1) Introduction to multimedia learning application

2) Student-centred learning

3) Features of the GNVQ Application of Number software

4) Configuring the student model – co-operatively

5) Use of the application with students

6) Assessment and multimedia – task and question levels

All tutors were volunteers and it was a requirement of the programme that they undertook the training. Some tutors were already experienced in the use of multimedia learning applications, though none had used a co-operative student model before. It is true to say that the specific requirements and methods of this project were new to all tutors. Training took place in a variety of formats, all involving face-to-face sessions with the instructor and took on average five hours. Evaluation and feedback sessions took place at the end of the project and lasted approximately one to two hours, including time to a produce a written report, as described in section 7.4.4. Tutors were able to access a central help facility at any time during the project.

7.4.2 Participants

Students followed the course in several learning and vocational contexts. Tutors used the multimedia application in the course of their normal work with students taking the Application of Number level one course.

Learners were required to attend briefing sessions where the application was explained and demonstrated in a group. Diagnostic testing and pre-tests were performed at these sessions in order to establish initial parameters for the student model. Technical staff created student configuration files automatically

using a simple computer program. Files were copied into secure accounts on the network. Applications were designed to be run on local machines but to read configuration files and to save users' data on the network.

Learners followed the section of the course related to assignment one of the course, as directed by their tutors. Learners were required to complete tasks, answer questions and gather evidence for their portfolios. All participants had at least two meetings with tutors to review progress, and establish interim targets and objectives. At the end of the period, assignments were completed by students, away from the computer.

Groups of between 6 and 12 volunteer learners in six FE colleges took part in the study as part of their GNVQ key skills course. Each group was mirrored by a similar group in the college that followed the same course, but delivered by traditional methods, including lectures and tutorial sessions. These mirror groups had the same age and gender profile and underwent similar progress and targeting sessions with tutor as members of the multimedia groups. These sessions in mirror groups however differed from the multimedia group sessions in that the latter were *prescribed* as part of the course and mirror group tutorial sessions were not. The same teachers at each location were involved in tutoring multimedia groups and mirror groups. Tutors were asked to ensure that learners in both groups had the same study times on their courses, in line with the course guidelines. As far as possible, all learners in both multimedia and mirror groups had access to the same study and support facilities at their colleges.

A total of 52 learners followed the multimedia course and 50 learners followed the mirror course. Table 7.2 below shows a summary of the participants in the final study.

Table 7.2

Summary of participants taking part in the final study

College	Number of learners Multimedia	Number of learners Mirror group
College 1	11	7
College 2	6	8
College 3	9	9
College 4	12	10
College 5	6	11
College 6	8	5
Total	52	50
Average Age	17.4	17.9
Gender M:F	31:21	26:24

7.4.3 Data collection

This section describes the main methods of data collection used in the final study. In general, data collection was co-ordinated by the project manager (the author of this thesis), who was responsible for the preparation of, training in the use of and distribution of evaluation tools to locations involved in the study. Tutors at these locations were responsible for collecting and returning some data, for example, video recordings, student logging files, questionnaires and tutor reports. Other data, for example, interviews and focus group sessions were carried out by staff from the software development team who visited each

location in order to do this. All data was collated and summarised by the project manager who was responsible for preparing summaries and weighing the evidence presented. The project manager discussed data collected with colleagues from the software development team and considered their views and interpretation of the data prior to the preparation of this report. Throughout the duration of the study, the software development team met regularly to discuss progress and to ensure that correct data collection procedures were being followed. In this way, data collection was systematic and its interpretation was as objective as could be made possible. Interviews with students and focus group sessions were carried out by staff from the software development team who followed guidelines prepared by the project manager in collaboration with the software development team. All interviews with staff were carried out by the project manager. Interviewers and the focus group facilitator underwent training and shared fully in the evaluation objectives prepared by the project manager and software development team. Video recorder technicians at remote locations also received guidelines and advice from the software development team, who visited each site at least once to assist in video recordings. Expert evaluators and independent raters were selected by the project manager after discussion with the software development team. Tools used in the data collection stage are presented in the Appendices 16 to 25 and are referenced in the following sections.

7.4.3.1 Video recordings

It was intended to make video recordings of one sample session in each college. However, only four colleges sent in complete video recordings at the end of the trial. One recording was incomplete and ignored. One other recording was not submitted. Video recordings were made by groups according to a script that was sent to each group prior to the beginning of the trial. The scripts used are shown in Appendix 17. The scripts were very general in nature and left opportunity for exploration by tutors, students and video makers. Additional information was

provided in the script to assist in this exploration activity. The most useful video recordings, it is argued, are those made in consideration of the local environment and circumstances. For example the script required the video to provide some idea of the environment in the learning centre or study room. Lighting, noise levels, seating arrangements and other facilities were thought to be important. The relative importance of any aspect of the environment, however, was best left to those on site at the time.

Tutors were asked to provide video of students working on tasks together in groups and students working alone. Students were asked to log in to the system, log out and navigate, locate and undertake various activities either alone or in groups. Scripts were provided for short tasks to be recorded during the sessions and these are shown in Appendix 18. The script required recordings to be made of how tutors interacted with learners in these sessions, if indeed they did.

When videos were returned, they were viewed by an experienced rater who compared the content of the video with the script provided. A written summary report of each video was made by the rater, under headings related to the requirements of the script. For example, the levels of the various interactions within the session were rated as high, medium or low. Other features such as the environment, ease of task completion were rated in a similar way.

7.4.3.2 Interviews

At the end of the trial, 24 students following the multimedia course, 4 selected from each of the 6 participating colleges, volunteered to undergo a short interview. These interviews were semi-structured in that a script was provided for the interviewer, yet exploration was encouraged within the questions. If, for example, an interviewee reported that one section of the course was difficult, then the interviewer could explore this, asking questions intended to find out more information about reasons for the situation. The interview script used is

shown in Appendix 19. Interview sessions were kept as short as possible and were recorded onto audio tape. Interviewers were also asked to keep a note of any points they considered important, separately. Tapes and interviewers' notes were handed in at the conclusion of the trial for analysis.

Analysis of the notes involved making a partial transcription of comments and coding these against the categories identified previously in the process of selective coding, described in chapter 6. The process employed here had the following features

1) Causal relationships were identified where possible.
2) Reasons for differences were recorded.
3) The magnitude of effects was estimated and recorded.
4) The effect of change in circumstances and how these related to the magnitude of variables was noted.

The objective of this coding exercise was to attempt to relate the impressions of learners to the categories identified earlier as important in the phenomenon.

7.4.3.3 Pre and post-tests

All participants on the multimedia course and the mirror course participated in a Pre-test and post-test study. A test containing twenty calculation type questions, directly related to the material in assignment one of the course was prepared by a subject expert for use in a pre-test. The pre-test was administered immediately prior to the start of the course. For the post-test, twenty different equivalent questions were prepared. Post-tests were administered at different times after the course, depending on when the course had been completed. The timing of the post-test was controlled by the course tutor. Although there were some differences between locations, all post-tests were completed by learners within one week of finishing the course. Sample questions from the pre-test and post-

test are shown in Appendix 20. The results of these tests are presented in the next chapter.

7.4.3.4 Data logging

The multimedia application was designed to record all navigation and interactions that users made whilst following the course. This was saved to a user log file located on a network file server. Data was appended to these files during subsequent sessions, providing a complete log of all interactions that took place. In addition to navigation and interaction data, the users' files held information on login and logout times, inline questions and tasks attempted and scores and time spent in sections of the course. Use of the help system was also recorded, including level of help requested as well as frequency.

Data was stored at a sufficiently high level to allow analysis of user's intention. This contrasts with other systems reported where low-level data in the form of key strokes and mouse movements precluded any attempt to understand high-level user intentions (Laws and Barber 1993). It was possible to examine some user's files in detail and all files provided useful summary information, though the sheer volume of data made it impossible to examine all interactions in depth. Results relating to user log files are presented in summary form in the next chapter.

7.4.3.5 Questionnaire

All learners following the multimedia course were asked to complete a questionnaire at the end of the course. The questionnaire was intended to measure features of the learning experience in following the course. The questionnaire was delivered on-line in a multimedia format. Results were saved directly to the network and results were analysed automatically using computer

software specially designed for the purpose, at the end of the study. The questionnaire used is shown in Appendix 21.

7.4.3.6 Tasks and questions

All learners completed questions and tasks during their progress through the course. The level of questions and tasks users were asked to perform were set by the tutor in response to diagnostic information and pre-test scores as previously described. This information was held in a file that the system used in order to determine for each user, the level of task required (user configuration file). Tutors and students were asked to keep a record of performance on tasks and questions set by the system. It was possible to compare how performance on these tasks and questions was related to the level at which they were configured for the individual.

Tasks required users to undertake an activity at the computer or away from the computer singly or in groups. Tasks rarely had an absolute right or wrong answer.

Questions were delivered on-line and mostly had right or wrong answers. Question levels and scores were recorded for all learners. Changes in the task and question level throughout the course were also recorded. Changes in question level in relation to improvement in scores were considered to be a better measure of progress than simple question scores.

7.4.3.7 Focus groups

A focus group is an important way of finding out information about how learners used the application and what learners and tutors felt about the application. It was hoped to perform one focus group session at each location for the study.

However due to time factors, focus groups were held at only two locations involving staff, students and a facilitator. The same group facilitator (a member of the software development team) was employed at both sessions performed in this study. The richness and directness of information obtained at these sessions made them extremely useful methods for collecting high quality information.

A focus group tool was developed for the sessions based upon a subset of the categories developed earlier in the project. The objectives of the session were shared with the facilitator who was instructed in the use of the tool. The tool is shown in Appendix 22. The facilitator was encouraged to explore issues and questions raised by the groups more fully. Tutors were asked to join in discussions any place where they felt it was appropriate, but not to lead, encourage or discourage discussion. Learners who followed the multimedia delivered course were mixed with learners who followed mirror courses. A few questions were addressed specifically to multimedia course followers and some to followers of both groups. Most questions however were open to participants from both multimedia and mirror groups and to the tutors. With the agreement of participants, group sessions were recorded on video tape and analysed at the end of the study. The analysis involved identifying categories brought up in the focus group and analysis of these is presented in the next chapter.

7.4.4 Staff evaluation

The views and attitudes of staff using the application with students were considered to be central to the study. Several measures were taken to elucidate staff opinion regarding the application and its use. These are described in the following paragraphs. The staff evaluation of the application centred very much on how effective the student model was in configuring learning for the individual, and also upon features that facilitated tutor involvement in using the application.

7.4.4.1 Staff diary

Staff were asked to keep a diary or record of their use of the materials. This log was used to record times and dates of sessions, number of learners present and also to record anecdotes and incidents that occurred during computer and discussion sessions, along with their interpretation. No guidance was given relating to keeping the diaries. They were a useful source of anecdotal information about the sessions and also rich sources of insights into tutors' attitudes to the applications. Any movement in tutors' opinion during the project was also evidenced in the diaries. Three such diaries were collected at the end of the study for analysis of the content. The content of the diaries was coded to the categories and sub-categories used to describe the structure of the phenomenon earlier.

7.4.4.2 Staff interviews

Six tutors involved in the project agreed to undergo an interview at the end of the study. An interview tool was created that focused on the use of the multimedia course. It was also concerned with comparisons between the traditional delivery of the course and the multimedia method. The interview was structured as follows:

- Initial needs of tutors involved in the project
- Preparation of students prior to the course
- Configuration of the student model
- Implementation issues
- Effectiveness of the co-operative approach
- Students' attitudes
- Staff's attitudes
- Management of the process

- Suggestions for improvements in systems
- Other issues

The interview tool used in the project is shown in Appendix 23. Interviews were semi-structured and exploratory in nature. The average duration of an interview was approximately one hour. Interviews were recorded on audio tape and were transcribed at the end of the study.

7.4.4.3 Staff report

Tutors provided a summary report at the end of their work. Part one was a structured part that focused on the use of multimedia, the use of the student model, learning and the management of the learning process in the course, including issues relating to the learning environment provided. Structured questions were based on the categories and variables identified as being important, earlier in the study. There was also a free or open section in the report, where tutors were able to comment in any way they liked on any part the course or overall process. Tutors were asked to relate their reports directly to their experience of delivering the Application of Number course. The tool provided for tutors is shown in Appendix 24.

At the end of the study, information contained in reports was collated and coded against relevant categories and sub-categories.

7.4.5 Expert review

Expert review is one of the primary evaluation strategies used in both formative and summative evaluation of computer applications. An expert review checklist based on Reeves and Harmon's expert review tool was provided for use by four experts in instructional design (Reeves and Harmon 1994). These were experienced teachers who had been involved in multimedia learning materials

production and delivery in an FE context for several years. They each understood the objectives of the material, but none of them had been involved in the material design, or in any earlier stages of the project. Each was given an introductory briefing by the project manager immediately prior to the evaluation. The tool that they used and briefing notes provided for them are shown in Appendix 25.

7.5 Final Report

After all data had been collected, it was subjected to analysis by the project manager and coded into the categories and sub-categories determined at the preliminary stage of the project, described in sections 7.3.1, 7.3.2 and 7.3.3. The organisation of these data was managed using QSR Nudist software. Analysis of the data was undertaken using methods and techniques described by Strauss and Corbin (1990). During this phase, a major restructuring of the categories and sub-categories was undertaken in the light of the evidence (see Appendix 15).

In the next chapter the results of the final study are presented.

Chapter 8

A study into the use of a student model in a multimedia application: Results

8.1 Introduction

In the previous two chapters, a study in the use of differentiated multimedia learning materials was described. In chapter 6 the study was introduced and the framework for the use of a co-operative student model to control the individual configuration of a multimedia learning application was established. It also laid out the principles of the Grounded Theory research method employed in the study. In chapter 7 the development of the multimedia learning application and the stages in the method used to evaluate the use of the student model approach in learning with multimedia were described. In this chapter the results of the study are presented,

8.2 Evaluations

The evaluation of the final study involved the collection of data using several methods which were presented in the previous chapter. The results of the evaluation that took place are presented in the following sections of this chapter. In this chapter, each type of data collected is discussed in isolation. In the next chapter, the results of the evaluation are placed in the full context of the final study.

8.2.1 Video recordings

Video recordings were made of learning sessions at four locations as described in the previous chapter. These included recordings of users as they undertook specific task scenarios within the application. The ease with which tasks were accomplished was rated by an independent expert who viewed the video recordings and rated the sessions according to guidelines provided and shown in Appendix 17 and 18. A summary of the results of these recordings are shown in table 8.1 presented below. Ratings were also made of the quality of the learning environment and also of the interactions between learners and tutors during each sessions. These are also shown in table 8.1.

Table 8.1

Table of results showing ratings of multimedia sessions involving learners and tutors, based on video recordings

Task / Activity Feature	Location 1	Location 3	Location 4	Location 6
Environment				
Noise level	1 High	2 Medium	1 High	2 Medium
Light level	2 Adequate	1 Bright	2 Adequate	1 Bright
Space	3 Crowded	1 Roomy	1 Roomy	Adequate
Scale 1-3				
Location				
LRC Learning Res. Centre CR Computer room	LRC	CR	LRC	LRC
Room organisation				
How well was the room arranged for the needs of the session Scale 1-3	3 Poor	2 Medium	1 Good	1 Good
Student organisation Did students know what to do? Scale 1-3	3 Poor	1 Good	1 Good	1 Good
Introduction to session	None	Completed	Completed	None
Duration of session				
approximate time (hr)	1.5 hr	1 hr	1 hr	2 hr
Tutor present	Yes	Yes	Yes	Yes
Number of students present	8	5	8	7
Interaction level				
Student/student Scale 1-3	1 High	3 Low	2 Medium	Medium
Interaction level				
Student/tutor Scale 1-3	3 Low	3 Low	1 High	High
User attention Scale 1-3	3 Poor	1 High	2 Medium	1 High
User attention Scale 1-3	3 Poor	1 High	2 Medium	1 High
Student involvement				
General involvement in session Scale 1-3	2 Medium	1 High	2 Medium	Medium
Invested effort in				
Prescribed Tasks Scale 1-3	3 Low	1 High	2 Medium	2 Medium

Table 8.1 continued

Table of results showing ratings of multimedia sessions involving learners and tutors, based on video recordings

Task/Activity Feature	Location 1	Location 3	Location 4	Location 6
Invested effort in Group Tasks Scale 1-3	3 Low	1 High	2 Medium	2 Medium
Ability to complete Individual tasks Scale 1-3	3 Low	1 High	1 High	2 Medium
Ability to complete Group tasks Scale 1-3	3 Low	1 High	1 High	2 Medium
Ease of logging In Scale 1-3	1 Easy	1 Easy	1 Easy	Easy
Ease of logging out Scale 1-3	1 Easy	1 Easy	1 Easy	Easy
Ease of locating specified Information Scale 1-3	1 Easy	2 Medium	1 Easy	Easy
Application Robustness Scale 1-3	1 Robust	1 Robust	1 Robust	1 Robust
Ease of navigation Scale 1-3	1 Easy	1 Easy	1 Easy	2 Medium
Ease of Orientation Scale 1-3	2 Medium	2 Medium	1 Easy	2 Medium

The learning environment is a major factor in the delivery of learning. It was important to obtain a measure of the conditions of the learning environment during sessions. This would be useful in several ways, for example to ensure that any differences in results between locations was not due to differences in the environment.

Video recording of sessions was an important measure in comparing the environments involved in the study and showed some variation in the learning

environments in the four locations. Noise level ranged from high to medium which interfered somewhat in group activities. Indeed group activities themselves contributed to the general level of noise in the rooms. Learners used headphones when using the multimedia application, but had to remove them continually when discussing and communicating with the tutor. Interactions between students and the tutor were inhibited in the location that exhibited the most crowded environment, yet interactions between students and other students were high at this location.

Lighting levels were good or adequate in all locations as far as could be deduced from the video evidence. This measure related to glare on computer screens and the general level of background lighting. There was no screen glare at any of the locations, yet two had reduced levels of background illumination.

Introduction to the session took place in only two locations, despite the requirement for such sessions. Tutors were present at all locations throughout the sessions which lasted from one to two hours.

General student involvement in sessions seemed to be better in those sessions where an introduction was given. The invested effort in prescribed and group tasks as rated by the expert, was least in the session with the poorest environment, i.e. location 1. This session also recorded the highest student interaction and also, low tutor interaction. The general level of organisation in the sessions tended to correlate to how much effort learners invested. Group tasks might normally have been undertaken at separate sessions at some locations but were performed in these sessions for the sake of the recording.

The application was robust in all sessions and learners had little problem logging in or out and undertaking specific navigation, location and orientation tasks. Task scenarios were accomplished completely and without problem for the most part.

The data from video recordings of sessions will be discussed in the context of the final study as a whole in the next chapter.

8.2.2 Interviews with learners

Interview sessions were conducted at each location in the study, with four volunteer learners selected randomly by the tutor. Interviews were intended to investigate how learners used the application, their attitude to the application and how using the application influenced their learning experience. Table 8.2 presents a summary of the analysis of the scripted part of the interview sessions.

The interviews were used to identify causal relationships between the categories identified in the preliminary open and axial coding stages of the study, as described in chapter 7. In order to achieve this, interviewers were encouraged to explore *reasons* for any differences in learners' responses. Recordings made of interviews were later analyzed by the project manager in order to estimate the magnitude of any effects and relate these to differences in circumstances. The objective of this coding exercise was to attempt to relate the impressions of learners to the categories identified earlier as important in the phenomenon. The data in table 8.2 represent the number of learners' opinions or responses that could be coded against the category.

Table 8.2

Analysis of scripted interview data for 24 learners following a multimedia course in six locations
n=24[1]

Part a) **Relative to other courses:**	This course was:	This course was:	This course was:
Enjoyment[1]	Better 18	Same 3	Worse 2
Workload[1]	Less 14	Same 6	More 3
Difficulty	Easier 12	Same 8	Harder 4
Tasks	Easier 20	Same 2	Harder 2
In line Assessment	Easier 10	Same 12	Harder 2
Final coursework	Easier 8	Same 14	Harder 2
Time spent	Less 16	Same 4	More 4
Part b) **Relative to other courses:**	This course was better because of this aspect	This course was the same as others in this aspect	This course was worse because of this aspect
Attitude towards study	15	6	3

[1] Two sections of table 8.2 do not sum to 24 due to an error in tape recording

Table 8.2 continued

Analysis of scripted interview data for 24 learners following a multimedia course in six locations
n=24

Part b) continued **Relative to other courses:**	This course was better because of this aspect	This course was the same as others in this aspect	This course was worse because of this aspect
Working alone	10	4	10
Working in groups	15	7	2
Working with the tutor	18	4	2
Achieving targets	16	4	4
Knowing what to do next	14	8	2
Organisation of the course	12	12	-
Sense of personal satisfaction	10	11	3
Part c) **Changes I would make**	Agree	Neither agree nor disagree	Disagree
Would have preferred more computer time	12	10	1
Would have preferred more lectures	6	5	13

Table 8.2 continued

Analysis of scripted interview data for 24 learners following a multimedia course in six locations
n=24

Part d)	High	Medium	Low
The quality of the following parts of the course			
Tasks	15	5	4
Questions	13	9	2
Images	18	1	5
Text	8	12	4
Video/Animation	20	1	3
Part e)	Yes		No
Would undertake a similar course again Yes or No	19	N/a	5

The results of these interviews suggest that in general the course was well received. Nineteen of the twenty-four learners interviewed stated that they would be prepared to follow a similar course in the future.

The unstructured part of the interview session was intended to explore in greater depth issues that arose whilst answering the structured questions. There were several common themes or issues that arose in almost all of the interview sessions. For example, one reason for increased enjoyment of the application was related to the perceived quality of the multimedia presentation. This was

considered by most (over 60%) to be high. The quality of video, animation and images was frequently mentioned by learners as contributing to enjoyment.

Learners often reported that they understood the objectives of the course and were confident that they knew what was required of them as they undertook the course. The language demands of a course, when delivered in a traditional format were rated as high in comparison to the multimedia course, by one learner, who had previously failed the traditional course. Simple language was cited by eleven learners and the use of structured organisers (simple graphical devices providing information to help orientation in the course) was mentioned by six interviewees as being reasons for their good understanding of the objectives. The involvement of the tutor in establishing targets was almost unanimously cited as a reason for achieving objectives and by most as a reason for understanding them. The course was perceived as being well-organised, which several learners cited as giving them additional confidence. When drawn on what they meant by 'knowing what to do next', thirteen learners stated that the ability to review what they had already done and/or to see what they still had to do was important. Six learners stated that the flexible way they could organise the use of the application helped them to know what to do next.

The use of image, animation and video was cited by twenty of the twenty-four participants as leading to their enjoyment of the course. 'The animations helped me understand what was going on' stated one learner. Another mentioned that seeing the numbers animate into columns helped them to complete one exercise. For ten students, the most liked feature of the application was the video sequences, for five students it was the images and for five students the sound. The most disliked feature of the application was the off computer tasks (cited by eleven students) and the questions (cited by six students).

The use of hyper-linking to related areas was cited by eight learners as being a useful feature of the application. However, six others stated that this feature

caused some confusion. The feature was only available in full to learners provided with the minimum of help or scaffolding, i.e. those working at the higher levels of the course presentation. At lower settings of the course, hyper-linking was disabled and help was provided without the need for hyperlinking . Despite this, all interviewees stated that navigation in the application was simple to use, although thirteen admitted to getting lost in the application on more than one occasion. Evidence from log files (see section 8.2.4) suggests that the number getting lost on occasions may have been higher.

Learners were questioned about navigational strategies employed as they worked through the application. Some learners reported that they worked in a linear way through the application, followed examples, obtained help and undertook tasks and questions as they occurred and related to what they were studying. Other learners preferred to use the application in more of a browsing manner, following links around an area more or less randomly and only when they had investigated the area would they undertake tasks and questions. Learners reported that the navigational functions provided for locating information were simple to understand and use.

Learners frequently reported that they felt motivated as they followed the course. Six learners stated that immediate feedback was important in this. Four others stated that working with the tutor to targets assisted motivation while nine others cited working in groups or in pairs as adding to motivation. Several learners stated that they would have preferred more lectures to support the multimedia delivery. Seven participants stated that they enjoyed the freedom of using the materials at their own pace. Three others stated that they enjoyed working in learning centres. Seven reported that using learning centres limited their enjoyment of the course. All of these would have preferred to follow the course in a classroom and four would have preferred using the materials at home. Three stated that an Internet version of the course would be a good idea.

Learners reported unanimously that they enjoyed the activities provided on-line, but some reported that the off-computer tasks were de-motivating. The course was perceived to be as easy or easier than similar courses by twenty of the interviewees. When asked why this was, it was interesting that eleven included reference to how well-organised the course was in their responses. Several stated that it was 'just easy'. Others stated that immediate feedback and the ability to try again straight away was important. Sixteen cited the help system as being good and simple to use. This was despite the fact that the sample of learners interviewed had experienced the help system at different levels. It was interesting to note that there was an almost universal perception of its benefit. An important feature of the help system was the provision of help in a differentiated way.

Students in general rated their participation in the course highly. It was clear from the responses of some learners that, despite working flexibly and often alone, they felt part of a larger well-organised and supported system. 'You always felt that you were in control of what you were doing' stated one learner. 'The lecturer could direct you to some place or other on the computer and the answer was there', stated another.

8.2.3 Pre-test and post-test results

Learners following the multimedia course and a matched group of learners following a non-multimedia version of the course undertook a subject pre-test prior to starting the course. At the end of the course learners in both conditions underwent a post-test. Table 8.3 below, presents the mean pre-test and post-test scores recorded for learners in each of the six locations involved in the study. Sample questions from the pre-test and post-test are shown in Appendix 20.

Table 8.3

Mean pre-test and post-test scores for learners on a multimedia course compared with learners undertaking a similar traditionally delivered course in the same location

Location	Multimedia Course n = 52		Mirror Course n = 50	
	Pre-test %	Post-test %	Pre-test %	Post-test %
Location 1	46.5	59.6	37.6	49.7
Location 2	58.3	68.8	50.9	56.6
Location 3	51.1	66.4	36.7	48.7
Location 4	45.0	57.3	48.6	53.2
Location 5	38.8	55.5	43.5	49.2
Location 6	55.5	60.8	50.4	50.8
Overall %	**48.8**	**61.0**	**44.7**	**51.3**

Standard deviation data is not available for the means displayed in table 8.3 above. An analysis of variance (ANOVA) was performed on the data and the results of this analysis are presented below.

Table 8.4

Repeated measures analysis of variance performed on the data summarised in table 8.3, Mean Pre-test and Post-test scores

Within-Subject Effects

Variable	Type III Sum of Squares	Df	Mean Square	F	Sig
Test Score	4284.51	1	4284.51	73.11	0.000
Test Score x Condition	352.049	1	352.049	6.007	0.016
Test score x Group	557.801	5	111.560	1.904	0.101
Test Score x Condition X Group	5274.388	90	58.604	0.429	0.827

The results of this analysis indicate that there was a significant within subjects effect ($p<0.001$) for the difference between pre-test and post-test scores. This is taken to indicate that both the multimedia and traditionally delivered courses led to improved scores for learners taking them. There was a significant effect of condition on the pre-test and post-test scores ($p<0.05$), indicating that there was a significant difference in the means between the multimedia results and the traditionally delivered course results, the multimedia scores being significantly higher (table 8.3). There was no significant effect of group on the test scores ($p>0.05$), indicating that any differences in scores due to variation in group

composition could be ascribed to chance alone. The significance of these results will be discussed in the next chapter.

8.2.4 Data logging

The following tables 8.5 (a-e) present summaries of data obtained from learner log files. The data are based on a sample of nine learners selected because they did not change language, help, task or question level during the course. An objective of the analysis of these data was to compare performance on in-line questions and tasks for learners working at different levels of the student model. It was hoped to demonstrate that learners performed confidently and well at the level set for them in the student model.

Table 8.5 a

Summary of data from user log files of learners using the Application of Number multimedia application

Verbalisers, Bi-modals and Imagers

Condition	Verbaliser N=3	Bi-modal N=3	Imager N=3
Mean time spent in each presentation screen	39 seconds	45 seconds	23 seconds
Time spent per question screen	63 seconds	68 seconds	61 seconds
Mean % score per question	83%	78%	69%

Table 8.5 b

Summary of data from user log files of learners using the Application of Number multimedia application

Language level

Condition	Language level Low N=6		Language level High N=3
Mean % score per question	76%		81%

Table 8.5 c

Summary of data from user log files of learners using the Application of Number multimedia application

Task level

Condition	Task level 1 N=4	Task level 2 N=2	Task level 3 N=3
Time spent per task screen	89 seconds	103 seconds	126 seconds
Mean % score per task	89%	76%	82%

Table 8.5 d

Summary of data from user log files of learners using the Application of Number multimedia application

Question level

Condition	Question level 1 N=4	Question level 2 N=2	Question level 3 N=3
Mean score in-line questions	84%	75%	71%

Table 8.5 e

Summary of data from user log files of learners using the Application of Number multimedia application

Help level

Condition	Help level 1 N=3	Help level 2 N=3	Help level 3 N=3
Mean number of help screens accessed per session	8	7	4
Mean time spent in help per screen	78 seconds	64 seconds	23 seconds

The navigational and in-line question and task data presented in tables 8.5 (a-e) was obtained directly from the user log files which were stored centrally on network file servers, as described in section 7.4.3.4. The results of the user logging data presented in table 8.5 will be discussed in the next chapter.

It was also possible to obtain from the data logging information, a measure of the frequency of navigational errors that learners made as they interacted with and moved about within the application. This was possible since the application provided navigational tools which were intended for the correction of users' navigational errors. For example learners were provided with a 'return to previous screen' function and a map function that could be used at anytime as a navigational help feature. It was hypothesised that the frequency of accessing the map or the return to previous screen options was related to how often learners were getting lost in the application. However, investigation of user log files indicated that there was no difference between groups of users in how often they were accessing these recovery features in the application. Rather, the rate of use of these functions seemed to be related more to the length of time users had been using the application than to any other feature. Frequency of access

was initially high for all users and showed a decrease as users became more familiar with the structure of the application and the navigational features provided.

8.2.5 Questionnaires

Table 8.6 presents a summary of data from multimedia questionnaires completed by learners following the multimedia learning application.

Table 8.6

Results of multimedia questionnaires completed by learners following the multimedia learning application at 6 locations
n=49[2]

Question	High / Agree Easy / Useful 1	2	3	Low / Disagree Difficult/ Not 4	5
Clarity of course objectives	28	4	10	3	4
Feedback : enough/not enough	14	25	5	5	0
Difficulty level of course: Easy/hard	34	12	1	1	1
Subject content : useful/not useful	12	18	9	4	6
Pace of course : Fast – Right – Slow	8	10	17	6	8
The course was planned : well/poorly	14	15	6	10	4
The language used : high/about right/low	3	8	20	6	12
Using the system : easy/hard	26	13	2	2	6
Questions : easy or hard	23	11	5	2	8
Tests and assignments : fair/unfair	11	21	7	3	7
Tasks : easy or hard	8	14	16	4	7
Working in groups: enjoy/not enjoy	5	16	12	10	6
Explaining things to others : enjoyed/not	16	16	11	4	2
Own learning : in control/not in control	20	14	10	2	3
Working with tutor : useful/not useful	8	12	16	10	3
Help systems : useful/not useful	19	13	10	3	4
Use of images : useful/not	26	15	8	0	0
Use of interactive activities : useful/not	24	9	14	1	1
Use of video : useful/not	20	14	11	1	3
Use of sound : useful/not	12	18	5	6	8
Use of text : useful/not	6	6	19	10	7
Finding way around : easy/not	34	4	8	1	2
Working at the computer : useful/not	21	16	4	7	1
Working away from the computer : useful/not	10	17	7	7	8
Facilities in room were : good/bad	9	15	10	8	7
I got what I wanted from the course : Completely/Not at all	16	12	15	6	0
I will be able to use what I learned on the course : Lots/little	20	16	11	2	0
Content was : too much/about right/too little	13	14	11	5	6
Quality of the application : high/low	15	17	10	5	2
Would you recommend the course to others Y/N	Yes 41				No 8

[2] Three questionnaires were not completed

The multimedia questionnaire data shown in table 8.6 supports the view that learners were satisfied with the presentation of the course overall, since 84% of learners would recommend the course to another person. Only 14% of learners were not satisfied with the quality of the application, scoring below 3 on the 1-5 scale. Only 9% found the course difficult and all but 6% considered that they were in control of the learning process. The use of video and images in the course was reported as being more useful than that of text. The results of the multimedia questionnaire are discussed more fully in the next chapter.

8.2.6 Tasks and questions

The results of computer delivered task and question sessions undertaken on the course were saved for each learner in an individual's log file. The establishment of individual levels of tasks and questions for learners made it not meaningful to compare performance across individuals. Table 8.7 presents mean scores obtained in tasks and questions on the course to the level of task and questions set. The results are necessarily a snapshot, since many learners changed the level of task and questions from time to time.

Table 8.7

Relationship between performance on in-line tasks and questions in a multimedia course and the individual level set for the learner

n=52

	Level 1	**Level 2**	**Level 3**
Mean score obtained on Tasks	76%	84%	78%
Mean score obtained on Questions	79%	81%	87%

The results suggest that learners in general performed equally well on tasks and questions at each of the levels established for them in the student model.

In most cases the initial level set for the in-line tasks matched the level set for the in-line questions. There was however a slight upward drift on task levels throughout the duration of the study. It is interesting to note that there was a corresponding downward drift on question levels as indicated in table 8.8. Help levels remained approximately as they were established at the onset of the study.

Table 8.8

Changes in on in-line tasks, questions and help levels during a multimedia course

n = 48[1]

	Level 1 to 2	**Level 2 to 3**	**Total**
Learners changing upwards **Tasks**	12	7	19
Learners changing upwards **Questions**	6	6	12
Learners changing upwards **Help**	5	4	9
	Level 2 to 1	**Level 3 to 2**	
Learners changing downwards **Tasks**	4	6	10
Learners changing downwards **Questions**	8	11	19
Learners changing downwards **Help**	6	8	14

[1] Data on changes in levels were received for only 48 learners

The co-operative nature of the student model ensured that changes in level took place regularly on demand. There were several instances where students completed a section at a low level and repeated the section at a higher level after negotiation with their tutor.

There was evidence from the users' log files that most changes in level downwards took place early in the course and that changes in level upwards took place relatively later. This is taken to support the view that learners would initially negotiate a comfortable level where they were able to work confidently. Later, they were able to take on additional challenges by raising task and question levels.

There was no corresponding change in the language level and support. Evidently the diagnostic testing established appropriate levels at the start of the course and neither tutors nor students were keen to change the level. There were only two learners who moved from no language support to additional support and none in the other direction.

8.2.7 Focus groups

In the following section, a summary of focus groups conducted at two locations is presented, as described in section 7.4.3.7. The report below is a summary of focus group sessions at both locations.

1 What is your opinion of the Application of Number course?

Students reported that they were satisfied with the multimedia application in general. A range of issues emerged from discussions about the quality of the application. Students felt that the quality of design of the application and the quality of the media was high in the application. This they felt was an important point. Several members agreed that they would have been less inclined to use

the application if it looked 'home grown' or 'unprofessional'. The level of the design and feel of the application was considered to be about right, though some of the animations were a little simplistic for some users. One person commented that some areas were a little "cartooney" and they felt that this lowered the appeal for themselves and possibly some other users. The application was almost universally robust and performed well on the machines upon which it was installed with a few exceptions. One user experienced corruption of video playback which may have been due to a faulty CD-ROM. All users reported that robustness was an important consideration in using the application. Speed of response was also an important issue for all users. Sound had the effect of slowing down some areas of the application which was reported as being a poor feature by some. Sound was disabled by some users who said they could read faster than the sound that was presented. Other users reported that the sound was useful in supporting their reading and were not aware that others thought it to be a limitation. Users concentrated very much on performance of the application and screen presentation in their discussions on quality issues. When the facilitator pursued the issues of quality of learning and the quality of the course in general, users reported that they were satisfied with their experience. Conversation however, would return quickly to usability and design features of the application. This was apparent in both focus group sessions.

Followers of the non-multimedia course (the mirror group) also appeared to enjoy their course and rated it highly at both focus group sessions. There was some dissatisfaction with some areas of both multimedia and mirror courses, but these were emphasised far less than the positive attributes of the courses.

2 Did you follow the course at times and places convenient to you?

The response to this question showed some differences between two locations. Evidently there had been some time-tabling problems at one location which delayed the start of the course and forced sessions to take place at less

convenient times. This did not appear to have any effect on learner's appreciation of the course however. The other group reported that they were able to work flexibly at their own pace. This feature was judged to be important by the tutor present as well as many of the users. Mirror group followers did not report feeling disadvantaged by the less flexible way their course was presented. They did not however report that the additional constraints imposed by less flexible working were beneficial in any way. Multimedia group workers on the other hand emphasised benefits of independent working, including the possibility of going over difficult topics again when they wanted to. All learners valued highly the presence of a person to help them in the form of a tutor or other support staff, though most participants stated that there was not much need for help whilst following the multimedia course.

3 What could be done to improve the interactive multimedia system?

Most comments centred on the presentation of the media, better hyper-linking and small improvements and suggestions about screen layout. There was little mention of the pedagogical content of the course itself from learners. Even when the facilitator asked direct questions about the quality of teaching and learning in the course, discussion was seen to move quickly to issues of presentation of the course. Learners seemed satisfied with the course on the whole, although some bugs were mentioned. There was also mention of other performance issues, including sound speed, speed of screen transitions and video performance. On the whole the course was rated well by participants.

4 Did you feel that the material was presented in the most appropriate mix of text and images for you personally?

This question was intended to approach the issue of the value of individual configuration of presentation according to learners' cognitive styles. There was general agreement that this was the case. One tutor reported that some learners

preferred the Bi-modal configuration, where they could choose between a text-based presentation and image-based. This however may not relate solely to cognitive style. It was the lower ability students who also seemed to benefit from this approach. Students for the most part were unaware of the cognitive style differentiation. Tutors were able to change the cognitive style presentation, based on discussions with students and student progress on the course. For the most part tutors did not change presentation mode, except in the case of some learners who they considered may benefit from a Bi-modal presentation.

.

No students at the focus group sessions reported serious problems with the textual/image content of the materials, indeed all present considered that the balance was about right. To make certain that this question was understood by all, the facilitator was asked to present the group with two direct questions:

5 Were there too many pictures in the course?

6 Were there too many words used in the course?

The response to these questions by participants suggested that the balance of text to images in the course was about right. No participant suggested that there was a poor balance of text to images. In discussion that followed from the questions, some learners reported that images were useful in aiding textual explanations. Other learners emphasised how written and spoken explanations assisted in understanding images and animations.

Many learners considered that the text was a useful addition to the other media, including the images. Mirror group participants reported that images, diagrams and graphs were rarely used in lectures. The interactive use of talk and chalk was mentioned by mirror group participants. Lecturers would often use words and pictures to explain something 'on the board'. This was rated highly by mirror group followers.

7 Did you have trouble understanding the images, pictures or animations?

A few learners considered that the images used in the example assignment sections were not clear. Most participants reported that the images were not explained well enough in this section, for example graphs of survey data.
Two learners identified these images as being their least-liked part of the course, specifying the images themselves, not the assignments. The assignment examples had no specific support for learning styles, This was a requirement of the course, that assignments were presented to all learners in exactly the same way. It is interesting then, that this area was identified as being either more difficult to understand, less enjoyable or an area where the balance of text and image was inappropriate.

8 Which of these was most useful to you in helping you understand the course, text, spoken word, images or videos?

There were similar numbers of participants on the multimedia course reporting that the textual content of the course and image content of the course were most useful in helping their personal understanding. Most participants reported that the video sections of the course were useful to them. These sections of the course were designed primarily to assist the intrinsic motivational aspects of the course. Learners however rated them highly as aids to understanding the course. The benefit of video to express complicated ideas was mentioned by several learners in both multimedia and mirror groups. Mirror group followers reported that only books and handouts were used to support their course. All agreed that the use of video and animation would benefit the presentation of the non-multimedia course. One tutor mentioned that future presentations of the non-multimedia course would contain more diagrams, images and videos as a result of this experience.

9 In what way was sound important in the application for you?

Several multimedia users agreed that the use of sound was important in helping understanding complex ideas. Such ideas were difficult to understand for some learners with just pictures and written text. Hearing explanations was a benefit to these learners. Spoken words with animation was reported as being especially useful, for example, focus groups at both locations almost unanimously considered the use of animation and explanation to be good, especially in the addition and subtraction areas of the course, where this feature was used extensively. Some participants stated that the sound was too slow on occasions and hindered progress through the course. Other learners stressed the help sound gave when dealing with difficult words. The ability to repeat sound was important to some learners. Others emphasised the ability to turn sound off as important. Sound effects were rated highly by most users as adding interest and 'personality' to the application.

10 What was your experience of working on your own?

Independent study and the requirement to work flexibly was perceived as a positive feature of the multimedia course by some learners. Others appeared to enjoy group work and saw working on their own and at their own pace as a negative feature of the course. Mirror group participants considered that the pace of their learning was controlled to a much greater extent than did multimedia participants. They experienced fewer group activities and in general felt that they were working alone. Some participants remarked that working closely and individually with the tutor on the multimedia course made them feel that they were 'taking part in something' and not just on their own. The necessity to attend group meetings and computer sessions in groups for the multimedia course also was reported as removing any feeling of isolation.

11 How difficult did you find the course?

There was fairly common agreement in the discussions that the Application of Number course was quite a difficult course to follow. The multimedia learners tended to consider the course to be easier than did mirror group members. Participants who had not followed the multimedia course expressed less contentment with the course in respect of difficulty than those who followed the multimedia course.

12 What was your experience of working with tutors on the course?

Both multimedia and mirror groups reported that working with tutors was a positive aspect of their courses. It was not possible for the facilitator to draw any negative comments from groups about working with tutors, which may have been ascribable to the presence of tutors in the sessions. Tutors reported that they found working with students to be an important feature of the multimedia application. The facilitator attempted to find out what the most positive aspect of working with tutors was. The opinion of the groups was that tutor feedback was a major factor in this. The participants following the multimedia course rated this slightly more highly than mirror group members. Other reasons cited included the ability to get another 'version' of an explanation. Tutors can 'put things in another way', and tutors will 'keep on until you get it'. One learner stated that they liked the feeling of 'working for someone', rather than just getting marks.

8.2.8 Staff diaries

Staff diaries contained mostly factual information relating to the time, duration and attendance at sessions. The following table presents a summary of the contents of the three staff diaries that were handed in at the end of the study. (Three tutors were unable to provide a copy of their diary). Lecturers' comments and the anecdotal content of the diaries was coded to the categories and variables identified earlier in the open and axial coding stage of the study.

Table 8.9

Summary of information related to the Application of Number multimedia course contained in three staff diaries

	Diary 1	Diary 2	Diary 3
Number of weeks duration of the course	4	6	6
Number of Computer classes reported	8	6	11
Number of students present	5.3	6.4	6.1
Mean duration of class (hours)	1.5	1	1
Number of one-to-one sessions reported	45	106	56
Approximate duration per one to one session (minutes)	15	10	10
Number of group meetings	6	5	4
Mean attendance per group meeting	4	5.2	4.2
Mean duration per group meeting (hours)	0.5	1	1
Time spent setting targets for students (hours per week)	3	7	4
Time spent marking student work (hours per week)	5	4	Not reported
Number of lectures given over course	4	3	6
Mean duration of lecture (hours per lecture)	1	1	1

The data summarised in table 8.9 show that the course was followed quite differently at different locations. Diary 3, for example reported nearly twice as many computer sessions as diary 2, which reports a larger number of one-to-one

sessions than either diary 1 or diary 3. Diary 3 reports a larger number of supporting lectures than either of the other diaries. It is interesting to note the different ways that courses were reported as being followed in these diaries. In the next chapter these results are discussed in the context of influence of the different learning environments on the results of the final study.

8.2.9 Staff interviews

Six tutors involved in the project agreed to undergo an interview at the end of the study, as described in section 7.4.4.2. The results of these interviews are reported below.

1 Comment on the initial needs of tutors involved in the project.

In general tutors thought that the course was well-organised and that the level of organisation was high from early on, in the training period. Two tutors expressed some concern that the level of initial support might not always be as high in future multimedia courses. The training programme was rated highly by all tutors. Three would have preferred more sessions and two tutors would have welcomed the opportunity to design the training themselves. In this way the content would have been directed more at individual teacher's needs.

2 How well were students prepared prior to the course?

Three tutors felt that students were well-prepared for the course in terms of IT skills. One tutor felt that there needed to be specific IT study skills support for students following multimedia courses. This should include note taking, searching and presentation of information. There was some concern that learners were browsing rather than learning and that students should have more initial preparation for this type of work. All tutors agreed that appropriate study skills would become more widely available as this type of course became more common.

3 What was your attitude to configuring the student model?

All tutors stated that configuring the student model became easier as they became more used to the process. Most tutors felt that the tools provided were too 'technical' and the process would have benefited from more automation. No tutor felt that configuring the student model was very difficult, though it was universally stated as being time consuming. Better automated systems would be required if similar systems were adopted universally. The learning styles and language tests were mentioned as being positive for the students and also mentioned as a positive feature to focus staff on good practice. Configuring task, question and help levels was more difficult. Trial and error was cited by three tutors as the method used to establish the initial values of task, question and help levels. Three tutors devised their own tests to assist in the process. All tutors were happy that the learners were following the course at the most appropriate levels, after some initial re-configuration. The ability to re-configure the levels was mentioned by all tutors as being a benefit.

4 What problems did you encounter as you followed the course?

No really bad experiences during the implementation stage of the study were expressed by tutors. The main problems were applications not installed correctly (two tutors) and network problems affecting initial logging in (two tutors). These problems were solved in all cases before learners used the application. Four tutors were concerned that in future projects, the level of support during implementation might be less. Two other tutors were satisfied that the level of support was likely to increase as the frequency of such courses increased.

5 What was your opinion of the Application of Number course?

Tutors considered the Application of Number course to be of high quality. When pressed on the quality of the course compared to commercial alternatives, five tutors considered the Application of Number course to be superior in terms of the learning opportunities it presented. One tutor expressed the opinion that the ideas it contained might provide a template for other courses. The Internet was mentioned by four tutors and comparison between the multimedia course and Internet courses was made. These tutors expressed a preference for this type of course over similar Internet applications. Speed, content, interaction, quality of the media, level and the potential for individual configuration were mentioned as positive benefits of this type of course over Internet delivered courses. One tutor declined to provide a comparison, as the issues involved in comparison were complex and not fully understood by them. The possible benefit of browsing in Internet applications was mentioned by one tutor. The Application of Number course was not considered by them to provide a similar opportunity.

6 What was the effectiveness of the co-operative approach to the student model?

Tutors were in general agreement that the student model approach led to improved performance on the course. Three tutors reported that they considered this to be due to specific pedagogical features of the application, such as the emphasis on language level and cognitive style differentiation. All tutors agreed that setting task and question levels improved performance, yet two tutors considered this to be 'lowering standards' or 'dumbing down'. Four tutors did not agree with this view. Two tutors put forward the idea that by differentiating the question and task levels, rather than lowering standards, students gained confidence following the course and the overall standard of the 'final product' was increased. One tutor noted that the final assessments were not differentiated in this way and it is was these that establish the academic standard of the course. All tutors reported that, in their opinion, learners had done as well or better on average than mirror groups or previous years' cohorts in the final assessment.

One tutor noted that the supporting evidence provided by students doing lower level tasks was less well-presented and organised than those set at the higher task levels. This was not reported by other tutors.

Tutors were in general satisfied with the co-operative approach adopted in the course. Tutor involvement in establishing the levels of students, setting targets and off-computer activities were cited by all tutors as being positive features of the application. Time was cited as the major limitation of the approach by all tutors. One tutor noted that setting and supervising group tasks was a problem with small groups, since there were often not enough students at higher task levels to take on leading roles. This was mentioned by another tutor who on occasions had to play the role of group leader herself for some sessions. It was generally agreed that as group size increases in the future, group tasks will become easier to organise, but probably more difficult to manage. It was a general view that more help would be required in the future, in the form of learning centre staff and additional tutorial staff. Students in general were reported as taking the group and individual tasks seriously and performing them in a well-motivated way. One tutor felt that he would prefer to write some of the tasks himself or at least to have more control over the process of creating tasks.

Co-ordinating target setting and monitoring even a few students was cited by four tutors as being a problem. It was generally agreed that more tools should be available within the application to monitor progress and set targets for learners. Time was again considered by most tutors to be a major consideration or limitation.

7 What were students' attitudes to the course?

These were reported as being better than on other courses by three tutors, and approximately the same by three others. No tutors felt that the multimedia method led to a decrease in motivation or to worse attitudes than on normal

courses. Tutors that mentioned an increase in motivation ascribed it to the quality of the materials (3 tutors), individual configuration (2 tutors), task-based learning (2 tutors) and flexible learning (2 tutors). Two tutors expressed a pessimistic view of students' attitudes in general and noted that it was difficult to be sure that students were actually following the course in the prescribed way in their institutions, until some time later when log files were ready to inspect. This was a feature of independent learning in general and the network systems at their locations rather than being features of this multimedia course in particular. All tutors agreed that the multimedia course had adequate methods of tracking student progress, even if results were sometimes delayed.

8 What was you attitude to following the course?

To the question 'How would you best describe your attitude to a) multimedia in general and b) this course in particular? three tutors reported a positive attitude both to the multimedia materials and to the course. Two were neutral to both and one person was slightly negative to multimedia in general yet positive to the course specifically. Task features, constructivist learning and individual configuration were most often cited as being positive. Language level, cognitive styles and differentiation were mentioned by two interviewees as contributing to the quality of the application. Job security, the threat of new technology and cost cutting were most often cited as negative influences on attitudes. Job security was mentioned by all six interviewees as an important concern. Three tutors saw the positive benefits of skills in new areas of educational technology, two were neutral to the potential threat and opportunity, while one tutor considered the threats to outweigh the opportunities. Reasons for negative attitudes to the application were almost always related to the learning or social environment and not to specific features of the application itself, or indeed how the application was used. Positive features mentioned almost always related to the application itself or its use.

9 What was your experience of the management of the process?

The main limitation of the management of the process was cited by five tutors as being lack of time. One tutor emphasised the need for training in new methods of managing learning with new educational technology. On the whole, tutors were satisfied that the process had been managed well, given the constraints imposed by lack of time. All tutors valued the necessity for tutor involvement in the management of the learning process. This was considered to be an important feature by four tutors. Comparisons were made by two tutors with other similar multimedia courses which largely excluded the tutor from the process. 'In that course all we had to do was collect in the marks', stated one tutor about a similar CD-ROM based experience. The question of assessment in general was a concern of one tutor who considered that the requirement for students to perform final assessments off-computer was important. This tutor considered however, that this may not be the case for long and that there would be an increasing demand for on-computer final assessments in the future.

Other positive features of the management of the learning process was the provision of tutor tools within the application. This included summaries, overviews and objectives. An overall structure of the application was provided which three tutors mentioned using. The overall structure provided links between the application, assessments and the performance criteria for the course. This was cited by those tutors as being an important feature of the application.

10 What suggestions would you recommend for improvements in the system?

Again tutors frequently mentioned time as being a limitation of the whole process. Improvements suggested often involved time saving devices such as automatic progress print-outs for the entire group and methods of configuring the student models for groups of learners.

There were many improvements suggested for the course itself, ranging from bug fixes and a few typographical errors to changes in methods of explaining principles and processes. Many of the issues addressed at the formative stage of the development of the application reappeared here. The difficulty of creating materials for general use was often mentioned and all tutors expressed a desire to be able to change or customise features of the material themselves.

11 Please summarise your experience of the course.

Asked to summarise in a few words their experience of using the application, the following responses were obtained:

1 "Interesting"
2 "I will consider using this type of approach again in the future"
3 "An interesting experience which I enjoyed immensely"
4 "This is the future and I suppose I'd better get used to working this way"
5 "The student model approach used in this way is the intelligent use of multimedia"
6 "I always felt part of the course, unlike other multimedia and Internet things I've used which take over control"

8.2.10 Staff report

Tutors provided a summary report at the end of their work. This report was presented in two parts, the first of which followed a set structure, and the second of which was free-form as described in section 7.4.4.3.

The structured part of the report was divided into three sections, multimedia, the student model and learning. This was intended to focus the reports into areas

directly related to important categories identified in the preliminary open and axial coding stage of this work.

Tutors were also asked in their reports to provide a list of their main activities in the course. The following list is a summary of the main activities tutors undertook on the course.

- Induction of learners
- Introducing learning sessions on the computer
- Managing learning sessions
- Giving lectures
- Setting up and adapting the student model
- Organising group work and taking part in group activities
- Assessing learner progress
- Acting as an expert - providing additional scaffolding and help
- Motivating and encouraging
- Meta-level activities, for example, placing into context
- Assessing evidence and final outcomes
- Recording progress
- Setting targets and monitoring progress against targets
- Marking off computer activities
- Day to day administration of the course

In the following section, summaries of the main points made in six staff reports are presented under the headings and sub-headings provided for tutors for the first part of the report. The free-form part of the report which included general comments and anecdotal evidence was subjected to detailed analysis and later coded to the categories and variables identified in earlier stages of the study. Issues that arose from the anecdotal data are discussed in chapter 9 of this work.

8.2.10.1 Multimedia

The objective of this section of the report was to find out whether the use of a multimedia application was perceived by tutors to be important in their delivery of the Application of Number course or not. The results of this section are presented below summarised under the headings provided in the guidelines to the report.

1 What were the advantages of using multimedia in delivering learning on the Application of Number course?

All tutors reported that they found the motivational aspect of the multimedia system to be important in the course.

Five of the six tutors emphasised the opportunities presented by the use of a rich multimedia environment in the presentation of ideas in different ways as enhancing the learning experience provided by the course. One tutor reported that providing information in a range of different ways led to greater interest and possibly better performance on the course. This included the use of high quality animation sequences with commentary, (reported by four tutors as being important) and the use of images and video in presenting complex ideas. Animated graphs, charts and tables were mentioned by three tutors as being useful in aiding explanation.

The quality of images and video was emphasised as was the 'professional' look of the application which one tutor reported as being 'unexpected'. The use of the multimedia simulations in the example exercises was seen as a positive use of multimedia by three tutors.

All tutors mentioned the use of sound and video in their reports and in general it appeared that this was viewed highly in terms of quality and the use to which it

was applied. The use of sound specifically was reported by five tutors as being important for learners with poor language skills.

Finally, differentiation of learning, the provision of fast paths and the provision of additional help and support were mentioned as being an important advantage in all reports.

2 What were the disadvantages of using multimedia in delivering learning on the course?

Tutors' reports were divided over this question. Three tutors reported that there were no disadvantages in the use of multimedia in their delivery of the Application of Number course. Three others tended to stress some rather general negative features related more to the disadvantages of distance learning than the use of multimedia *per se*. For example, two tutors stated that isolation was a disadvantage in using multimedia, though it was evident from the context that this was a general concern and did not relate to following the Application of Number course. One tutor noted that multimedia was a teaching tool like any other and its use on this course was well considered. Two tutors discussed the general use of multimedia in learning and emphasised general abuses, rather than the specific use of it in this course. Other disadvantages were mostly of a technical or management nature, including the possibility of systems failing, the need for costly equipment and training.

3 Please comment on the technical support provided for you in supporting the delivery of the course, explaining how this influenced the quality of the course

Tutors in general were concerned about the level of support required to undertake such courses. The perception of the quality of the support available for the delivery of this course was high in five reports and adequate in the other. Concern was expressed that this may not always be the case, should resources

become stretched due to excessive demand. All tutors noted this potential problem.

Other disadvantages included the need for high-quality computers in order to make use of the application. This was considered to be an important factor by one tutor who reported that this was a problem outside of time-tabled hours in their location. Another tutor along a similar theme noted that their staff room machines were not able to play the multimedia courses and that this presented problems with individual work with students and also with learning the applications themselves. The provision of staff facilities was reported as a concern in three reports.

4 Please summarise your experience of delivering learning in this way on the Application of Number course.

Five of the six reports provided summaries that were positive about the experience of working with the course. One report described a neutral or slight negative experience of the course. Positive summaries described the experience as being demanding, time consuming, yet interesting. The negative report, although not critical of the multimedia application itself, described an experience that was centred in an environment that failed to provide support for their work in some areas. The issue of the importance of a supportive environment will be discussed further in chapter 9.

The involvement of tutors in all stages of the process was also emphasised as being a positive feature. Language and cognitive style differentiation were emphasised as important features of the application by all reports. The use of task and question level differentiation was more equivocal. Although all tutors valued the task-based, assessment-led approach, there were some comment in three reports that this might present problems with the quality of the course or the value of the qualification.

8.2.10.2 The student model

Some features of the student model approach were transparent to students taking part in the course. The requirement to set task, help and question levels co-operatively was presented to students as integral to the target setting process. Language level and cognitive style were configured based on testing prior to starting the course. As this part of the process was not directly visible to students undertaking the course, the views of tutors involved in this process was therefore central to understanding the effectiveness of the approach. The following sections of the report were intended to establish tutors' views of the student model approach.

5 How important was the use of a configurable student model to students following the course?

Some tutors reported that in the initial stages of the project, there was some concern as to the student model approach and the requirement for automatic configuration of the presentation of the course. It was reported that tutors' views of the student model approach changed over the duration of study by three tutors, becoming more positive. The co-operative approach was cited as being the reason for this. One tutor had a previous negative experience of an Intelligent Learning System where configuration was automatic for learners. The co-operative student model used in this course was rated as being more useful and 'more accessible' by this tutor. Three tutors felt that the student model approach was not the most important feature of the application, stressing the interactive multimedia as being more important. Two of these three reports were positive about some aspects of the model however. Only one tutor disliked the approach in general, though even this report valued the co-operative approach and requirement to involve tutors.

6 What were the most useful variables in the student model?

Two tutors cited task level, two tutors cited question level, one tutor cited language and one tutor cited cognitive style.

7 What were the least useful variables in the student model?

Task and question levels were cited as being the least useful by two of the six reports. Cognitive style was cited by three reports and language level by the other.

8 What if any additional variables might be added to the student model in the future?

Five reports contained suggestions for additional variables that might be added in future. Other cognitive styles were suggested in four reports, consisting of surface-deep (1) and serialist - wholist (3). Two reports suggested the use of additional language features in the student model, including more control over sound presentation and a picture glossary. One report suggested the incorporation of IQ, age, gender and special learning needs in the model.

8.2.10.3 Learning

9 Please report on the learning experience provided by the Application of Number multimedia course.

Reports were in general positive about the learning experience provided by the application. Individual target setting and the task based approach were rated highly in general. The ability to configure the question and task level was cited by tutors as important in the target setting process. The need for tutor and student involvement in this activity gave a measure of control of the learning

process for some tutors. This feature of the individual configuration of the application, however, was perhaps the most controversial for most tutors. Two tutors expressed some concern in reports over the requirement to establish lower level tasks and questions for some learners. It was important for them, that this was a lowering of standards for the course. Tutors' involvement in the configuration of this descriptor was therefore seen to be especially important. Despite these reservations by some tutors related to establishing differentiated task and question levels, the *process* of doing this was seen as being a positive feature of the course by all tutors. The configuring of tasks and questions and its influence on tutors' attitude is discussed more fully in chapter 9.

The use of multimedia was cited as contributing to the quality of the learning experience provided. Flexible learning and the availability of help on demand, working at the learner's own pace and differentiation were all cited as benefits to the learning process. Three reports mentioned the positive benefits of students controlling their own learning and the necessity for them to understand learning objectives.

The need for new skills to make the most of the experience was stated to be important by three tutors. Required new skills included technical skills related to setting up and using multimedia applications, skills related to managing a flexible learning experience with a student model approach and skills related to creating and authoring similar applications in the future.

8.2.11 Expert Review

The results of the expert review described in chapter 7 are given in table 8.10 below.

Table 8.10

Expert review of the learning application

n=4

AREA 1 - INSTRUCTIONAL DESIGN REVIEW	Mean score / 5
This application provides learners with a clear knowledge of the program objectives.	3.75
The instructional interactions are appropriate for the objectives.	3.75
The instructional design was based on sound learning theory and principles.	4.25
The application was constructivist in its design	4.00
The feedback in this application is clear.	3.50
The pace of this application is appropriate.	4.25
The difficulty level of this application is appropriate.	4.25
Cognitive overhead was low.	3.25
The application was task based.	4.25
The application was vocationally centred.	3.75
Help provided was good and at the correct level.	4.50
The use of language in this application was appropriate.	4.50
On-line questions and tasks were good.	3.50
Off-screen activities were well planned.	3.75
The application was differentiated.	4.50
The application was individually configured.	4.50
AREA 2 - SCREEN DESIGN REVIEW	
The screen design of this application follows sound principles.	3.75
Color is appropriately used in this application.	4.00
The screen displays are easy to understand.	3.75
Video and animation was useful.	3.75
Screen layout was simple and effective.	3.50
The application displayed high-quality design features.	3.75
The use of sound was well-planned.	4.25
AREA 3 - PROGRAM USABILITY REVIEW	
This application operated flawlessly.	4.50
Navigation was simple.	3.75
Orientation was simple.	4.00
Searching for information was easy.	3.50
The application response times were fast.	3.25
Logging in and out was flawless.	5.00
Creating new users was efficient.	3.75
Configuring the student model worked well.	3.75
Data handling worked well.	3.50

The results of this evaluation are taken to support the view that the application was usable, well-designed and incorporated sound pedagogical features.

8.2.12 Staff reports on the attitude and central role of the institution to information and learning technology (ILT)

The following instruction was included in the staff report guidelines as described in section 7 and presented in Appendix 24.

Please comment freely on the attitude of your institution to the following issues as they relate directly to the integration of information and learning technology.

- Philosophy of your institution to ILT
- Philosophy of your institution to flexible/open/distance learning
- Your institution's attitude to cultural change
- Provision of support by your institution for ILT
    - Staff training
    - Technical support
    - Provision of hardware
    - Provision of software

Staff reports on the above were rated by an expert on a scale 1-5, where 1 indicated a report of a negative or not-supportive institution and 5 indicated a positive or highly-supportive institution.

Table 8.11 below presents the results of this rating exercise at the 6 locations involved in the study.

Table 8.11

Staff reports on attitude of institution to the integration of information and learning technology (ILT)

Location	Score rated from reports at 6 locations 1-5 scale 1	2	3	4	5	6
Question						
Philosophy of the institution to ILT	2	3	4	5	4	5
Philosophy of the institution to flexible/ open/distance learning	2	3	5	4	3	5
Institution's attitude to cultural change	1	3	4	3	3	4
Provision of support						
Staff training	2	5	4	4	3	4
Technical support	4	3	2	3	3	3
Provision of hardware	3	2	4	4	3	4
Provision of software	3	3	3	5	3	4

Staff were also requested in their reports, to provide information on the central role of the institution in information and learning technology (see Appendix 24). The responses of staff were rated by experts on a scale 1-5, where 1 indicates the absence or poor implementation of the feature and 5 indicates that the feature is present or implemented fully. Table 8.12 presents a summary of staff's perceptions of the central and local support systems provided by the organisation for ILT.

Table 8.12

Staff reports on the central role of the organisation in information and learning technology (ILT)

Location -	1	2	3	4	5	6
Whole institution approach to ILT	2	5	5	4	4	3
Stated ILT policy	1	5	5	5	5	5
Top-down approach	2	4	4	3	4	2
Bottom-up approach	4	3	3	4	3	4
Support for individuals	2	3	4	3	4	5
Support from centre	2	3	3	3	4	3
Evolutionary approach	3	2	4	5	3	3
Revolutionary approach	2	4	2	2	3	3
Supportive atmosphere at work	1	3	4	4	3	4
Shared goals	1	3	3	3	4	3
Dissemination of achievements	2	4	4	3	4	2
Perception of success	1	3	3	3	3	4
Effective point of contact	2	4	3	5	4	5
Individual approach to ILT	3	3	4	3	4	4
Team approach to ILT	2	2	2	5	4	3
ILT integrated into existing courses	2	3	2	4	3	4

The information provided here was used to assess the nature and type of ILT environment provided by the institution. This was related to the quality of the learning experience provided, as described later in chapter 9.

8.3 Conclusion

A large amount of information was collected in the evaluations of the final study. In the previous section these data were presented and discussed in the context of the individual evaluation. The aim of the final study was to present an overview of whether or not a multimedia application configured for an individual learner, using a student model approach, was beneficial in the delivery of effective learning. In the next chapter evidence from all the evaluations of the