Abstract

This paper describes the intelligent multimedia authoring system "SHIVA", developed as part of DELTA project D1010, "Advanced Authoring Tools". SHIVA is the result of combining the "ORGUE" multimedia authoring tools developed at CNRS-IRPEACS (France) with the ECAL system, developed at the Open University (GB). The system enables authors to define the high-level structure of a course graphically, in terms of a set of concepts which are linked to multimedia frame modules. In this context we understand the term 'multimedia' in terms of the integration within a computer of audiovisual data representations, treated digitally at least at some point in the course of processing. On the basis of implicit connections thus established between concepts, ECAL provides adaptive decisions concerning the presentation order of frames to the student. After describing the system, we concentrate on a programme of evaluation, designed to ensure that the integrated system is easily learnable at the interface level, and that it is adapted to industrial training needs in a European socio-economic context.
[*] This paper is based on work carried out by all partners of the DELTA project D1010. Participating organisations are: CNRS-IRPEACS (Lyon, France), The Open University (Milton Keynes, GB), Standard Elektrik Lorenz (Pforzheim, W. Germany), DATAMAT (Rome, Italy) and APIGRAPH (Lyon, France). The University of Nottingham (GB) is providing consultancy in Human-Computer Interaction to the project.

Intelligent Multimedia Authoring : Advancing Towards Users in a European Context

(To appear in proceedings of the conference "DELTA and Beyond", October 1990, The Hague, Netherlands).

Michael Baker
Christian Bessière [*]

CNRS-IRPEACS
93 Chemin des Mouilles
BP 167, 69131 Lyon-Ecully
France
Telephone 72 29 30 40
Fax 78 33 33 70.

1. Introduction: origins of SHIVA

This paper is focussed on the problem of how an intelligent multimedia authoring system may be adapted to its intended users, and hence on the evaluation of the system. Our discussion is based around the 'SHIVA' prototype multimedia intelligent authoring system, under development as part of DELTA project D1010, 'Advanced Authoring Tools'. The evaluation of a tool which requires users to articulate their knowledge for a specific purpose - training - offers new problems for Human-Computer Interaction (HCI) research, and the integration of artificial intelligence into training technologies poses new problems for their use within the organisation of industrial training. There are therefore two main dimensions to our evaluation: the cognitive dimension concerning the authors' model of the system, and the socio-economic dimension, concerning the insertion of a complex computer-based tool into industrial training in a European context. After a discussion of the SHIVA system itself and its origins, we concentrate on evaluation from these two perspectives.

Within existing research concerned with the use of computers in education and training we can observe two main tendencies: on the one hand, research and development in CAL ("Computer-Assisted Learning") educational technologies - strongly linked to existing training needs - and the development of authoring tools, and on the other, research into the application of artificial intelligence and cognitive science to produce 'Intelligent Tutoring Systems' (ITS). SHIVA results from an attempt to 'bridge the gap' between these two tendencies, and its name (originating in an Indian God with many arms) is intended to capture the idea of multiple media directed by a powerful and intelligent centre. Our methodology was to combine existing systems and adapt the resulting system to usage, rather than to perform a needs analysis leading to a specification and implementation. The two systems of which SHIVA was originally composed are the 'ECAL' system ("Extended CAL"), developed at The Open University (GB) and the ORGUE multimedia graphical authoring tools, developed at CNRS-IRPEACS, France. From a technical point of view, we therefore have a prototype system which was quite easily integrated. From the point of view of usage, however, the system poses the problems of integration at the level of the interface provided for authors, and the consistency and usability of the global model of the authoring process which results from the two kinds of systems and their attendant courseware design methodologies. One important goal of the evaluation is therefore to assure that technical integration preserves a coherent and easily learnable model of the authoring process.

2. The components of SHIVA

2.1 MULTIMEDIA EDITOR IN ORGUE

ORGUE forms part of a general system termed a Courseware Engineering Tool ("CET") - a name which underlines the essential technical link between CAL and other fields of computing applications. The author's task consists in 'teaching the machine' with the aid of a software tool - CET - to produce courseware which takes into account, through anticipation, the learners to whom it is geared. The visual dimension made possible by the integration of audiovisual materials and computing gives authors the means to see what learners will see, but also to foresee future interactions with them. Clarifying pedagogical alternatives, and trying to model the training process, are tasks at the heart of courseware design: the system must be especially focussed on the author so that the author is focussed on the learner.

ORGUE is made up of a set of specialised editors according to media used, levels of knowledge representation and particular functionalities. An appropriate editor with specific funtionalities, is dedicated for each particular task, but in each editor the very simple functions are available to novices. Some kind of linkbetween each editor is essential in the team work of authors. In order for the final product to be harmonious in its different dimensions (technical, mediated and semantic) and focussed on the cognitive activity of the learner, all the produced components must be coherent amongst themselves. Author synergy is possible only if each

one is aware of the possibilities and limits of the work of the others. Therefore the general homogeneity of the graphical dialogue in the different editors helps the whole system adapt to the different types of users and makes possible their necessary cooperation. In specific terms, a number of inconsistencies exist, the elimination of which is one problem for our evaluation, described later in the paper. Let us begin by examining the presentation editors.

Figure 1 : MINIGR

MINIGR is a graphical colour editor (figure 1). Its vectorial structure allows the production of dynamic visual scenes. It can also import drawings or bitmap photographs from other editors, do graphical animation, insert and synchronise analogic or 'on the fly' digitised video.

DIESE allows text retrieval in its graphical context and the need for word processing, whilst respecting the visual layout in which it is inserted. A portion of text can be selected, edited (translated) and reinserted into its graphical context. Its basic application is finalising translations of courseware, which is important in its linguistic adaptation in a European context.

PICCOLO is a tool for modifying digitised still photographs, rather than for creating them. It allows digitised photograph windows to be inserted into the screen composition, and adjustment of their characteristics using graphic editing tools - for example, the relative intensity of component colours can be modified. The principal interest of PICCOLO is to adapt an image which possesses a large number of colours to other digital graphics cards, or to edit digitised pictures originating from different sources.

For these editors which produce visual materials, a visual mode of authoring is clearly required, and is provided by graphical interaction as illustrated in the editors described below.

SAXO is a numerical sound editor (figure 2), allowing the recording, modifying and retrieval of natural sound at several quality levels, in a mode compatible with the Integrated-services digitalized network. (I.S.D.N.).

Figure 2: SAXO

Once natural sound is digitised, words, music, noise can be represented graphically. The possibility of 'seeing sound' allows for visual manipulation. Suppressing, moving, or transferring a sound can be obtained by doing the corresponding action to the drawing.The sound layers can then be assembled with other medias according to the conditions of interactivity foreseen by the author. Graphical interaction allows sound editing in a mode homogeneous with that of the other editors. Courseware can also contain sound interactions for the learner who will have to look, hear, and talk.

DIGITISED VIDEO EDITOR

New facilities have been incorporated into ORGUE for editing high resolution digitised video images (from a videodisc). The editor allows the insertion of video sequences into courseware, windows which are resizable during real-time playback, hypermedia navigation between different sequences, and pedagogical graphical interactions as supported by MINIGR. A number of new problems for intelligent multimedia authoring systems are thus posed, including the ability of the learner perform graphical interactions in real-time, on a moving image.

SIMENU's function is to create or modify the dialogue of all the CET editors. It can also be used by the authors to produce specific learners' menus such as the control panel of a simulation. This packaging of person-machine interface proposes made to measure ergonomics that adjusts to users, authors or learners, and adapts to their tasks, according to a more comfortable and complex interactivity. There is thus a separation between the tasks of courseware development and interface design, since SIMENU permits modification of the interface without recompilation of the application program.

MULTIMEDIA EDITOR

In order to facilitate 'horizontal' links between different media editors, and the creation of multimedia 'scenes', a new multimedia editor is currently being developed (by APIGRAPH, Lyon). The editor contains a screen where windows ("reserves") containing scenes from each editor (video, graphics, sound, etc.) can be composed into multiple-media scenes, and provides a central point of access to each separate media editing tool. The integration of the multimedia editor into the functional architecture of SHIVA is discussed in a later section of this paper.

2.2 ORGUE AND VISUAL AUTHORING

With ORGUE the author textually or graphically programs interactivity and the progressive succession of courseware. A composition function makes it also possible to assemble the information produced by the other audiovisual editors. A source program is then automatically generated and compiled. Finally, link editing provides an executable (runnable) program. The tree-like representation used in ORGUE (see figure 3 , left window) does not result from the historical instruction flowcharts developed by computer scientists in the ’60s, but rather from more recent observation of the paper designing methods used by authors.

Figure 3: The ORGUE interface

The ubiquity of graphics clearly lends itself to the expression by and for the author of conditional decisions in flowchart diagrams, and visualisation of the possible courses of progression of different types of learners. Other windows provide the author with a global vision of the courseware (upper right) and, in reduced size, what the learner will see at a specific step of the programme according to his answers (lower right). The author must be able to see the different mediated elements, the structure and the links of his pedagogical steps, the alternatives in the learners choices, and as much as possible, see all of this at the same time. The author's work often implies the analysis of complex situations and the manipulation of the relations between the elements of the pedagogical environment he is creating. In this sense, graphical interaction is a means for reflection and action.

The underlying metaphor is the creation of a pedagogical map of the knowledge field and the visualising of the significant and foreseeable progression courses of the learners. Another metaphor combined within ORGUE with that of the map and the learning progression within the courseware is that of 'boxes'. These 'boxes' are entities that the author 'opens', 'fills' with media or logic objects, that he 'closes', 'places' one after another or one within another like 'Chinese boxes'. In the pedagogical editor, graphical interaction basically allows visual programming, foreseeing the learner’s activity through a spatial representation based on the metaphor of possible courses of his cognitive progression.

The complexity involved for authors in conceiving courseware, as well as the rigidity of courseware for learners has motivated a move towards using AI techniques in order to overcome existing limits. Our aim in applying AI in a multimedia authoring system is thus to increase adaptivity of courseware towards learners, and to improve modularity and extensibility of courseware for authors.

2.3 TOWARDS AI

Our evolution towards using AI is progressive and is being developed in the AAT DELTA project within the context of a collaboration between IRPEACS and the Open University, by the combination of ORGUE and of ECAL (Elsom-Cook 1988; Elsom-Cook & O'Malley 1989; O'Malley, Elsom-Cook & Ridwan 1989). ECAL uses simple AI techniques to represent knowledge of the high-level structure of a course, and to model the learner's knowledge as an indexed subset of that knowledge representation. ECAL was intended as an extension of existing CAL systems. The model of course design upon which the system was based was that of Posner & Rudnitsky (1986), whereby the author uses 'design processes' to create a static curriculum, which is operated upon by educational processes to produce a specific educational interaction. In simple terms, the author creates the static curriculum (applying a 'design process'), and ECAL takes care of adaptive and dynamic decisions concerning of ordering of material. ECAL implements a modified and restricted subset of the Posner and Rudnitsky model, notably in terms of restricting "intended learning outcomes" ('ILOs') to concept learning (it does not deal with cognitive reasoning or psychomotor skills). In addition, ECAL contains some notion of 'iterative course design', in the sense that authors are provided with 'debugging tools', for understanding the system's frame-ordering decisions, leading to possible refinement. Authors can view the course created in the manner of a student in the 'presentation system'.

2.4 ECAL + ORGUE = SHIVA.00

We can now begin to understand the way in which the model of authoring which is embodied in SHIVA is a combination of modified versions of the models of authoring in both ORGUE and ECAL. The two systems are integrated by eliminating the necessity to create links for ordering between the frame boxes created in ORGUE at the highest level, the presentation order of which is then determined by ECAL, using the high-level concepts/ILOs which the author links to each frame. In SHIVA, authors create links between high-level concepts underlying the course to be taught and multimedia frame modules using a tool called PSAUME. A diagram of the PSAUME interface is shown below.

Figure 4 : The PSAUME interface

The function of PSAUME is to allow the author to define a set of high level concepts which constitute the learning goals of the course to be created. As with other editors in SHIVA, this task is performed graphically:

authors can create concepts, name them and link them to representations of multimedia frames created in ORGUE. With reasonably large courses, there is a marked increase in the visual complexity of the frame-concept link diagram created. There are therefore additional facilities for moving concepts and frames, highlighting parts of the network, and for showing part of the total network in a number of 'subviews'. In order to make decisions as to which concepts are being taught by particular frames (how to link the concepts to the frames), it is clear that authors may need to be reminded of the contents of those multimedia materials which they created in ORGUE. Authors therefore have the facility to view (but not edit) frame contents by simply clicking and 'opening' them in PSAUME.

The result of the author's activity will be a runnable course, where the ECAL component makes adaptive decisions concerning the presentation ordering of frames, as a function of the student's responses and the specific frame-concept links which the author has established. ECAL bases its decisions primarily on a simple student model and on a model of coherent shifts in focus of the teaching dialogue, in terms of the high-level domain concepts. The confidence value of a concept taught is incremented when the student makes a correct response and when a frame to which it is linked is presented, and is decremented on incorrect responses. Coherent focus shifts are controlled via an implicit concept network which the system creates automatically from the frame-concept links established by the author: if two concepts are both linked to the same frame, then an implicit link is created between the two concepts. Given such a network, the system calculates matrices for relatedness, proximity, generality and connectedness values between each concept (see Elsom-Cook & O'Malley 1989 for details), upon which a set of teaching decision rules can operate. Since pedagogical decisions will be ultimately based on this network, the author can view the implicit network (but not edit it). A complex set of rules are used by the system for controlling shifts to new concept foci in the teaching dialogue, and for deciding the order of presentation of the frames linked to concepts. The rules for dialogue focus shifts operate in conjuction with rules for progressing to a new concept depending on the extent to which it is believed to be known to the student according to the student model.

Pedagogical rules operate at two levels - choosing a frame to present amongst those connected to the current concept focus, and choosing a new concept focus when there are no further "acceptable" frames attached to it which can be presented. Frames which are "acceptable" are those which are not yet used, and diagnostic frames are acceptable if there is at least some confidence that the student 'knows' (has had frames connected to the concept presented) the concepts to which it is connected. Once there are no further acceptable frames attached to the current explicit concept focus, the set of rules for choosing a new focus are applied. 'Implicit' concept foci are those which are directly attached to the explicit focus in the concept network created by the system from the author's activity with the PSAUME interface. 'Acceptable' concepts are those which have not been used or inspected, and which have a confidence greater than zero for all attached prerequisite concepts (these can be indicated by the author upon the concept network in PSAUME). In general, the concept focus shift rules prefer to choose an implicit focus, or else a previous focus, preferring concepts with maximum relatedness and importance, or those which have been least discussed. These rules are currently undergoing modification in response to authors' comments during evaluation. They are summarised in figure 5.

Figure 5: Pedagogical decision rules of SHIVA

At the present state of development of SHIVA, no a priori limit on the size of multimedia branching frame units has been imposed - indeed, the optimum size of such frames for authors is one major question for evaluation. However, the creation of such large frame modules would decrease the adaptive decision making capabilities of ECAL, since the student's interaction within a module is not taken into account by the student model. In order to address this problem, the author can indicate which of the concepts attached to a frame are to be decremented in the student model when the student passes via a particular route in the flowchart diagram. The author performs this task when viewing frame contents in PSAUME, indicating graphically which concepts are "assigned the blame" for the incorrect response. These matters are treated in more detail in Elsom-Cook & O'Malley (1989).

In order to view the course as presented to the student, the author must leave PSAUME, and try the course from ORGUE. Since the control which authors have over the presentation order of frames is now indirect in SHIVA, we anticipate that they may want to successively modify the concept-frame links, and experiment with the effect on frame presentation order. A set of simulation tools for describing frame presentation order from PSAUME (given assumptions concerning the student's responses) are thus under development. For evaluation of SHIVA we anticipate that authors will need to understand the teaching decisions of the system - at a certain degree of generality - in order to establish a link between their actions and those of the system. These tools for presenting frame ordering decisions are therefore intended to complement a set of tools for explaining the system's teaching decisions (called "debugging tools") which are provided within the student presentation environment.

2.5 THE STUDENT PRESENTATION ENVIRONMENT

The student presentation environment allows the author to see the course which has been created in the way which the student would see it, and provides a number of additional tools. The student can accept the teaching decisions of the system, or else change mode to one of free navigation at any point in the teaching interaction. We view these alternatives - constraint or freedom - as a first step towards implementing the concept of Guided Discovery Tutoring (Elsom-Cook 1984), being a teaching strategy which moves flexibly between the extremes of complete constraint (as in classical CAL), and complete freedom (as in the 'learning environment' approach). A "debugging" environment is provided for the author in the student environment, with which (s)he can inspect the state of the student model (a set of confidence factors attached to each concept), view the number of frames already used attached to a particular concept, and so on.

2.6 TECHNICAL EVOLUTION OF THE SYSTEM

Since SHIVA is currently undergoing rapid technical evolution, our evaluation work does not therefore aim at a 'static' single redesign in the short term, but rather a series of such designs as evolution takes place. Two important extensions to the system which are currently being performed are the integration of an additional and complementary ITS for pedagogical decision making - the DOMINIE system (implemented by the consortium of ESPRIT project 1613; see also Elsom-Cook & Spensley 1988) - and the related integration of a generic network editing tool (performed by the team led by Mark Elsom-Cook, Open University GB). The purpose of integrating ECAL into SHIVA was to provide a single demonstration system which showed how AI could be integrated with multimedia CAL, enabling research and experimentation. The long-term objective of our project is wider, in that we aim to define general requirements for authoring in intelligent multimedia CAL. Our strategy is therefore to demonstrate that the SHIVA authoring tools can also be used to define the knowledge representation for a second ITS (DOMINIE), which teaches complementary skills to ECAL. DOMINIE is a system which is designed to teach procedural skills involved in performing a computer-based task (such as word processing). Its knowledge representation therefore requires the definition of goal operators and interface tasks in the domain, together with some conceptual knowledge underlying those tasks to facilitate generalisation and learning, which will be perfromed by the generic network editing tool. The editor will enable the creation of different node and link types, whose specificity is defined by the specific target ITS for which the authoring tools are being used. For example, ECAL requires node types for 'concept' and 'frame' with simple undirected links; DOMINE requires node types for goals, interface tasks, interface actions and concepts, with directed links ('concept of', 'subgoal of', etc.). DOMINIE is being integrated with SHIVA at CNRS-IRPEACS, and the new integration will be evaluated by SEL (GDR) and DATAMAT (Italy). The evaluation will be closely integrated with evaluation work described below.

3. Evolution of the system towards users

3.1 QUESTIONS FOR EVALUATION OF THE SYSTEM

We need to define a coherent model of the authoring process in SHIVA, not only as input to future implementation plans, but also in order to present the model to users as part of the evaluation process itself. In general terms, SHIVA requires (or 'permits') authors to perform all of the processes required of them from ORGUE - conception and realisation of multimedia frames, and the specification of pedagogical branching in subframe units - in addition to representing high-level concepts in PSAUME, linked to frame submodules. Advantages of the new system therefore lie in the increased individualisation and adaptivity of teaching offered, and decreased production time for modifying existing courses. Our most general question for evaluation is: do the tools provided enable authors to achieve their goals?

We divide the goals of authors into three broad categories:

1 knowledge representation goals
2 system modelling goals
3 interface goals

With respect to knowledge representation goals, we ask whether the authors are able to represent knowledge for teaching in the manner required by the system (are they able to identify high level concepts in a teaching domain, and separate these from decisions as to how they are to be used?). System modelling goals concern the way in which authors anticipate the system and its interactivity with the student, in order to incorporate this model into the courseware design process (are authors able to anticipate and understand the system's behaviour?). Interface goals concern the ease with which users can realise these higher level goals with the interface tools themselves (are interface actions consistent and easily learnable?). We propose that at the level of interface goals, we can model the user's activity in terms of an information-processing paradigm, where users learn to search the space of interface actions which can be performed with the system (Card, Moran & Newell 1983). Important specific questions which we seek to answer are:

What's in a frame?
What is the optimum size of a (multimedia) frame module in order for a course to be comprehensible to an author, and to make efficient use of the pedagogical decision-making module? Is SHIVA more appropriate for authoring at the level of large-scale course modules, or is it more appropriate at the level of smaller units?
Explanation
Are authors able to understand the system's teaching decisions, and to establish connections between their own actions in knowledge representation and the system's behaviour?
Representing concepts
Are authors able to actually identify high-level concepts in a course for a specific teaching domain?
Existing methodologies
Are authors who already have a highly developed training methodology able to adapt their methods to the authoring process embodies in SHIVA?
Interface actions
Is the system consistent and easily learnable at the level of the interface?

We already have an indication of the importance of these questions from preliminary studies of users of SHIVA, in exploring the appropriateness of a number of evaluation techniques.

In order to address these questions we are currently performing two kinds of evaluation: the first centres on an application of cognitive science to human-computer interaction, and the second on the comparision of organisationally defined goals in an industrial training situation, with the authoring goals which are defined by SHIVA. Both kinds of evaluation can provide different and complementary sorts of answers to our questions stated above.

3.2 THE COGNITIVE DIMENSION

Since SHIVA results from a software development methodology of combining existing systems, there is a need to carefully evaluate the extent to which the combined tools present a coherent and consistent interface. Our evaluation work in this dimension is applied to both the high-level functional architecture of the system and to the specific level of consistency of interface tasks and actions, both within and across tools. Our evaluation is clearly formative in the design of the system, rather than resulting from a prior requirements analysis, design, specification and implementation.

Figure 6: The new functional architecture of SHIVA

At the level of the functional architecture of the system, analysis of the role of component editors has led to a proposed new general architecture in which editors for linking and organising teaching materials - ORGUE and PSAUME - are clearly separated from those for creating multimedia materials. In the present system, PSAUME is accessible from ORGUE, and thus in the new functional architecture these editors are indepently accessible from a general 'orientation menu'. In addition, the set of multimedia editing tools will be accessed from a general multimedia editor (see earlier section 2.1), implemented by the "APIGRAPH" company, Lyon, to

enable authors to compose frames which integrate any number of media - for example, graphics with video, graphics and sound. The necessity to return to ORGUE in order to try a course will be replaced by a 'try' environment available from each editor, to enable authors to try parts of ORGUE frames, subviews of concepts linked to frames in PSAUME, and successions of multimedia 'scenes' in the multimedia editor (see
figure 6).

In terms of 'lower level' HCI, a number of evaluation methods are available, each of which has different advantages and disadvantages (see Simon 1989 for a review). For example, the "GOMS" method of Card, Moran & Newell (1983) gives precise numerical measures of the relative efficiency of sets of actions required to perform tasks in computer-based environments, but is time-consuming to apply (a search space of goal operators and selection methods needs to be defined). Since SHIVA is currently still evolving, we have opted for an analysis method based on task-action grammars - the "TAG" method of Payne & Greene (1986) - and the variant designed to be applied to display-based systems (DTAG, Howes & Payne 1989) - since we need to identify inconsistencies by analytical methods before attempting to apply numerical methods. Preliminary work on applying the method to PSAUME has been encouraging, since the method is relatively easy to apply, and has led to to identification of a number of inconsistencies in the interface. The approach adopted was to represent the tasks which can be performed with the interface in the form of a set of task-action grammar rules, which can then be examined for syntactic and semantic consistency. The purpose of such analysis is to guide selected experimentation when an inconsistency is identified. Given the complexity of SHIVA, performing a complete task analysis would be an extremely time-consuming exercise. We have therefore videotaped four authors (professional experts with ORGUE) performing a simple authoring task. Analysis of the tapes helps us to focus task-analysis on those areas of the system where users appear to have problems, and in addition to elicit qualitative information concerning their high-level models of how SHIVA functions. Experimentation is required in order to demonstrate that the inconsistency does present genuine learning problems for users since certain changes in the interface may represent more programming work than others. In order to test differences in learnability of alternative proposed interface designs, alternative interface simulations are being programmed in HYPERCARD®, enabling a simple experimental paradigm of comparing relative time required for learning given tasks between alternative methods for implementing tasks as action sequences, for statistically significant groups of users.

Some of this work on HCI evaluation will be performed as part of the "SHIVA-Géographe" project (directed by N. Balacheff, CNRS-IRPEACS), in which we are working with geography teachers at the Joseph Fourier University (Grenoble), to produce courseware for teaching the processes involved in changes of the water-table in the Rhone-Alpes region. Since the course emphasises teaching the dynamic aspects of the processes involved, the frames envisaged involve several simulations and the use of multiple teaching analogies ('water table as bath', 'as system', etc.), which may pose interesting questions for the representation of their semantics in SHIVA. The teachers have little experience of computer-based education, but have a well-developed set of teaching methodologies derived from didactics ("didactique" - see Brousseau 1986).

3.3 THE SOCIO-ECONOMIC DIMENSION

A standard technique in the application of HCI to system design (Waern 1989) consists in a definition of the "external task" - i.e. the set of goals and methods to achieve them with which a given group of users conceive a given task - and the "internal task" - i.e. the goals and tasks which are embodied in a set of computer-based tools designed to facilitate performance of the given task. Given a representation of the two, we can then consider the extent to which the internal task matches the external task, and the extent to which the goals and methods possessed by a group of target users can transfer to the computer-based system. We can view the HCI studies described previously as attempts to define and examine the consistency of the internal task of authoring in a multimedia system. In order to define the external task, we are currently performing qualitative evaluation studies with a number of groups of users. In this case we must remember that the goals of authors are partly defined by the socio-economic environment in which they work, and by the special nature of the authoring task - the representation of knowledge for training and education. An example of a project which is currently in progress is the WESTMILL company (Paris). WESTMILL is a company which provides training in the use of commercial English, particularly in the Banking sector. The company has a well-defined training method, with a good track record of success. A specific 'audit' of training needs for each job function is provided for a particular company, in terms of a set of linguistic activities (eg "speaking on the telephone", "small talk", etc.), each of which are analysed into a set of grammatical structures required, together with the precise vocabulary which would be needed. We are presently working with this company in order to take a

small part of one of their courses for remedial English, including booklets for linguistic competences, together with videos, and attempting to perform a 'reconception' of the course in terms of the authoring process demanded by SHIVA. This study promises to provide interesting results in terms of the extent to which an existing course design methodology can transfer to SHIVA, and the extent to which the epistemological assumption of SHIVA - that a course can be analysed into a set of high-level concepts - can apply to this domain. For example, it is apparent that WESTMILL have a number of ways of conceptualising the training domain - in terms of linguistic competences, job-specific activities, and so on - which do not at first seem to fit easily into the single conceptualisation incorporated in SHIVA. The special nature of learning methods used in language teaching may prove to provide a strong test of the relative 'domain independence' of SHIVA, and on the other hand may demonstrate the relative advantages of a multimedia system for training in specific domains.

4. Conclusion

The central theme of this paper has been the interaction between software development of a complex multimedia intelligent authoring system and evaluation studies designed to ensure a consistent integration at the interface level, which meet the education and training needs of users in an institutional and socio-economic context in Europe. Such an authoring system comprises a highly complex ensemble of computer-based tools, and therefore demands extensive research in order to ensure its ease and appropriateness of use. Our enterprise is facilitated by the multinational and multicompetence nature of our research team, which includes experts in computer science, training and CAL, audiovisual, artificial intelligence, cognitive science and human-computer interaction research, in France, England, Germany and Italy. The contribution to research and development of our project will be a design specification for the requirements of an intelligent multimedia authoring system in a European context. The project is exploring new ground in the imposition of authoring requirements on Intelligent Tutoring Systems, on the combination of AI and multimedia and on the attempt to combine research in CAL educational technologies with ITS research tools. We believe that our research strategy of combination of existing systems and complementary evaluation strategies is proving to be a fruitful method for addressing these new and complex problems.

Acknowledgements
Members of the multidisciplinary team of the "Computing and Training" department at CNRS-IRPEACS, directed by Jean-Louis Leonhardt have assisted

with this paper. The team includes Romain Zeiliger (principal implementor of ORGUE and the ORGUE-ECAL integration), Christian Bessière, Michael Baker, Michel Giry, Jacqueline Vacherand-Revel, Christophe François and René Chalon. Sylvie Bouguet provided expert assistance in document design and production. Evaluation work is being carried out jointly with Claire 0'Malley and Peter Bibby at the University of Nottingham (GB), the team led by Mark Elsom-Cook at the Open University (GB), and in coordination with the team at Standard Elektrik Lorenz (GDR). The integration of DOMINIE is being carried out at CNRS-IRPEACS, together with DATAMAT (Rome) and SEL (GDR).

Bibliography

Brousseau, G. (1986). 'Fondaments et Méthodes de la Didactique des Mathématiques'. Recherches en Didactiques des Mathématiques, vol. 7, no.2, pp. 33-115.

Card, S.K., Moran, T.P. &Newell, A. (1983). The Psychology of Human-Computer Interaction. Lawrence Erlbaum Associates, New Jersey.

DELTA Project D1010, 'Advanced Authoring Tools', Workpackage 8, Deliverable 1: Authoring for ITS, The Open University, Great Britain. Workpackage 1, Deliverable 2: Authoring for CAL, CNRS-IRPEACS, France.

Elsom-Cook, M. (1984). Design considerations of an Intelligent Tutoring Systems for Programming Skills. PhD thesis (unpublished), Department of Psychology, University of Warwick (GB).

Elsom-Cook, M. & O'Malley, C. (1989). ECAL: Bridging the gap between CAL and ITS. CITE Report 67, I.E.T., The Open University, Great Britain.

Elsom-Cook, M. & Spensley, F. (1988). Knowledge Representation in a tutoring system for procedural skills. CITE Report No. 36, IET, The Open University (GB).

Howes, A. & Payne, S.J. (1989). Display-based Competence: Towards User Models for Menu-driven Interfaces. Report of Alvey/SERC Project GR/D 60355, Lancaster University (GB), British Telecom plc.

O'Malley, C., Draper, S. & Riley, M. (1984). Constructive Interaction: A method for studying human-computer-human interaction. INTERACT '84, (ed.) Shackel, B., Elseivier Science Publishers (North-Holland).

O'Malley, C., Elsom-Cook, M. & Ridwan, E. (1989). The ECAL Authoring Environment. CITE Report 67, I.E.T., The Open University, Great Britain.

Papert, S. (1980). Mindstorms: Children, Computers and Powerful Ideas. Basic Books, New York.

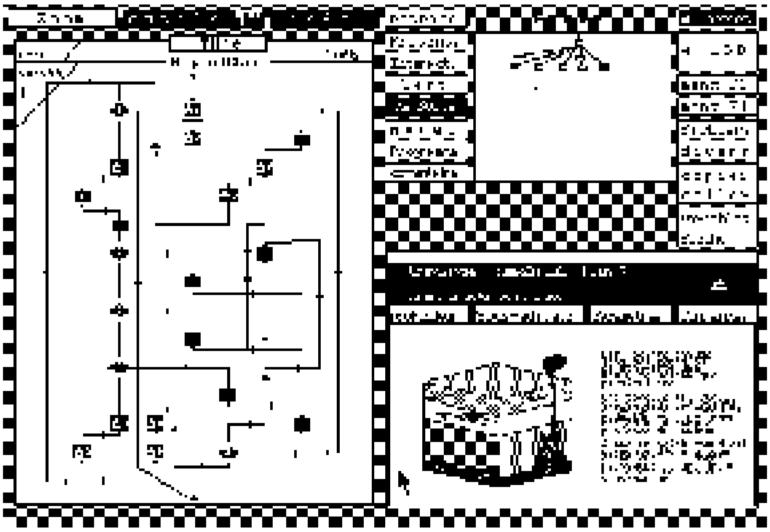
Payne, S.J. & Green, T.R.G. (1986). Task-Action Grammars: A Model of the Mental Representation of Task Languages. Human-Computer Interaction Vol.2 pp. 93-133. Lawrence Erlbaum Associates.

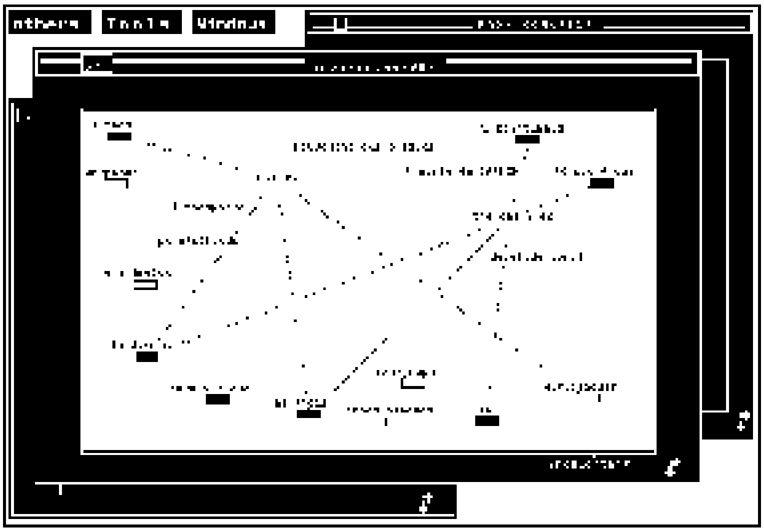
Posner, G.J. & Rudnitsky, A.N. (1986). Course Design: A Guide to Curriculum Development for Teachers, 3rd Edition. Longman, London.

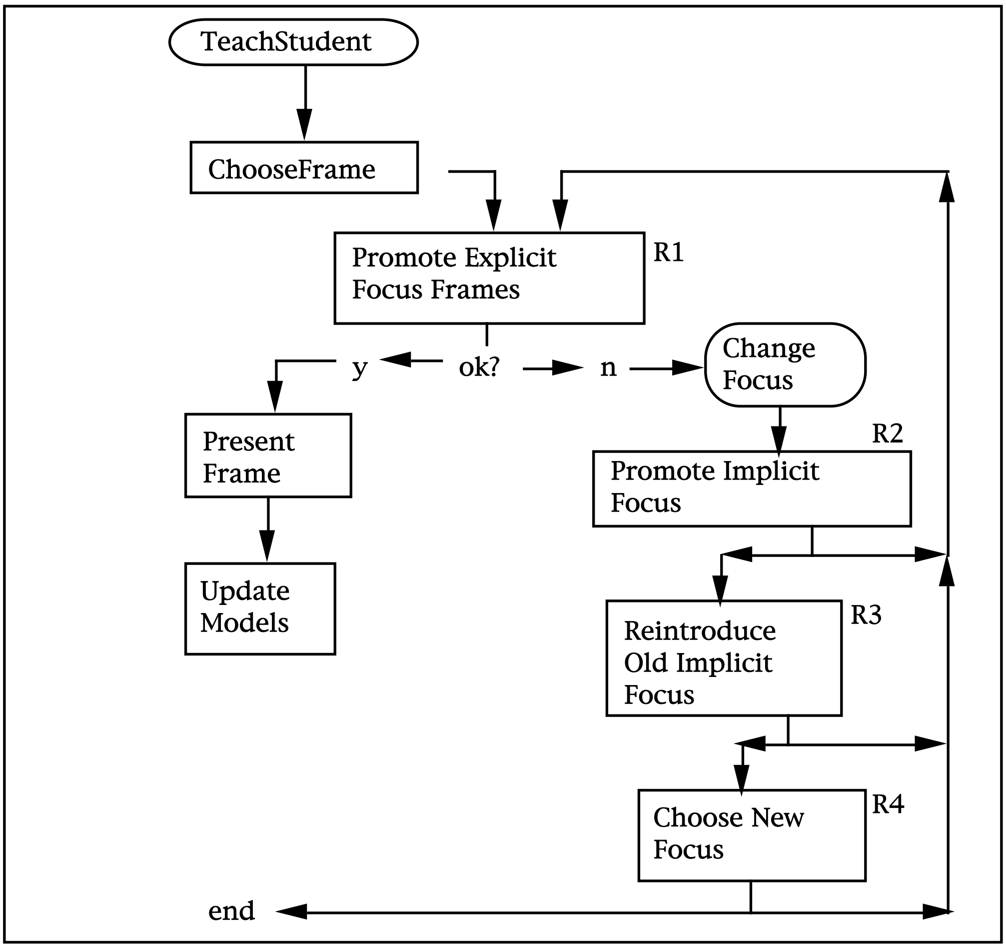
Simon, T. (1988). Towards a Rational Taxonomy of Cognitive Models in Human-Computer Interaction. HCI '88.

Spensley, F. (1989). Generating Domain Representations for ITS. Artificial Intelligence and Education, Bierman, D., Breuker, D. & Sandberg, J. (eds.), IOS Publishing, Amsterdam.

Waern, Y. (1989). Cognitive Aspects of Computer Supported Tasks. John Wiley & Sons, New York.




Tools



"Acceptable frame" =
not yet used & (diagnostic) only if confidence > 0 in all related concepts.

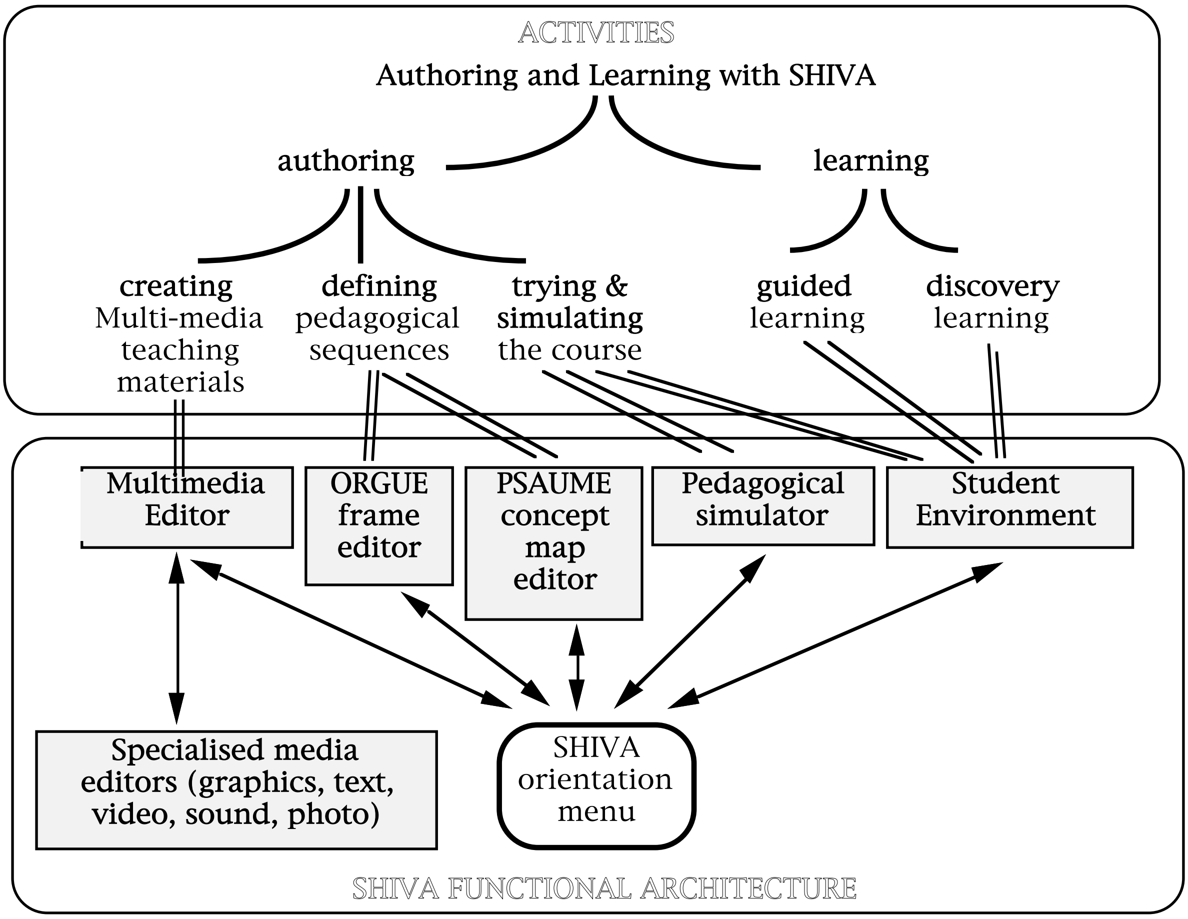
"Acceptable concept" =
not all used & not already inspected & lowest prerequisite confidence > 0.

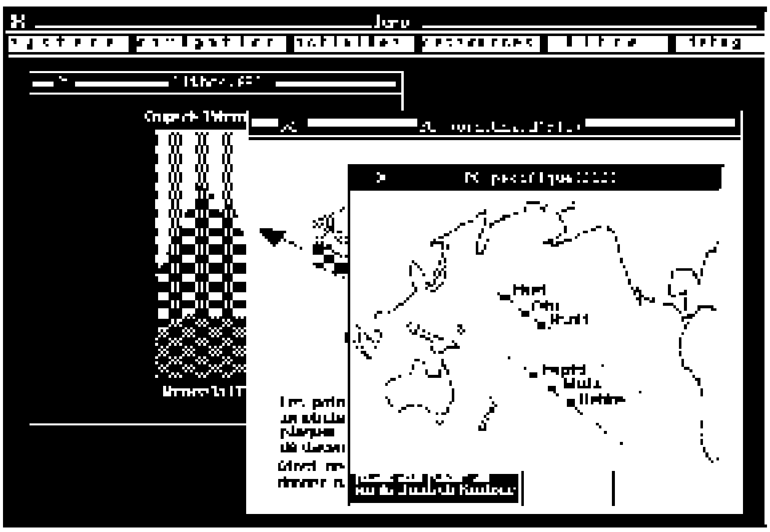
R1: among acceptable frames, choose the one with maximum frame confidence.

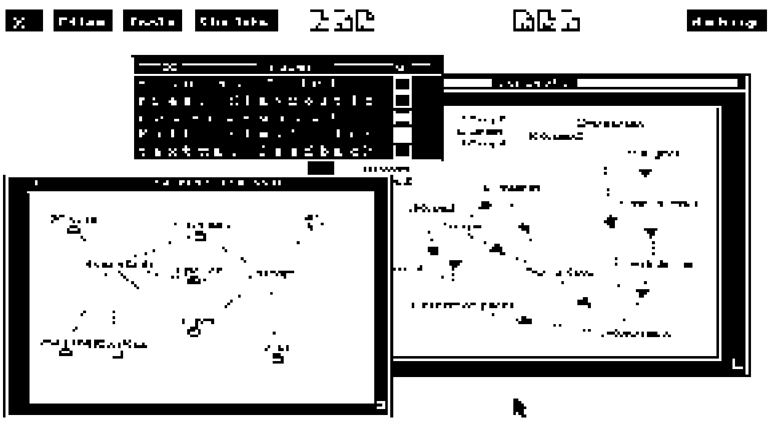
R2: among acceptable concepts, choose the one with the highest relatedness.

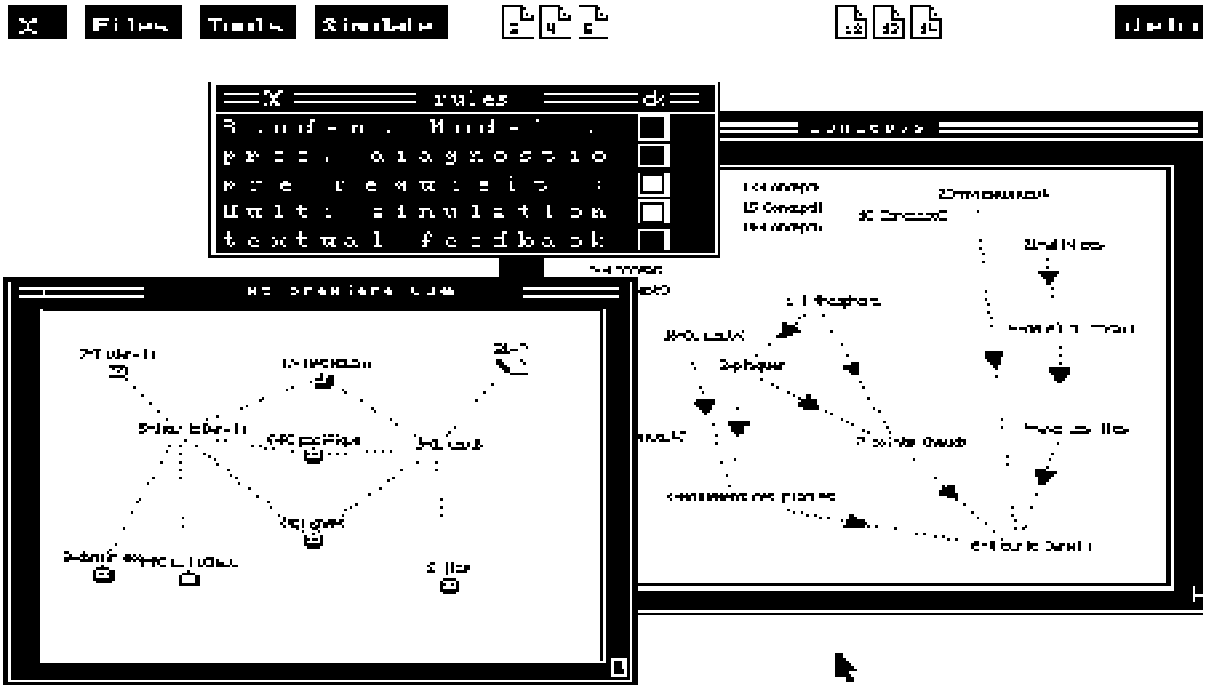
R3: Among acceptable concepts, choose the one least discussed.

R4: among acceptable concepts, choose the one which is most important.


ACTIVITIES
Authoring and Learning with SHIVA
authoring
learning
creating Multi-media teaching materials
defining pedagogical sequences
trying & simulating the course
guided learning
discovery learning
Multimedia Editor
ORGUE frame editor
PSAUME concept map editor
Pedagogical simulator
Student Environment
Specialised media editors (graphics, text, video, sound, photo)
SHIVA orientation menu
SHIVA FUNCTIONAL ARCHITECTURE






Files
Tools
Simulate
rules
ok
textual feedback