Paper 4:

Supporting Database Design Learners

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Introduction

- A large body of high quality teaching materials is currently available in the Department of Computing at the University of Northumbria at Newcastle (UNN), in the form of lecture slides and accompanying notes, practical exercises and their model solutions, past examination questions, etc. As part of an on-going effort within the department to make courses available to students in a distance learning mode, this material is currently being adapted to make it suitable to access via the World-Wide Web. However, although 'passive learning' material such as lecture slides and handouts can be easily adapted for delivery via the Web, the more practical aspects of the courses that we deliver are problematical. A parallel research effort within the department is currently addressing this problem. The initial focus of our efforts has been on adapting a course on Database Design to delivery by Distance Learning mode. The rest of this paper is organised as follows: the first section describes the problems inherent in learning database of systems analysis and design, database design can only truly be learned by practical application of the relevant techniques (McLeod, 1996). In addition to introductory and background material such as that found on the web site, students must also be given the opportunity to apply their knowledge to practical problems in database design. Traditionally, this takes the form of pencil and paper exercises based around pre-prepared scenarios.

Database Design

- Database design is taught as a component of many Higher Education computing and information systems courses. Database design is initially introduced to the student by means of a series of lectures which outline the relevant concepts, notations and methodologies which are fundamental to the subject. Within the Depatment of Computing at UNN, daabase design teaching materials have recently been adapted to delivery in distance learning mode via The World Wide Web. Figure 1 shows a screen shot of the Department of Computing database design website. Basically, this contains lecture slides and accompanying notes, practical exercises and their model solutions, past examination questions and model answers etc. There is also a bulletin board, in which staff and students can leave messages, ask and answer questions about any aspects of database design. The site covers the three fundamental techniques in database design - Physical, Entity Relationship Modelling and Normalisation.

  Our intention was that the website could support converntional learners on-site, as well as distance learners. However, although we believe web-based material should prove to be a valuable resource for all our students, we believe that its usefulness on its own in supporting the learning of the practical techniques of database design will be limited, particularly with regard to distance learners. in common with most other aspects of systems analysis and design, database design can only be truly learned by practical application of the relevant techniques [7]. In addition to introductory and background material such as that found on the website, students must also be given the opportunity to apply their knowledge to practical problems in database design. Traditionally, this takes the form of pencil and paper exercises based around pre-prepared scenarios.

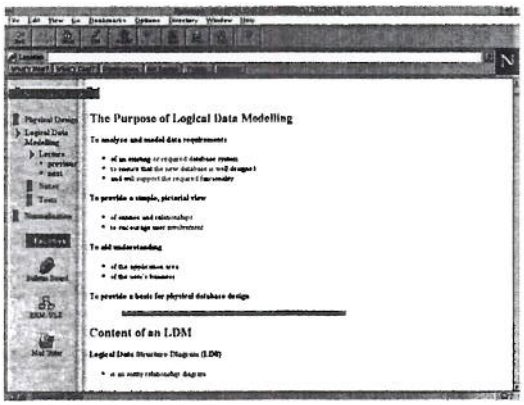

Figure 1 A Screenshot of the UNN Database Design Website

One of the fundamental techniques in database design is Entity Relationship (ER) Modelling. The ER model (Chen, 1996) and its extensions (Teorey, Yang and Fry, 1986) are widely used for software development in industry. ER modelling is a technique for capturing the data requirements of an information system. The underlying concepts of ER Modelling are simple. An ER Model consists of only three types of constructs: entities ('things about which we wish to store data', e.g. 'customers', 'orders' etc.); attributes of these entities ('customer name', 'order number'); and relationships amongst these entities (a customer 'places' orders). The task of the ER modeller is to analyse a textual description of a given scenario, to identify the salient elements of that scenario, and to assign each of these to one of the three ER construct types, using a diagramatic notation. This is a complex task, and novice modellers make many mistakes when attempting it (Batra and Antony, 1992). A great deal of practical experience of ER modelling is required if a student is to become proficient in the technique. This requirement for extensive practice can be very demanding of a tutor's time. Because of the difficulty of ER modelling, it is essential that errors made by novices are corrected as soon as possible, ideally as they are committed. This is because, as in many other areas of design, an 'anchoring heuristic' is widely observed in novice ER modellers, whereby they become reluctant to review any parts of a model that they have already constructed. Without appropriate and timely feedback, novices will frequently anchor to an incorrect model, and this model will becomes increasingly incorrect as further elements are added to it. If a database design course is to be delivered successfully in a distance learning mode, distance learners

must receive the required level of support when practicing database design techniques such as ER modelling. We are currently building a learning environment to provide this support.

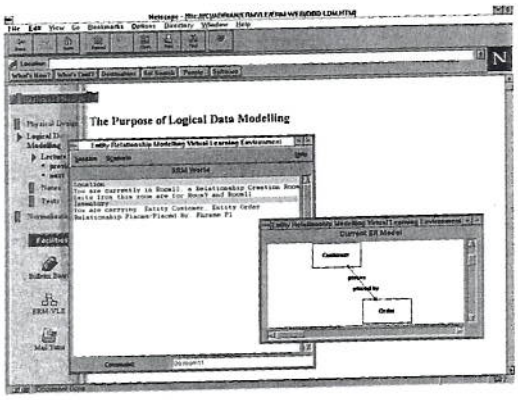

Figure 2: The ERM-VLE client interface running on top of the UNN database design website

ERM-VLE

- ERM-VLE (Entity Relationship Modelling - Virtual Learning Environment) is a text-based virtual learning environment for ER Modelling (Hall and Gordon, 1998). The system uses the Multi-User Dimensions paradigm, which has seen increasing recent use for educational purposes (Fanderclai, 1995; Hughes and Walters, 1995). In ERM-VLE the task of the learner is to study a textual scenario and construct an ER model which correctly reflects the data requirements implicit in this scenario. The virtual space within ERM-VLE represents both the scenario and the modelling task. In order to construct a model, the learner must navigate around in this virtual space, collecting and manipulating objects as she goes. The virtual space in ERM-VLE is made up of a number of interconnected locations or 'rooms' of different types. Scenario rooms are locations where the learner can collect textual elements of the scenario. Other rooms represent locations where model elements can be built from elements of the scenario, such as Entity Creation rooms, and Relationship Creation rooms. The task structure of the ER modelling problem is reflected in the topological organisation of the virtual world. For example, learners are not allowed to progress beyond the Entity Creation rooms before all entities from the scenario have been correctly identified. By implicitly embodying a method for ER modelling in the virtual world, learners are encouraged to follow an ordered rather than a chaotic task sequence (as is often observed in novice learners).

As well as being encouraged to follow a structured task sequence, learners are given immediate feedback about the correctness of their model as they are building it (thus counteracting the anchoring heuristic). As well as the learners themselves, ERM-VLE is populated with 'pedagogical agents' which provide this feedback to the learners (Gordon and Hall, 1998). Essentially, these pedagogical agents have a model solution to each scenario, and know about the correct correspondances between elements from the scenario and elements from the correct ER model for that scenario. They also have knowledge about the common errors that learners make when building ER models. Whenever learners attempt to build an incorrect part of an ER model, the pedagogical agent will intervene, and explain why the action that the learner is attempting is incorrect.

A second important source of support is available to learners other than that provided by the pedagogical agents. ERM-VLE is a multi-user system, so that multiple learners can attempt to solve the same problems simultaneously. Although each learner within ERM-VLE inhabits a separate, though parallel, virtual world, learners can communicate accross virtual worlds, using simple commands such as 'tell' (pass a message to one user in particular) and 'broadcast' (pass a message to all other users). This opens up the possibility of learners supporting one another in collaborative problem solving.They may also seek help from their instructor, who may also be present within the virtual world.

ERM-VLE uses a client-server architecture, so that users of the system can be either local or remote.The ERM-VLE client interface is written in Tcl/Tk, a script based language for implementing graphical user interfaces (Ousterhout, 1996). The virtual world itself, and the pedagogical agents within it, are implemented in CLIPS, and expert systems programming language (NASA STB, 1997). As can been in Figure 1, there is an icon within the UNN database design web site which is

labelled 'ERM-VLE'. Clicking on this icon starts up the client interface to ERM-VLE. The user can then connect to the ERM-VLE system, and can begin to attempt ER modelling tasks. While doing so, they will have simultaneous access to the support provided by the UNN database design website (lecture slides, notes, the bulletin board, etc.) and to the more directly practical support provided by ERM-VLE itself (pedagogical agents, other learners, the instructor). Figure 2 shows the client interface to ERM-VLE superimposed over the UNN database design website, as it would appear to the learner when running it.

Two of the panes that form the ERM-VLE client interface are shown in figure 2 (a third displays the scenario to the learner in its entirety, in so far as it has been discovered by the learner). The first pane, labelled 'ERM world' in the figure is where the learner interacts with the virtual world. This consists of a command entry box, and a panel which records the interactions of the learner with the virtual world, the pedagogical agents, and with other users of ERM-VLE. Learner input is indicated by a grey background, responses from the world have a white background. The second pane, labelled 'current ERM', contains a graphical representation of the ER model that the learner is currently building. This changes dynamically as the learner adds to or changes elements in the model. This pane was added so that the learner would not be required to remember the current state of her ER model.

Discussion

- Early indications as to the usability of the ERM-VLE system have been encouraging. We are currently about to undertake a full-scale study of the system's effectiveness as a learning environment for Entity Relationship Modelling. We are also confident about the generality of our approach to learning the skills required in many sub-disciplines within Information Systems and Computing. We feel that it would be relatively straightforward to adapt the ERM-VLE architecture to deal with normalisation and physical database design, the other two fundamental techniques of database design. We are also currently looking at the feasibility of adopting the same approach to supporting novice computer programmers. However, we also feel that there may be many other disciplines in which relevant skills are related to the manipulation of textual scenarios to produce some kind of model or design. Disciplines such as the Built Environment and Law might yield some interesting possibilities, for example.

Although we need to do more research in order to establish the generality of the ERM-VLE approach, we do feel that it offers interesting insights into the way in which learners, especially those learning in distance mode, might be supported in learning skills which can only be learned through extensive practical experience. we feel that the use of learning environments which embody pedagogical agents, and enable collaborative learning can for the basis of such support.

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