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ABSTRACT

Educational technology and artificial intelligence (AI) are natural partners in the development of environments to support human learning. Designing systems with the characteristics of a rich learning environment is the long term goal of research in intelligent tutoring systems (ITS). Building these characteristics into a system is extremely difficult: each requires the use of techniques from AI, including knowledge representation, diagnosis and user modeling, planning, machine learning, and natural language understanding. Artificial intelligence techniques are usable now in practical systems. To illustrate this, several working systems that use artificial intelligence and that have been developed in the ARIES Laboratory (University of Saskatchewan, Canada) are discussed. The SCENT advisor can be used to provide robust diagnosis in a wide variety of problem solving domains. The learning by teaching system inverts the usual instructional paradigm: the system acts as an inquisitive learner, thus stimulating the human learner to refine and extend his/her knowledge. G.E.N.I.U.S. takes advantage of the credibility invested in a programming advisor by human learners in order to provide "ignorance-based" advice on programming errors. Finally, the VCR Tutor provides help to learners on how to program a video cassette recorder. The general lesson is that AI and educational technology can interact in a natural synergy to the mutual benefit of both. (Contains 11 references.) (MAS)

Artificial Intelligence and Educational Technology: A Natural Synergy

-Extended Abstract-

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Abstract: It is argued in this extended abstract that educational technology and artificial intelligence are natural partners in the development of environments to support human learning. Moreover, artificial intelligence techniques are useable now in practical systems. To illustrate this, several working systems that use artificial intelligence and that have been developed in the ARIES Laboratory are discussed.

It is sometimes assumed that the key to supporting learners is to provide them with a "flashy" interactive discovery environment that has fancy graphics, lots of colour, sound, sturm und drang. This is contrasted to "stodgy" old "computer assisted instruction" (CAI) systems that march the learner lockstep through a pre-programmed instructional sequence. I would like to argue that neither the flashy discovery environment nor the stodgy old CAI system will stimulate learning in the long term. The key to motivating a learner for the long haul is to provide him or her with a rich learning environment that

- supports the learner's development at the deep cognitive levels;
- allows the learner choice in setting goals (within the context of the domain);
- responds to the learner's changing needs;
- helps the learner to focus on a task or goal that is particularly relevant;
- knows the domain and ways of learning the domain;
- communicates with the learner in ways natural to the learner.

The essential point is to combine learner control with deep support. The learner is neither left on his or her own, as in the flashy discovery environments, nor dictated to as in the stodgy CAI approaches.

Designing systems with these characteristics is the long term goal of research in intelligent tutoring systems (ITS). Unfortunately, building each of these characteristics into a system is extremely difficult. Each requires the use of techniques from artificial intelligence (AI), including knowledge representation (if the system is to "know" the domain), diagnosis and user modelling (if it is to "understand" learner behaviour), planning (if it is to help the learner focus on relevant goals or tasks), machine learning (if it is to understand various ways of learning about the domain), and natural language understanding (if the system is to communicate with the learner on his or her own terms).

There have been two main criticisms of the ITS agenda:

- ITS is following the wrong star; it is trying to replicate the human teacher, rather than using computing technology in ways more natural to the technology;
- the AI techniques upon which ITS depends are not well enough developed to be used in actual systems.

Neither criticism is fully justified. There is nothing explicitly in the ITS agenda that necessitates replicating the functions of a teacher. In fact, the word "tutoring" in "intelligent tutoring systems" is meant to indicate flexible notions of supporting learning, as a tutor does, rather than directing learning, as a teacher does. Even if the goal is to enhance a discovery environment it is necessary to employ many of the same AI techniques that would be needed to replicate a teacher. Thus, the functionality and interface of a discovery environment could be tailored to meet the individual needs of a learner through user/learner modelling. The discovery environment could provide knowledge-based help and/or advice using natural language. Tasks to work on could be suggested based on an instructional plan being kept within the discovery environment.

The second criticism seems more justified. Many ITSs have indeed had to drastically narrow their domain or restrict the learner in order to keep within the capabilities of the system. The AI problems are not nearly solved. However, this doesn't mean that AI can't be gainfully employed to provide "value-added" to a learning environment, even without fully solving all of the AI problems. This is particularly true if clever ways are found to offload from the learning environment the need to be fully responsible for all possible behaviour patterns of the learner. As Self (1990) discusses, such offloading can either be on to the learner or onto a human facilitator working in symbiosis with the learning environment.

Much of our research in the ARIES Laboratory at the University of Saskatchewan is aimed directly at the second criticism. We have been explicitly exploring how AI techniques can be used in real systems to be deployed with actual human learners. This has required us to take a variety of approaches. We have refined and extended the AI techniques themselves, as in our work on granularity for diagnosis.(the SCENT project (McCalla, Greer, and the SCENT Research Team,1990) or our work on instructional planning (carried out in collaboration with Darwyn Peachey and Barbara Wasson and reported on in (McCalla, 1992)). We have been able to make clever use of existing AI techniques (as in the VCR Tutor (Mark and Greer, 1991)). We have carried out basic research into AI issues (as in our work on belief revision for student modelling (Huang, McCalla, Greer, and Neufeld, 1991)). We have been able to find applications suited to a particular AI technique (as in our learning by teaching system that exercises machine learning techniques (Srinivas, Greer, and McCalla, 1991)). It has even proven possible to take advantage of the social context of a particular learning situation in order to create a robust learning environment (as in the G.E.N.I.U.S. program advising system (McCalla and Murtagh, 1991)).

In this talk I will discuss several of these systems, showing how AI can be practically employed now to enhance the capabilities of real systems for real world use. The systems I will present have all been implemented and tested with human subjects.

In particular, the SCENT advisor will be discussed, and I will show how the granularity-based representations (McCalla, Greer, Barrie, Pospisil, 1992) we have developed in the ARIES Laboratory can be used to provide robust diagnosis in a wide variety of problem solving domains. SCENT also comes equipped with the AROMA knowledge engineering environment which makes the development of a new application much easier than it would be otherwise. SCENT has been tested in the domain of LISP recursion in a couple of studies, one of which involved linking the system to another ARIES system, the scaffolding environment PETAL (Bhuiyan, Greer, and McCalla, 1992), in order to provide a distance learning capability. This study is reported on elsewhere in this conference.

I will also present the learning by teaching system (Srinivas, Greer, and McCalla, 1991). In learning by teaching the system inverts the usual instructional paradigm. The system acts as an inquisitive learner, thus stimulating the human learner to refine and extend his or her knowledge. Learning by teaching is still a prototype system, but does make clever use of machine learning techniques from AI in a way that does not require these techniques to have cognitive fidelity. Moreover, the system is very robust, working in any fact-based or taxonomic domain without needing any *a priori* specialized tuning.

The next system, G.E.N.I.U.S. (McCalla and Murtagh, 1991), takes advantage of the credibility invested in a programming advisor by human learners in order to provide "ignorance-based" advice on programming errors. G.E.N.I.U.S. uses a discrimination net to provide standard stimulus-response answers to questions from the learner. The result is a remarkably robust system that is relatively easy to engineer, although in its present form only partially successful in its effect on learners.

Finally, the VCR Tutor (Mark and Greer, 1991) will be presented. The VCR Tutor provides help to learners on how to program a video cassette recorder. But, it's main goal has been to show that a knowledge-based approach actually enhances learning. To this end four different versions of the VCR Tutor, ranging from a knowledge-based version to an environment that merely provides opportunities for exploration without feedback, were tested with 20 subjects each. This large-scale empirical study showed a clear positive relationship between the knowledge-based approaches and the capabilities of the human subjects in programming the VCR, as demonstrated in a post test. This study shows that AI indeed can provide value-added to a learning environment.

The general lesson of this talk is that far from being diverse research endeavours, AI and educational technology can interact in a natural synergy to the mutual benefit of both.

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References

Bhuiyan, S., Greer, J.E., and McCalla, G.I. (1992). Learning recursion through the use of a mental model-based programming environment. *Proceedings of the 2nd International Conference on Intelligent Tutoring Systems (ITS 92)*, Montreal, Quebec, 50-57.

Frasson, C. and Gauthier, G. (eds.) (1990). Intelligent Tutoring Systems: At the Crossroads of Artificial Intelligence and Education, Ablex, New Jersey.

Jones, M.L. and Winne, P.H. (1992). Adaptive Learning Environments: Foundations and Frontiers, NATO ASI Series F85, Springer-Verlag, Berlin-Heidelberg.

Huang, X., McCalla, G.I., Greer, J.E. and Neufeld, E. (1991). Revising deductive knowledge and stereotypical knowledge in a student model, *International Journal of User Modelling and User Adapted Interaction, 1*, 1, pp. 87-115.

Mark, M. and Greer, J.E. (1991). The VCR Tutor: Evaluating instructional effectiveness. *Proceedings of the 13th Annual Meeting of the Cognitive Science Society*, Chicago, 564-569.

McCalla, G.I. (1992). The search for adaptability, flexibility, and individualization: Approaches to curriculum in intelligent tutoring systems. In Jones and Winne (1992), 91-122.

McCalla, G.I., Greer, J.E., Barrie, J.B., and Pospisil, P. (1992). Granularity hierarchies. *International Journal of Computers and Mathematics, Special Issue on Semantic Networks, 23*, 2-5, 363-376.

McCalla, G.I., Greer, J.E., and The SCENT Research Team (1990). SCENT-3: An architecture for intelligent advising in problem solving domains. In Frasson and Gauthier (1990), 140-161.

McCalla, G.I. and Murtagh, K. (1991). G.E.N.I.U.S.: An experiment in ignorance-based automated program advising. *AISB Newsletter, 75*, United Kingdom, 13-20.

Srinivas, P., Greer, J. E. and McCalla, G. I. (1991). Learning by teaching. *Proceedings of the International Conference on the Learning Sciences*, Northwestern University, 357-363.

Self, J.A. (1990). Bypassing the intractable problem of student modelling. In: Frasson and Gauthier (1990), 107-123.