Report of a pilot study of individually configurable multimedia learning prototypes in the development of a co-operative student model of learner characteristics.

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Abstract

This paper describes the design, implementation and evaluation of a set of individually configurable multimedia prototypes that use a simple model of the learner to configure the presentation of learning. Participants in the study were students in a Further Education college following a range of courses. Student models were established for learners, based on diagnostic testing and also in co-operation with tutors.

The simple student model was developed to hold information on individuals' language skills, cognitive style and also on the level of help and scaffolding provided for learners and the level of tasks and questions with which they were challenged throughout the course.

A mixture of qualitative and quantitative research methodologies was employed to investigate the effectiveness of this approach in he delivery of the multimedia based courses. Findings from the study are presented and discussed from the point of view of the tutor, the learner and the systems necessary to support the use of individually configurable learning materials in the curriculum.

The implications of these results for the design, delivery and evaluation of individually configurable multimedia courses in general are discussed.

1 Introduction

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

One can understand the concerns of Hartley, since both CAL and AI have promised much to education, yet perhaps have delivered less than expected. However, recent advances in the power of the computer have seen corresponding developments in both areas, with the advent of interactive multimedia learning applications and Intelligent Tutoring Systems (ITS).

The research presented in this paper was motivated by concerns such as those of Hartley and also by a need to deliver effective learning in Further Education (FE) colleges. Open and Distance learning initiatives have been proposed as a method of delivering effective learning. These often rely on the application of new educational technologies, such as multimedia or the internet. This solution, although much vaunted and valued, has been less than effectual in changing outcomes for some groups of learners. Nonetheless there has also been a perception of increasing demand for ILT based solutions (Tergan 1997).

Multimedia is capable of providing a rich environment, ideal for the delivery of effective learning according to some authors. AI has been used to configure the presentation of information depending on the specific requirements of an individual user of an application. A model of user characteristics, a student model, is sometimes used to assist in configuring the presentation of information for the individual (Milne et al, 1996).

The term, 'student model' is used here to mean a special form of user model in the area of CAL according to Vassileva (1996). The term is used in this paper to mean the representation of characteristics of the learner in a form which is useful within a multimedia computer application to configure and control presentation. This usage is referred to as a 'global description' of the student (Ohlson, 1993), and may be contrasted with other types of student models based upon models of students' knowledge in the domain, overlay models (Vassileva, 1996).

The research presented here was undertaken in order to bring together the distinct methodologies of student modelling and multimedia and to investigate the usefulness of the approach in the development of a multimedia CAL application. The main bulk of the research took place in a college of Further Education (FE), although several other colleges and training institutions were involved in the evaluation of prototypes. This paper therefore, describes features of the design, implementation and evaluation of components of a simple model of the learner, a student model, used to configure CAL prototypes for use in FE.

2 Components of the student model.

In this section, the components of the student model under development are given and evidence for their efficacy is presented. The components of the student model are descriptions of characteristics of the learner. The following descriptors were used in the prototypes described in this paper.:

- Language level
- Cognitive style dimension
- Task level
- Question level
- Help and scaffolding level

In the first part of this paper two pieces of experimental work are presented which investigate the effectiveness of language and cognitive style as candidates for inclusion in a student model.

In the latter part of the paper an attempt to represent the level of cognitive skills possessed by learner within the student model is presented. To this end, task, question and help/scaffolding differentiation are assessed as potential descriptors within the model to represent the cognitive level of the learner.

Table 1 below, shows student characteristics and the type and range of descriptors used in the student model prototypes developed in this research.

Table 1

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

Student characteristic	Student model descriptor
Language level	0 Additional support / Low level text and narrative 1 No additional support / Higher level text and narrative (Barker et al 1999)
Cognitive style	0 Verbaliser 1 Bi-modal 2 Imager (Riding 1991a; Barker et al 2000)
Task level	0 Level 1 task 1 Level 2 task 2 Level 3 task (Bloom, 1956; Barker 1997)
Question level	0 Level 1 question 1 Level 2 question 2 Level 3 question (Bloom, 1956; Felder and Brent, 1994)
Help system	0 Low entry point 1 Standard entry point 2 Highest entry point (Minsky 1986)

Each descriptor is presented in the table with the range of levels at which it was configured within the prototype applications. References given in the table refer to details of research presented elsewhere that supports their inclusion in the student model. The nature of the descriptors and how they were used in the student model is presented in the following sections.

An important feature of the research was the method used to configure and adapt the student model. Often configuration and adaptation of student models is performed completely automatically, based either on measured learner characteristics, or on performance by the learner within the

application. In the student model being developed here, configuration and adaptation were performed in part by the tutor in co-operation with the learner. The effectiveness of this approach and some implications of the overall approach, including group working, are discussed in the final section of the paper.

In the next section, the results of two experiments are briefly presented. The first experiment investigated the effect of language support on performance in a multimedia application. The second experiment looked at how a learner's preferred cognitive style was related to performance in a multimedia application when their cognitive style was matched or mismatched to the presentation mode of the application. The potential of language and cognitive style as descriptors in a student model is discussed in the light of these results.

2.1 Language level experiment

The aim of the language experiment was to establish the importance of language as a global descriptor within the student model. Full details of this investigation are given by Barker and colleagues (1999). The following is a brief summary of the findings.

The experiment investigated how performance in a multimedia learning application was related to the level of language support available for learners following a multimedia learning application. Teachers from a College of Further Education, National Vocation Qualification (NVQ) level 2 catering students and Higher National Diploma (HND) catering management students took part. After a language and subject pre-test, participants were randomly assigned to presentations of a multimedia catering course having either full, or no additional language support available. Immediately after completion, a post-test and two weeks later a re-test were taken. Difference in post and re-test performance in these applications was related to the language skills of the users and the amount of language support given.

Details of participants and the language support provided for groups are displayed in table 2 below.

Table 2

Additional language support, age and language test scores

Sub Group	Additional Language Support Given	N	Mean age	Age Range	Mean Language test score
NVQ a	None	16	18.3	16-23	62%
NVQ b	Full	16	17.4	16-22	57%
HND a	None	16	19.0	17-25	81%
HND b	Full	16	19.5	17-22	80%
Staff a	None	10	29.2	23-47	94%
Staff b	Full	10	29.8	23-45	92%

2.1.2 Method

The following is a brief summary of the method used in the experiment. Full details of the method are given by Barker et al (1999).

- Initial language assessment test was undertaken by participants
- Initial subject pre-test undertaken
- User configuration file created prescribing amount of language support provided
- Course followed with prescribed language support
- Post test undertaken by all subjects after finishing the course
- Evaluation of the application by users
- Re-test taken two weeks after finishing the course.
- Data collected and analysed

The results of the experiment are shown in table 3 below.

Table 3

Mean Pre-test, post-test and re-test and user evaluation scores
For participants following the multimedia course.

Group Possible Score	N	Pre Test (30)	Post Test (30)	Re Test (30)	Evaluation. (5)
NVQ a	16	11.13	14.44	12.5	3.25
NVQ b	16	12.13	18.56	14.38	3.68
HND a	16	15.81	21.44	18.25	3.32
HND b	16	16.06	19.94	17.69	3.10
Staff a	10	14.50	20.3	17.1	3.20
Staff b	10	16.60	22.6	18.5	3.10

2.1.3 Summary of the results

- An ANOVA performed on the data presented showed significant differences in performance between groups.
- All groups had significant improvement in performance between pre-test and post-test.
- Some of this improvement was lost by the time re-test occurred
- Post hoc analysis showed that there were significant differences between NVQ groups with and without additional language support.
- Groups showed no significant difference in performance when their language skills were good.

2.1.4 Implications of the findings

- Language differentiation is effective when users skills are poor, but not otherwise.
- In multimedia we need to consider many of the assumptions we make, concerning the relative importance of text and image in the interface
- There may be implications for the internet and the way we present textual information

- There are wider implications for learning and the way we use language to present information

- Language is an important candidate as a descriptor for inclusion in a student model of learner characteristics.

2.2 Cognitive styles experiment

This experiment presents an investigation into the relationship between a learner's cognitive style and their performance on a multimedia application. An application was designed to present information in learners' preferred and non-preferred cognitive style and then to test their performance by means of a simple recall test based on information contained in the application. The experiment was based on Riding's Verbaliser / Imager cognitive style dimension (Riding 1991a). Differences in performance were recorded between Verbalisers, Bi-modals and Imagers in areas of the application where the presentation format either matched or mismatched their individual cognitive style.

2.2.2 Method

The following is a brief summary of the method used in the experiment. Full details of the method are given by Barker et al (2000).

- Participants were tested using Ridings (1991b) Cognitive Styles Analysis (CSA test) and assigned as Imagers, Bi-modals or Verbalisers depending on their score.

- Participants followed a multimedia application where the presentation format alternately supported (matched) and challenged (mismatched) their preferred cognitive style

- Performance in simple memory tests at the end of each section of the application was related to their cognitive style

Table 4 below presents characteristics of participants undertaking the learning styles and multimedia experiment.

Table 4
Characteristics of participants undertaking the learning styles and multimedia experiment.

Number (n)	Male To Female M/F	Age range	Average age	Wholist Analyst (WA) Range	Verbaliser Imager (VI) Range	Mean language test score %
51	1.43	16-21	19.3	0.67-1.8	0.72-1.87	78.2%

Table 5 shows scores obtained in supported and non-supported sections of the course for Verbalisers, Bi-modals and Imagers.

Table 5

Scores obtained in supported and non-supported sections of the course for Verbalisers, Bi-modals and Imagers.

Group	N	Mean VI score	Mean score Supported	Mean Score Non supported
All participants	51	1.28	64.7	62.0
Verbaliser	17	0.87	66.3	61.3
Bi-modal	17	1.27	62.9	65.2
Imager	17	1.60	64.6	61.0

2.2.3 Summary of the results

An ANOVA performed on the data presented in table 5 showed significant differences in performance between supported and non-supported areas of the course. Learners performed significantly better when information was presented in a way that supported rather than challenged their individual cognitive style.

This was apparent only at the extremes of the cognitive style dimension and was only significant when Bi-modal learners were excluded from the analysis.

Bimodal learners showed no difference in performance for presentations supporting either cognitive style

2.2.4 Implications of the findings

- Cognitive style differentiation is effective in influencing performance on a multimedia application when users are located at the extremes of Riding's Verbaliser/Imager cognitive style dimension.

- Cognitive style is an important candidate as a descriptor for inclusion in a student model of learner characteristics.

2.3 Task, question, help and scaffolding level differentiation

In order to study how a learner's cognitive skills may be modelled and held in a student model of learner characteristics, four multimedia courses were developed for use in this study. It was intended to use these to investigate how tasks, questions and the level of help/scaffolding provided could be used within a student model of learner characteristics.

The courses developed for this work had several significant features which were important for the study. Firstly they were centred around the use of tasks and questions, rather than the more traditional multimedia courses that delivered large amounts of information to the learner. Information was provided in these prototypes in a form mostly to support learner activities. Secondly applications provided different routes through the course for individual learners, depending on tasks and question level being followed.

Constructivist theories of learning have been described as 'subjective construction of meaning from experience in specific contexts' (Somekh, 1996). Participation in active learning tasks is seen to be important in such a constructivist view of learning (Grabinger et al, 1997; Park and Hannafin, 1993). Tasks provide a means of engaging student's attention, and users of computer-based instruction packages are therefore commonly required to interact with the material. Frequent decision points are important as are games and simulations in which the results of decisions can be immediately seen (Atkins 1993). The use of tasks and questions in constructivist learning is seen as important (Barker et al, 1997a).

It has been suggested that the task of building computer models may provide direct support for the construction of mental models. Wild (1996), and Khan and Yip (1996) see tasks involving free exploration and self-directed learning as important for the testing of such models. Khan and Yip suggest that for maximum effectiveness, task-centred instruction should be situated in tasks where knowledge is normally applied. The use of tasks to develop higher level cognitive skills in learning has been considered in the classroom by Felder and Brent (1994). Passive learning and an algorithmic approach to problem solving were cited as the among the reasons for high drop-out rates

in science courses. In-class exercises investigated as an alternative approach included recall, stage setting and problem solving, and provide inspiration for the development of tasks for incorporation in multimedia learning packages. The use of questions also is important in developing good approaches to learning according to Felder and Brent (1994). Questions may range from simple multiple choice selections testing recall of simple information, to tests of the organization and structuring of complex ideas. Felder (1993) describes how questions can be used in a range of ways to motivate learners by providing interesting challenges.

On the basis of work such as that described above, it is suggested that the appropriate use of tasks and questions in the design of learning applications is likely to be important. It was considered important to test this assumption in the exploratory study and to investigate how it might be applied to a differentiated multimedia prototype that was individually configurable. Many types of tasks could be used in the design of multimedia learning applications ranging from simple on-screen point and click activities to complex tasks involving groups of learners, taking place away from the computer. The importance of learner control and differential paths in interactive multimedia learning materials has been emphasized by Stoney and Oliver (1998). The ability of learners to construct their own paths through the material leads to increased motivation, engagement and supports the possibility of learners working at their own pace and level according to Stoney and Oliver. It was important to gain experience in the design and implementation of task based, differentiated learning materials.

2.3.1 Development of the materials

Multimedia learning applications were developed for this exploratory study using methods described by Barker and colleagues (1997b). The following materials were produced:

Catering studies:	6 NVQ units at foundation level (Horizon project)
Business studies:	4 NVQ units at level 2 (Horizon project)
Key skills:	1 unit for 'Application of Number' level 1
English Law:	1 unit for GCSE Law.

These materials were created as interactive multimedia applications, based on a single template. An iterative rapid application development method was used (Rushby, 1997; Preece, 1994). Pedagogical features to be included in the template were agreed within development teams as described by Barker and colleagues (1997b). The template was based upon a simple hierarchical structure that allowed learners to navigate freely between areas of the courses. Simple navigation, orientation and location tools were provided based on the recommendation of Allinson and Hammond (1990). Each area of the course had information to be presented, tasks, questions and review screens. The intention of these was to engage and involve the learner and also to be able to assess learner progress through the material. All

navigational data and results of tasks and questions could be saved to file for individual learners.

2.3.2 Differentiation of materials

Materials were differentiated according to the level of task available and the type of questions presented. Tasks at different levels were defined in relation to Bloom's taxonomy of learning levels (Bloom 1956) in which the first three levels are:

Level 1 - Knowledge: Fact recall with no real understanding
Level 2 - Comprehension: Ability to grasp the meaning of material
Level 3 – Application: Ability to use learned material in new situations.

Level 1 tasks and questions thus involve simple reproduction of the knowledge. Greater challenge was required to perform level two tasks. Comprehension of the material involving translation, interpretation and extrapolation was needed according to Bloom (1956). Level 3 tasks and questions involved the application of knowledge to practical situations. Tasks were implemented in several ways within the applications. Simple tasks involved pointing and clicking (or touching the screen), dragging and dropping and similar computer mediated activities. More complex tasks often involve thinking time, group activities away from the computer and involvement of tutors and work supervisors. Tasks and questions for use in the applications were written by subject experts at the three different levels described above. Some examples of tasks and questions, at the three levels, that were used in the multimedia materials are given in Appendix 1.

2.3.3 Procedure

The applications were installed on computer networks for use in open access learning centres in the college using standard multimedia computers with sound and video capabilities. Subject groups and tutors were given standard brief introductory talks prior to first use of the system. Tutors were given some additional help with the use of the materials with their groups. This included the constructivist use of the materials, working in groups, motivating students, the use of tasks and questions and how to situate the use of materials in context. Help was also provided in configuring the materials for individuals, setting task and question levels for individual learners and accessing user data. In all, 36 learners took part in the exploratory study as shown in table 6 below.

Learners followed the materials under the direction of their tutors. Studies lasted from 1 or 2 weeks for the GCSE Law course, to 26 weeks for the Catering NVQ foundation level applications. At stages throughout the course and at the end of the courses, tutors and students were asked to complete questionnaires and to participate in group discussions with designers and

sometimes tutors. Written reports and summaries were made of these meetings. Tutors also completed a short report on the use of the software with particular reference to the underlying pedagogy used in the development of the materials. Data was collected from user log files throughout the duration of the exploratory study. This was used mostly to uncover problems in navigation and usability.

2.3.4 Results

It was not possible due to the nature and size of the projects, to test the significance of the statistical analysis presented here. This is because the studies were small scale and much of the evidence obtained was qualitative or anecdotal. Despite this, a great deal of useful information was obtained from the study which is discussed in the following sections under the headings, User satisfaction, Usability, Pedagogy, Performance and Tutor attitude to the material.

2.3.4.1 User satisfaction

In general the multimedia learning materials were rated highly by the students. This contrasted with ratings for other similar materials in use at the same time by the students. These materials were either developed commercially (i.e. bought in), or developed internally but not individually configurable. For example, learners undertaking the catering courses consistently rated the differentiated materials higher than the Essential Food Hygiene CD ROM (Donaldson and Barker, 1995a; 1995b) in use at the same time. This application was developed in similar ways to the NVQ material used in the exploratory study, but it was not individually configurable. Ten learners following the NVQ Food Hygiene option were asked to place the applications and a traditional lecture in order of preference. All preferred the NVQ application to the Essential Food Hygiene application. The reason for this difference in preference was probably due to the fact that the NVQ application contained a far greater amount of task and question level differentiation. In most other respects the applications were very similar, though based on different courses. Nine out of ten learners preferred the NVQ Hygiene application to traditionally delivered lectures while only six out of ten preferred the Essential Food Hygiene CD ROM to traditional lectures.

Most students reported in group discussions that they enjoyed working in groups and that exercises completed away from the computer were especially enjoyable. The requirement to report back to the tutor regularly, either as individuals or in groups was often mentioned as being a positive feature of the materials. Many student liked the flexible way the materials were used in study centres at a range of times. Some however saw this as a disadvantage and preferred a more structured approach to their learning. There are several possible reasons for this, including learners' previous experiences, their computer skills, the requirement for greater responsibility in self directed learning, and motivational aspects of self learning.

Some students reported that courses were too slow in some sections. It is thought that this was because sound had not been configured correctly for them (non-interruptible instead of interruptible). The need to configure applications at an optimal level rapidly became apparent in the exploratory study. User satisfaction relies not only on the configuration of learning, but also on the many other factors such as sound and graphics that make up the experience.

It was possible within the iterative prototyping method used, to test some of the guidelines assumed in multimedia learning materials development. This was done by simple expert evaluation and by asking users to rate screens and other features such as sound presentation in the prototypes. In this way, not only was the standard of learning delivery improved, but also the aesthetic quality of the prototypes was improved. It was agreed at meetings of the project team that high aesthetic quality was to be aimed at, to ensure that applications were professional in their appearance. Early prototypes were rated poorly by learners, irrespective of their learning content, if their interface lacked good design quality.

The ability to repeat sections was often cited as important by learners, especially on the foundation level courses. Some learners reported following the material at one task / question level and negotiating with their tutor to follow the same material at a higher level. This was interesting in that it provided evidence that learners were engaging at a deep level with the material and were sufficiently motivated to take the work seriously. There was no opportunity for this kind of interaction between learner and tutor in the Essential Food Hygiene CD ROM, which was essentially a stand-alone application. The differentiated paths through the application could also be thought of as providing a safe route for the learner. Once the learner had gained confidence at the lower task and question levels, they were able to explore greater challenges. This in itself might provide motivation for following the course. Interaction with the tutor was on many occasions reported as important motivation. "Showing your teacher what you can do is better than a well done from the computer", according to one learner.

All learners were asked to complete a simple questionnaire which was developed for the exploratory study based on guidelines given by Oppenheim, (1992). The results of the questionnaire are shown in table 6 below.

Table 6

Mean scores obtained in questionnaire on learner attitudes to the four multimedia - delivered courses

Question	Average score (Range 1-5)			
Rated 1= Not at all 5 = Very much	Catering N=12	Business Studies` N=5	Application of Number N=14	GCSE Law N=5
How Interesting	3.8	3.2	4.1	3.9
How easy	4.1	3.0	3.8	4.2
How enjoyable	4.0	3.5	3.9	4.5
How much learned	3.6	2.9	4.1	4.0
How Useful were the following				
Working on your own	3.8	3.7	2.4	4.1
Working in pairs	3.6	3.2	3.9	4.1
Working in groups	3.9	2.6	4.0	3.1
Working with the tutor	3.2	2.1	3.9	3.7
Tests taken on the computer	2.9	2.8	3.2	3.7
Tests taken off the computer	3.1	4.3	2.8	4.3
Tasks done on the computer	3.4	3.8	3.5	3.5
Tasks done off the computer	3.5	4.1	3.5	4.2
Final Test or Examination	3.2	3.8	3.6	4.1
How Worried were you by:				
Using a computer	1.5	2.6	2.8	1
Using a mouse	2.4	2.9	2.5	1.4
Using headphones	1.5	2.1	1.9	1
Working in Learning Centre	2.9	3.6	3.8	3.4
Would you like to take another multimedia course In the future	% YES 83	% YES 100	% YES 86%	% YES 80%

Although the small size of the study limits the general applicability of these results, it is interesting to note that there are some differences between the attitudes of learners in different groups. It appears from the results, that learners in all groups enjoyed following the courses and found them easy to follow. The lowest scores were obtained from the Business Studies group. Application of Number is traditionally a difficult course for many learners and it was surprising that it rated so highly as interesting, easy and enjoyable. The data on the usefulness of different ways of working and tasks and questions is complex and will be investigated in greater depth in the final study of this work. Group work was rated higher in Catering and Application of Number, and working alone was rated lowest in Application of Number. Most students didn't seem too concerned about using the computer hardware, though

students in Business Studies, an area that uses Information Technology a great deal in their courses, had the least positive attitude to using the computers in learning. It is possible that students distinguish between using computers in their work and using computers for the delivery of their courses. It may be the need to use new computer based learning methods that causes additional concern for some learners. It is interesting to note that the results of the questionnaire provide a slightly different view of learner attitude than the group discussions. This may be due to the influence of peers, designers or tutors present at the meetings.

2.3.4.2 Usability

The usability of multimedia computer applications has been dealt with far less than other types of computer application according to Preece (1994), who presents many guidelines for creating usable interfaces for a range of applications. By the application of a user-centred approach to prototype development, many usability problems were identified in these exploratory studies. Designers were able to identify these problems, often working with experts as well as users. An interesting development was the reduction of unnecessary mouse clicks. Designers were often adding useless clicks in an attempt to make the software more interactive. Hall has emphasized the importance of providing real interaction rather than simple button pressing (Hall, 1994). Extra button presses were quickly identified and removed and it became an important feature of the prototypes that mouse clicks were reduced to a minimum.

Other usability issues identified in the exploratory study included speed through sections of the material. Comparisons based on data from user log files were used to identify areas of difficulty and areas of the material not engaging the learners sufficiently. Learners would spend as little as thirty seconds on each screen in some areas of some applications. This was mostly independent of the amount of material presented. Often hyperlinks provided were not followed, either because they were missed or were of no interest to the learner. Screen design and application behaviour was changed to reflect this. Font sizes were increased and complex screens were broken down to reflect the amount of information that could be taken in during the thirty second 'window of opportunity'. Particular attention was paid to colour schemes and layout in order that information was not missed for this reason. Yellow on blue was considered the most 'usable' colour scheme by learning difficulty experts, though preferences were very varied. Hyperlinks were suitably emphasized by use of bright colours, sounds and boxes. Warnings were presented to users if important ones were still missed.

It is be possible to take forward many lessons on usability from this exploratory study to future work. Most important was the need for user centred design and the use of experts. By combining the two approaches, usability problems were solved effectively, quickly and efficiently.

2.3.4.3 Pedagogy

It has been argued that, in the design of learning materials, it is vitally important to consider the pedagogical structure of the material and to base this upon a theory of learning in order to provide a suitable structure for the learning material. Pedagogical issues are important not only in the design of the multimedia materials, but also in how they were used. It was practically impossible to separate the design and use of materials in this exploratory study, so closely were they related. The need to understand design and use of learning materials was an important outcome of the study which influenced all subsequent design decisions in the full project. It was realized that the requirements for learning materials were complex due to the need for flexible use. This introduced ideas about how multimedia could be configured for the individual learner in ways which would permit flexible and constructive use. These ideas were extremely important in the design of the learning materials and related ideas used in the rest of this project.

Another important outcome of the exploratory study, identified by several tutors, was the fact that pedagogy was actually being considered in learning in a practical sense. Most tutors reported that they liked the off screen activities, though some did mention the additional load on their time that this imposed. The requirement for group working and the possibility of configuring the task and question levels were often mentioned as being good features by most. Some tutors did not use the materials in a constructivist way at all and left students very much to their own devices. Tutors did not always configure the materials for their students fully or take part in all activities. These tutors were less satisfied with the materials in general than those taking an active part or indeed than their students. These students seemed to enjoy the materials as much as those in other groups and still participated in the group and off screen activities to a large extent.

The use of the materials in a vocational context was considered to be important by students and tutors alike. This was especially true of the key skills materials where traditionally much teaching had been done by key skills specialists. The ability to use materials and apply them in vocational context was especially welcomed by those teaching in these areas. Constant links between the learning materials and activities taking place in the kitchen and store rooms were cited as important by catering lecturers. The materials were described as task based and assignment driven by one tutor who felt this was an improvement over most other materials available. An understanding of the need to base such curriculum materials as used in the exploratory study on real assessment with real rewards in real contexts was an important outcome for the future development of materials.

One important issue for the development of future applications used in the project was the use of scaffolding in the prototypes. Scaffolding is the provision of support and help, for learners, which may be removed when no longer required. It has been described by Stoney and Wild (1998) as a way

of providing differential support for learners. They suggest that a range of cognitive levels be supported in applications to increase motivation. Scaffolding is an important way of supporting learning according to Somekh (1996) it can also be used to help extend a learner's knowledge. Scaffolding helps learners to pass their current level of achievement and enter their 'zone of proximal development' so that next time they do not require this additional support to achieve this level of understanding (Vygotsky, 1986).

Scaffolding was provided in the materials used in the exploratory studies in several ways, including hyper-linked support systems providing additional information in the form of text, images, diagrams and explanations. By far the most popular method of providing this scaffolding involved differential help paths. Materials were largely task based as described above and only sufficient information to complete tasks was presented to learners in some cases. As learners progressed through the tasks, optional additional help was made available as needed. The level and sequence of this help was configurable in some places by the system, and in others by the tutor or the student. Tutors reported that this approach was more valuable than approaches used in other learning applications where student knowledge of the domain was assumed to be low or zero. In such applications information is often presented sequentially, irrespective of learners' prior skills. The ability to configure the assumed domain level so that scaffolding could be provided at the appropriate level was important in the prototypes according to tutors. Students liked the possibility of trying tasks and questions and then being able to obtain more help if they needed it and to then try again. In this way tasks were usually completed.

The correct balance between an instructive Behaviourist approach and a constructive, Cognitive approach is an important feature of the design of learning materials. Within this exploratory study, a wealth of experience in designing a range of materials with a mixture of approaches was obtained.

2.3.4.4 Performance

Although a major objective of the exploratory study was to undertake a formative evaluation, it is relevant to consider how well learners performed on the prototypes produced for this study. The evaluation of performance on a learning application is a complex issue. In its simplest form, It may be measured by test scores, but certainly involves more than just this according to Reeves (1992).

The following table provides a brief indication of performance on the courses covered in the exploratory study

Table 7

Performance on multimedia courses in the exploratory study.

Subject	Number of Students	Number of students Passing Objectives[1]	Average Scores on Questions (on-line)	Average Scores on Tasks (on-line)	Average Final test Score (off computer)
Catering:	12	12 (100%)	62%	53%	57%
Business studies:	6	5 (83%)	54%	58%	61%
Key skills: Application of Number	14	11 (79%)	59%	63%	52%
English Law:	5	5 (100%)	71%	69%	83%

Pass rates for the objectives covered were higher for all areas than for similar students following the same courses by traditional methods in the previous year. Mean pass rates obtained in the previous year for similar objectives are shown in table 8 below.

Table 8

Performance on non-multimedia courses in the year prior to exploratory study

Subject	Number of Students	Number of Students Passing Objectives[2]
Catering:	36	28 (78%)
Business studies:	56	45 (80%)
Key skills: Application of Number	124	74 (60%)
English Law:	15	12 (80%)

[1] 'Passing objectives' here relates to the objectives covered by the material in the study and not the final pass rate for the course.

[2] 'Passing objectives' here also relates to the objectives covered by the material in the study.

Comparison of the results for the Application of Number course are extremely interesting. The failure rate on this course was approximately 40% when delivered conventionally, yet 80% of learners achieved the objectives covered on the multimedia course. Final test scores were within the range of results generally obtained in the other subject areas, although on-line question and task scores appear to be higher than on standard presentations of courses for all subject areas except Business Studies, in the opinion of tutors involved in the courses. Staff in Business Studies curriculum area expressed some concern as to using computer delivered assessments. It is possible that on-line assessments were supported less well in this curriculum area than in some others. It was difficult to compare performance on specific tasks and questions on the exploratory study with previous years' exercises, as the formats were usually quite different. Differences in the number of students passing objectives between years could also be due to this factor. The importance of tutor attitude is discussed later in this paper.

These results emphasize the importance of considering systems outside of the multimedia application itself when evaluating performance. Such external systems include the tutor, the learning environment, technical support and a vast array of other influences on learning that became apparent in the exploratory study. These issues are dealt with in greater depth in the final section of this project.

In general, students were successful in using the materials. Most students achieved as good as, or better than average marks and benefited from using the multimedia courses. By configuring tasks and questions at appropriate levels, improved test and task results were obtained it is argued. Understanding the need for configuration of tasks and questions and the requirement for tutor involvement in configuring the applications was a major outcome of the exploratory study and is discussed in the next section.

2.3.4.5 Tutors' attitudes

It has been suggested that one major impediment to the implementation of modern technology in education is the attitude of tutors (Fitzgerald et al, 1997). Reasons for this fact range from feelings of threat, lack of involvement in the process, lack of technical support, lack of training and inadequate resources.

It was considered important to approach the issue of tutors' attitudes directly during the initial training period and also by involvement in the process. Teachers reported a feeling of sharing in the project, of being part of a larger support system, which gave them confidence in using the applications. Having experts available to help was also mentioned positively and the software development team considered that this feature should be included at least initially in any new project.

By far the most often cited reason for positive attitude change towards the application in tutors was the amount and quality of student involvement in the tasks. The task-based approach was cited as being important in all but one course. Tutors also considered that their involvement in the whole process influenced their feelings to the applications. The necessity to involve tutors in the process was taken up by the design team as an essential feature to be included in all later studies. The need to develop and evaluate the effectiveness of high quality tasks and questions for the iterative prototyping methods used in the application design ensured that tutors were involved in all stages of the design process. This feature will be discussed more fully in the final section of this work.

Some teachers did not like setting the task and question levels too low as they considered this devalued the course. This was particularly evident in the Business Studies course, where tutors were especially careful not to lower course standards.

It was considered important to involve tutors as widely as possible in setting questions and configuring levels for their students.

3 Conclusion

This study was extremely valuable in the development of a student model for use in multimedia prototypes. Although the software development team had experience in the practical design of educational software, it was important to test out theories and guidelines from the literature. There were also many new ideas that had to be tested and their usefulness evaluated, especially in the areas of task and question design and differentiation. The major lessons learned from the study are set out below. All of these ideas were important in the subsequent design of multimedia applications for use in later work with student models. Techniques were also developed for the rapid identification of usability problems in software, based on expert and user centred methods. Ideas regarding the balance between construction and instruction in multimedia modules were explored and models for achieving the correct balance investigated. The skills and tools necessary to create a range of tasks and at different levels were obtained. Models of how best to configure question and task level differentiation for the individual learner were generated and explored. The requirement to involve learners and tutors in human to human interaction emerged from the exploratory studies and became a design feature to be included in all future development work.

The effect of language and cognitive style differentiation was investigated and the potential of this in a student model of learner characteristics was explored. Differentiation based upon the cognitive skills of learners was also found to be important. Task, question level and help differentiation were found to be useful candidates for inclusion in a student model.

It was also found that other features needed to be included to support tutors in the individual configuration of learning materials, for example in the setting of task and question levels for learners. Some tutors did not implement this fully with their students. It would be important in future work to make sure that all tutors were fully trained and shared the project objectives fully. Fitzgerald and colleagues (1997) found that best use of multimedia materials only occurred where materials were fully integrated into course construction and technical support was provided. It would be important in future work to consider the quality of the full learning systems.

The importance of tutor skills and support for tutors in teaching effectively with interactive multimedia technology is paramount and was a significant outcome of this study. Although the exploratory study was intended to be a formative evaluation of the prototypes, enough learners completed significant amounts of work using the finished prototype applications for some conclusions about the quality and usefulness of the courses to be drawn. The results of this were very encouraging.

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