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ABSTRACT

This report summarizes the discussions at a seminar which provided the opportunity for 15 researchers and developers from the United Kingdom and other European countries to consider a number of short, medium, and long-term issues and assist in setting an agenda for future phases of research. The specific goals were: (1) to identify the tools necessary for the effective support of existing authors or development teams of computer-supported learning or training materials (short term goal); (2) to indicate where advanced developments in this and related fields might lead to better computer-based training development tools (medium term goal); and (3) to suggest areas of fundamental research which are needed to underpin more effective courseware development tools for the future (long term goal). General issues covered included computer-based training and users of authoring tools. Several topics related to what tools are needed to improve current practice are then considered, i.e., the limitations of current authoring systems; problems to be solved with better tools; assessment of organizational needs; analysis of training needs; design: prototyping tools; and user modelling. Software engineering techniques are described, including simulation and modelling, Smalltalk and direct-manipulation interfaces, HyperCard, integration, and expert systems. Several issues of instructional and learning strategies are summarized. The report concludes with outlines of tools and techniques that need to be developed and issues for the research on which such development depends. A list of seminar participants is appended. (MES)

ESRC

ECONOMIC AND SOCIAL RESEARCH COUNCIL

Support Tools for Authoring a seminar report

Occasional Paper InTER/7/88
December 1988

Edited by:
PROFESSOR R. LEWIS
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INTER

INFORMATION TECHNOLOGY IN EDUCATION RESEARCH PROGRAMME

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Origins of the ESRC INFORMATION TECHNOLOGY AND EDUCATION PROGRAMME

The Education and Human Development Committee was established with the reorganisation of the then Social Science Research Council in May 1982. In 1984 the Council changed its name to the Economic and Social Research Council. Early in 1983 the Committee identified and circulated for discussion an initial listing of important topics which warranted expanded support or accelerated development. The broad area of Information Technology in Education occupied a prominent place in that list. The Committee emphasised its intention that research would be centred not only on the effect on education of machines to help teach the existing curriculum, but on the development and adaptation of the curriculum to equip people, including those of school age, to deal with intelligent machines and to prepare them for a life changed by their arrival. For example, there are questions concerning both cognitive and organisational factors which facilitate or inhibit the adoption of Information Technology in Education, and allied to these, questions around the nature, characteristics and development of information technology literacy. These initial topics remain central to the Committee's projected agenda.

Two reports were commissioned and detailed discussion and workshops were held in 1983. In its further considerations, the Committee was conscious of the fact that the research community is widely scattered and has relatively few large groups of researchers. Furthermore, it recognised the importance of involving practitioners and policy makers in the development of its programme of substantive research and research related activities and the necessity of ensuring close collaboration with commercial organisations such as publishers, software houses and hardware manufacturers. It was this thinking that led the Committee away from the establishment of a single new centre to the appointment of a coordinator as the focal point for the development of the initiative throughout the country.

The brief for the Coordinator included:

- the review, evaluation and dissemination of the recent and current activity in the field of Information Technology and Education;
- the identification of the needs of education in relation to Information Technology;
- the stimulation of relevant research and the formulation of research guidelines;
- the establishment and maintenance of a database of relevant work and undertaking arrangements for coordinating and networking of those active in the field including cognitive scientists, educational researchers, practitioners and policymakers.

In January 1988 the Council of ESRC approved a new initiative which would have resources to support a substantive research programme. This programme, the Information Technology in Education Research Programme, started in the autumn of 1988. The new series of InTER Programme Occasional Papers has a similar format to the previous ITE Programme series and covers aspects of the Programme's work. These are listed on the back cover of this paper.

SUPPORT TOOLS FOR AUTHORING

– a seminar report

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CONTENTS

1. INTRODUCTION

This Occasional Paper* is the report of a seminar organised by the ESRC-Information Technology in Education Research Programme. The overall objective for this and other similar seminars is to assist the Programme in setting an agenda for future phases of research.

About 15 researchers and developers from the UK and other European countries (see Appendix A) participated in a 24-hour seminar in September 1988. The ESRC-ITE/Training Commission study report on *Authoring of Computer-based Training Materials* (ITE/27/88) was distributed to participants as a source document. At the seminar there were five sessions: three consisted of open-forum discussion; an evening session examined a range of 'advanced' software environments from the UK, France and Norway and North America; the fourth was conducted partly in smaller groups with reports back to a final plenary session.

The specific goals of the seminar were to review a number of short, medium and long-term issues:

- to identify the tools necessary for the effective support of existing authors or development teams of computer-supported learning or training materials, (short term);
- to indicate where advanced developments in this and other related fields might lead to better CBT+ development tools, (medium term);
- to suggest areas of fundamental research which were needed to underpin more effective courseware development tools for the future, (longer term).

This report does not attempt to give an account of the seminar in a time-ordered sequence but structures the points raised in relation to the goals stated above. Understandably, it has not been possible to come to a consensus of views on every suggestion or concern. In many instances, the points were raised by individuals or a minority of participants. Where dissenting opinions were voiced, however, they have been reported.

GENERAL ISSUES

There was an early discussion on the general issue of the place of CBT in general education as well as specific comparisons of CBT with other forms of vocational training. The discussion then focussed on the users of authoring systems.

2.1 Computer-based training

CBT shares with other forms of education the necessity of confronting some fairly intractable problems. Mixed-ability teaching, for example, "*is hard for human trainers and educators to do, let alone a computer system.*" Training in general also

* The ESRC-InTER Programme is grateful for support given in the preparation of this paper by the Learning Technology Unit of the Department of Employment, Training Agency and the editors are pleased to have received comments on early drafts from Claire O'Malley, Phil Butcher, David Riley and Peter Goodyear.

+ The acronym 'CBT' has been used in this paper to refer to the full range of learning and training tasks and opportunities which may be supported through the use of various forms of 'information technology'. The term 'courseware' has been used to cover all styles of CBT software and supporting material, from the most formal or didactic to the most open or heuristic teaching and learning strategies.

has to cope with the existing structure of an organisation, and to acknowledge that the provision of training will often change that organisation.

Another issue - one that surfaced under various guises - was the problem of 'making explicit' the objectives of a training course, whether that training is computer-based or otherwise. For example, *"characterising the learner requirements is a general educational problem, but it is especially relevant in CBT, where there is usually no interaction* (between designer and learner) *at the time the material is delivered"* and *"frame-based CBT embodies the objectives of the author and training manager, but these are not made explicit. The authoring system does not ask, 'What are your objectives for this piece of training material', nor does it have the ability to categorise or use this information." "People don't learn effectively if there is no structure; learning has to be based on previous knowledge. People need to be able to make mistakes, and receive support; there is very little learning without that interaction. This needs organisation, structure and strategy, which can only come from the teaching objectives."*

CBT, however, has special abilities and special problems compared with other forms of training: *"CBT is re-usable"*, *"CBT can reduce by half the time it takes to become proficient"* and *"CBT can encapsulate knowledge which may be very scarce within an organisation, and make it more widely available."* Whilst other training mechanisms may demonstrate some of these benefits, the rigour demanded by CBT programmes requires a more logical and detailed analysis of the interaction with the trainee.

Although it was generally agreed that CBT was a long way from fulfilling the apparently modest objective of providing *"at least as good as the worst human-student interaction"*, it has to be judged against its own objectives. *"It enables new kinds of interactions - don't try to compare it with human tuition."*

The discussion of CBT's special problems led to a consideration of how the process of producing courseware could be improved.

2.2 *Who will be the users of authoring tools?*

A major aim of the first session was to identify the target users for authoring systems. *"We've tried to make authoring systems available to teachers. But authoring should be done by professionals. If you design software for use by novice authors, it gets in the way of experienced software developers. We need different toolkits for different levels of user."*

Some felt that toolkits should be provided for subject-matter experts: *"teachers know what they want to teach"*, but that they would probably need a fairly supportive environment. *"For teachers, allow them to structure their ideas, especially with a courseware map"* and, *"novice authors need help with tactics and strategy."* More experienced authors, however, *"want to be able to be free of these constraints; they need a freer-format system."*

One solution discussed was to provide a 'non-prescriptive' system, one where *"all methods are available at once, and the tutor can decide which ones to ignore."* This feature is reported to be present in some systems currently under development. However, *"we need to consider the trade-offs between productivity and flexibility. The more highly-specialised a tool is, the more productive it will be within its area of*

specialisation. Flexible systems (which can address many different kinds of problem), may not be excellent at solving any of them."

Other than subject-matter experts and professional courseware developers, the users of such tools may even include the trainees themselves, or at least their managers: *"many clients (for example, the Navy) ask for the ability to make changes themselves".*

On the other hand, perhaps *"we should concentrate on building tools which enable us to build the environments, and the tools to use those environments."* There was no consensus on the approach to take and opinions varied from the view that easily accessible systems were needed, to the standpoint that, *"simple solutions for complex problems are usually inadequate."*

Participants had different preoccupations. In particular, some advocated the provision of authoring toolkits for children: *"the fact that learners have access to tools which enable them to build models means that they have to sort out the knowledge representation, and understand the underlying theory"* and, *"it's no good if only experts can produce (software) models."* Also, *"there are not enough tools to allow learners to build software models."*

To sum up. *"Users of authoring tools will vary enormously. Usually, a team of people will be involved in authoring: each person may well need different tools"* and, *"We need a series of different tools A tool for building simulations may not help with problems in knowledge elicitation."*

3. WHAT TOOLS ARE NEEDED TO IMPROVE CURRENT PRACTICE?

Support tools may be considered at three levels:

- those which speed up the implementation or coding process and hence boost the productivity of experienced developers;
- those which aid 'low level' preparation of text and graphics (spelling and style checkers, WYSIWYG (what-you-see-is-what-you-get) interfaces, paintbox/ drawing tools, and so on), which can greatly assist the non-expert;
- those which support high level educational/training design of CBT materials, and of sophisticated user interfaces. This level of expertise is currently only found in the most well trained and experienced human minds.

3.1 The limitations of current authoring systems.

Many deficiencies were discussed. For example, *"current authoring languages don't allow me to do much more than a conventional programming language would. They don't provide a 'theoretical basis' for CBT; they merely provide an environment for defining screen displays and interactions."* Other common complaints were a lack of support for the design stage of the process and the sheer lack of productivity of the existing systems

"There are no tools which help the design phase of the process." *"Although the presentation is getting better, there is no help in designing the experience the user will go through"* and, *"Paper-based design is the state-of-the-art; it must go We need tools that allow us to express the design, and to code it, without paper."*

"Anything that makes the process of turning an idea into screens of interaction, and then into code, will be useful. Mostly, we try to break out of the constraints that the existing systems impose upon us."

3.2 *What problems can be solved with better tools?*

The distinction between what a tool can and cannot do provoked much discussion. *"Tools only allow you to do existing things more effectively." "Tools don't help with the user experience - it's human intellect that does that."* More generally: *"You can't expect tools, however clever, to substitute for the intellectual process. Certainly, we would prefer to spend 150 hours to produce courseware rather than the 300 we spend at the moment. But each of us have more or less skill and ability to produce effective material and the quality of the product will always depend on that."*

Some participants, however, felt that there were counter-examples: *"A tool like NoteCards actually allows you to structure your ideas and arguments, it's not just a word processor. It augments your abilities."*

Some of the specific areas where tools were felt to be required are discussed in the remainder of this section.

3.3 *Assessing the needs of the organisation.*

As has been mentioned earlier, any kind of training must take into account the pre-existing structure of the organisation. An important part of designing a training course, therefore, can be to investigate the structure and dynamics of the existing organisation. Some techniques exist: for example, to try to identify the trainer or part of the course which causes difficulties: *"The 'odd one out' technique. Look for the eccentric bit - that may well be why the training problem exists in the first place"* and, *"you can analyse areas of conflict, this helps to identify the common ground."* So far, however, there are no tools to help with this process.

3.4 *Training Needs Analysis*

One participant reported problems in assessing the level of ability of the target trainees. *"The problem is that all our courseware contains a large proportion of redundant material, because we cannot identify the true abilities of the trainees as they enter the course. Often, we find that the training managers that we talk to underestimate the level of ability, literacy, competence, and so on, of the target population; we find that they're much brighter and more able than we had been led to believe."*

"A simple pre-test is not sufficient, because it doesn't take into account the fact that an individual may be at different levels of ability or experience in the various areas of the subject. We need a tool to help us do the analysis of the target population, to identify their true starting points, and to minimise the redundancy." This appeared to be a common problem: *"IBM insist on talking to the trainees, interviewing them to find out their true ability."* One participant saw an historical parallel: *"Thirty years ago, systems analysis was stressed as crucial, now Educational Systems Analysis, even the basic Training Needs Analysis is not emphasised enough."*

3.5 *Design*

The need to elicit, structure, and represent the body of knowledge involved in the course, and the ways in which it might be communicated to the student, currently suffers from a lack of support. In particular, *"most existing authoring tools are*

languages", offering no real guidance on how to structure a course or a series of interactions. Where guidelines do exist, they are not part of the tools. Authors of CBT should work at a high level of abstraction when they embark upon CBT construction; too often their preoccupation is with the nuts and bolts of the training rather than taking a more distant, overall view from the start. But how should this overview be attained?

The experience of the Open University was cited. Teams work in a well defined area when they produce OU course texts. The texts have a distinctive style consisting of objectives, aims, in-text questions, self-assessment questions, etc. and there is a recognised 'correct' way of putting the texts together, starting with the objectives. In practice, of course, not all authors follow recognised good practice in achieving the end product. Guidelines may exist but the underlying theoretical aspects of design are achieved through secondary actions rather than as a fundamental framework from the start. Academics are concerned to teach their subject matter and to explain it to the best of their ability; they do not start by working at a higher level of abstraction about how the various parts of the subject matter should link together. They may end up there, but they don't start there. If this doesn't happen when texts are prepared, can we expect it to happen during courseware production? One might even ask if we wish to promote such methods. Flexibility in authoring tools, providing a supportive environment in which ideas may be expressed and refined as production proceeds may be an appropriate way ahead; in other words, tools for flexible design and rapid prototyping are required.

The point was re-iterated that the existing software tools do not incorporate a methodology for courseware production, except by default: *"Tencore has a set of interactions that it supports, but we need a wider range of interactive styles."*

Once the course layout has been designed, the presentation of the screens themselves is also dependent on the individual skill of the authors. *"We need guidelines to put screens together"* – although, once again, whether a tool could help achieve this was disputed: *"If you want help with presentation, go to an art college, not to the art materials supplier."*

However, most people felt that such tools would prove useful: *"Advice on which colours to use, or a fog index* (an assessment of the literacy level required to read a piece of text, based on the average number of syllables in the words)." Such systems, however, should provide advice, rather than simply be a mechanical process: *"In all the books on 'How To Produce Good CBT', all you get is examples of Bad CBT. Tell us what Good CBT is, and incorporate it"*, and *"something like 'Style' on UNIX doesn't give you any advice, it simply points out what's wrong."*

3.6 Prototyping tools.

The low productivity of the existing tools has several important side-effects. Firstly, many training needs are simply not being addressed at all: *"Remember that the cost of a solution must be in relation to the cost of the need"* and, *"we need to train problem-solving skills"* but, *"simulations are beyond the scope of existing authoring systems, you have to incorporate calls to a general-purpose programming language."*

It also means that when courses are finally constructed, it is difficult to justify changing them. *"What usually happens is that the courseware is delivered late and*

there are great incentives not to make any last-minute changes because they are difficult to integrate."

Most delegates wanted the situation to improve: *"We shouldn't necessarily expect that courseware remains in the curriculum for long periods - in some cases we need better tools to produce 'throwaway' courseware, so that it can be re-written frequently." "We need a fast turnaround time on the interface, so that we can make changes more easily, so that the problems of adaption are not at that level."*

As in modern software engineering, the benefits of a 'rapid prototyping' environment are not confined to the speed with which applications can be generated; the ability to produce iterative designs allows the developer and user to communicate more effectively. But modularity is also important: *"We need prototyping tools. We need a system which enables us to make changes late on in the development process."*

3.7 User modelling.

'Adaptive CBT' is not a new idea; prototype systems, and indeed production systems, incorporating sophisticated branching strategies have been produced for some time. One application which had been constructed *"had 100 concepts, and 'stereotype' user groups as starting points. As you went through the course, you modified the user model if the response didn't fit."*

But it is still not generally cost-effective to incorporate such modelling in commercially-available CBT. To put it another way: *"It's feasible to a certain level of granularity - if you can identify perhaps four or five paths through the course, it's OK."*

Some participants, however, questioned the advisability of pursuing this goal too hard. *"In cases where the solution turns out to be more and more complex, often the best thing to do is to decide that the solution lies 'somewhere else' - look for alternative methods of achieving your original goal."* This brought the discussion back to the problem of making the knowledge explicit: *"CBT diagnosis is at the 'content', rather than the cognitive level."*

This topic, of course, is the subject of much lively debate elsewhere.....

4. WHAT SOFTWARE ENGINEERING TECHNIQUES ARE USEFUL?

4.1 Simulation and modelling

The topic of modelling of processes as part of courseware was discussed many times. *"Better courses, or individual lessons, often come about because people say, 'there is a different way of teaching this topic'. We need more models, for example simulation; most CBT hasn't used simulation."*

The reasons for the existence of little simulation-based courseware were also clear. *"The production of significant simulations is still hard and its success depends on the skill of the developer in modelling the ideas of the domain"*; and *"there is no clear methodology for how to develop and use models - we need to provide help and guidance for people trying to do it."*

It is, however, worth doing: *"As you move from simple simulations to more complex ones, the computer becomes much less of a 'presentation' device and increasingly has more 'awareness' of the subject-matter. This can provide a richer level of interaction, based on the model of the domain."*

4.2 Smalltalk and direct-manipulation interfaces.

Many participants had experience with Smalltalk, both directly and by being influenced by its underlying approach. One idea in particular which provoked discussion is the 'Model - View - Controller' paradigm.

As applied to CBT courseware, the following (outline) definitions emerged;

- The 'model' is the knowledge or behaviour that is codified. It may be a mathematical model, or data, or heuristic or logical rules; it be may considered as the 'content' of the courseware.
- The 'view' is how that knowledge is presented to the user - the 'presentation' of the course.
- The 'controller' is the mechanism by which the user affects the session - the 'interaction'.

This approach encourages modularity - the content, the presentation, and the interaction with the student should be considered as three separate design issues, any one of which can be changed without affecting the other two.

This type of software environment offered new possibilities. *"The Alternative Reality Kit (a software environment which allows users to gain an appreciation of physical laws such as gravity, by presenting them within a 'world' where the rules can be changed), offers something that couldn't be done using traditional methods."*

4.3 HyperCard.

This product, available on Macintosh computers, has begun to be used for authoring, with some success. *"HyperCard removes a limitation; it gives us an area where we can improve our service. We found that we could produce CBT frames in half to two-thirds the time it normally takes us."*

There are limitations. *"On the Macintosh the screen is black-and-white, and the system doesn't provide answer matching facilities"*, but there are compensations: *"We can zoom into the material and allow the trainee to jump around a body of knowledge with greater freedom, and so on. It allows us to give solutions to training needs that were too costly before."*

Another big advantage comes when the client changes his mind at the last moment. *"With HyperCard, the material is divided into identifiable chunks of information, so that we can make changes to one part of it without altering the underlying structure."*

4.4 Integration.

This theme appeared in many contexts. *"We should resist the temptation to make tools do more than the jobs they were originally intended for. That just leads to bad tools. What we should aim for is better integration between tools, so that a number of special-purpose tools can exist and work well together."*

4.5 Expert Systems.

One participant reported that a system incorporating expert system techniques was beginning development. *"The system aims to cope with both the initial, and the continuing training needs. It works in two 'modes' - an advisory mode, which consists of an expert system which can give advice on what to do under particular conditions, and a 'training' mode which can teach the concepts required in order to make the decisions. We expect that incidental learning will take place while the system is in the advisory mode - this is quite often a time of great stress."*

As usual, however, there are dangers: *"There are at least two problems with using expert systems for training. Firstly, when you introduce them, you can disrupt the normal process by which people get better at problem-solving - that is, through social interaction with peers (eg. anecdotes) which provides updates to a changing knowledge base - a knowledge base which is usually distributed amongst a community of experts rather than residing in one or two individuals. Secondly, you have the problem of actually making sure that trainees are really doing what you tell them to. If the expert system says, 'Look at component A. Is it faulty?', and the trainee answers 'Yes', you don't know whether she really has looked at the correct component."*

5. ISSUES OF INSTRUCTIONAL AND LEARNING STRATEGY.

Almost all the discussion introduced earlier (which tools were needed and should be produced), pointed to some fundamental research which was needed in order to evaluate what has been done, and to formulate categorisations and guidelines based on what constitutes 'good practice' in the various areas. These are listed in Section 6. Also, research is needed which may lead to a taxonomy of instructional strategies.

The assertion that current courseware had an impoverished set of styles in which the trainee could interact led to the notion that we might provide, *"facilities for the author to help decide what sort of user interface to create - what style of interaction."* Very often, *"these types of interaction are embedded in courseware as a 'house style'"*, but what we need is *"a language to express the different kinds of interaction"*, to be able to say, *"this class of problem seems to be best tackled by this approach."*

Once a taxonomy of student interactions has been established, *"we should provide a high-level interface for designing sessions based on them. For example, if we decide that a Socratic dialogue is an appropriate method, the system should provide a framework for that."* Others argued that the decision could also be left to the user. *"Let the trainee choose, say, frame-based versus simulation learning styles."* and account should be taken of, for example, holistic and serialist learners.

In any case, one participant thought that *"what we are missing is considering the thing from the student's point of view. Current authoring systems consider things from the author's point of view - we should start with the student view, with the idea of a 'learning transaction' - and then design the tools from there."*

Instructional strategies at the 'macro' level should also be investigated, and guidelines produced, for example, *"when to intervene, when to allow the student to carry on making mistakes, etc."*

6. TOPICS FOR RESEARCH AND DEVELOPMENT.

As indicated in the Introduction to this paper, the main objective of the seminar was to assist the InTER Programme in defining an agenda for research in the area of support tools for the authoring of CBT courseware. Perhaps more than in other areas of the Programme's concerns, the distinction between research and development in not distinct in this field. It may be argued that tools to support training needs analysis would be valuable in training materials definition and design. What is not at all clear is whether we have sufficient understanding of training needs analysis so that the development of the necessary tools can be undertaken without further research.

Despite this difficulty, participants worked in small groups during the final session of the seminar and attempted to identify both key issues for basic research and tasks which required development effort. The distinction was not taken as a purely academic exercise, but rather to identify where the various agencies concerned with authoring environments should focus their efforts.

6.1 Tools and techniques which need to be developed:

These may be divided into tools which:

a) speed up or make the production process more efficient;
b) should result in more effective learning through CBT.

a1 to assist the stages from design to implementation; different tools for various parts of the process;

a2 to help members of the development team to communicate more effectively, and to document the system (not necessarily paper-based);

a3 to make it possible to take the output of one tool and use it in another environment for which it was not originally intended;

a4 to feature the model-view-controller paradigm which encourages modularity: the content, the presentation, and the interaction with the student should be considered as separate, any one of which can be changed without affecting the other two;

a5 to produce 'metatools' - tools for producing tools - based on a programming environment which is object-oriented, easily-extensible, etc.;

a6 to build advice systems, for example, principles of graphic design for courseware authors, or advice on building models, so that individuals who are subject-matter experts can produce effective CBT.

b1 for training needs analysis;

b2 to help highlight the form of interaction (the 'transactions') between the student and the system;

b3 to help the knowledge elicitation process, (eg. structured conversation analysis).

6.2 *Issues for Research on which development depends.*

There is clearly a danger when considering research issues to identify general issues in the understanding of learning. This is not the goal of this paper. Rather it is to highlight somewhat more tractable questions which relate directly to the concerns of authoring environments and the specific opportunities offered by CBT.

The issues are divided into:

c) those which focus on the learner and a view of the learning process;
d) those which relate to the development of CBT materials.

c1 understanding the way in which learners change their knowledge representation over time (how the structures change);

c2 categorising the different metaphors for user interaction, in terms of 'this metaphor seems to be appropriate for this kind of interaction';

c3 identifying principles of good instructional strategies and formulating guidelines, eg. when to intervene, when to allow the student to carry on making mistakes, etc.

c4 evaluating different learning styles against different training problems (both from the author's and the trainees' viewpoints);

c5 categorising the strengths and weaknesses of different instructional styles to arrive at statements such as 'This class of problem seems to be best tackled by this approach';

c6 developing a taxonomy of instructional strategies;

d1 evaluating and codifying the underlying theories which will enable courseware 'critiquing' tools to be developed for CBT design and presentation standards;

d2 evaluating methodologies and knowledge engineering tools;

d3 work on treating authoring as the process of producing abstract structures - of representing the knowledge of the domain - and then using delivery systems which can embody knowledge in a behavioural sense, of how to formulate the interactions with the student;

d4 developing metaphors for authoring environments which can be easily grasped by trainers (as opposed to programmers) and lead to the effective use of powerful tools by a wider, and often more sensitive, community;

d4 analysing the existing tools, and categorising their mechanisms in terms of the model-view-controller paradigm.

Appendix A: Attendees

Christian Bessiere, IRPEACS

Jonathan Briggs, Kingston Polytechnic

Phil Butcher, The Open University

Peter Goodyear, University of Lancaster

Julian Hilton. University of East Anglia

Terry Hinton, University of Surrey

Bob Lewis, ESRC InTER Programme

Terry Mace, Information Learning Systems

Harvey Mellar, Institute of Education, University of London

Richard Millwood, King's College, London

Jeff Oliver, Castle Learning Systems Ltd

Claire O'Malley, The Open University

Michael O'Reagan, Research Machines Ltd

David Riley, King's College, London

Rod Rivers, Logica Cambridge Ltd

Janet Rothwell, MENTOR Interactive Training Ltd

Keith Shaw, SYSTEM Applied Technology Ltd

Dag Svanaes, University of Trondheim

Ken Tait, University of Leeds

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