Artificial Intelligence and Education

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The remnants of regimental battle flags from the Southwest of England on display in the Exeter Cathedral bring to mind long past battles of a once glorious Empire. High above the picturesque cathedral lies the campus of the University of Exeter, itself the battle site for a remarkable scientific controversy in September of 1985 at a conference on "artificial intelligence and education". For a change, this time it was not proponents and opponents of using computers in education who clashed vehemently, but rather two sides from within the artificial intelligence camp itself. For the first time they held a joint conference at critical mass capacity, so to speak; representatives of the LOGO school of thought, who had flown in from the USA, proceeded to launch a massive offensive against the home-based "intelligent tutoring systems" group, which counterattacked with equal intensity [10].

The LOGO school has its origins in the Artificial Intelligence Laboratory at MIT. Its pedagogical ideal is independent, self-guided learning as postulated by Piaget and as practiced in such model schools as A.S. Neill's Summerhill: pupils and students are to learn and explore in special didactically developed, "micro-worlds" such as have been, for example, demonstrated by their principal advocates Papert [8] and Lawler [4]. The main thrust of this approach is that the pupil autonomously and independently explore a certain realm of study while merely receiving guidance from his instructor. The intent behind the method is that the pupil not only grasp certain learning concepts, but also learn autonomous and active problem-solving. Yet beyond a few prototypes of the medium "micro-world" -- such as the well-known turtle graphics – hardly any didactically sound micro-worlds exist, making clear the immense need for the creative construction and didactic "tuning" of micro-worlds. Internationally, however, there are but few centers with a sufficient number of qualified researchers and the proper equipment to set themselves these goals, due to the inertia in educational policy-making.

The "intelligent-tutoring-systems" (ITS) group is a derivative of the "Computer assisted instruction" (CAI) school of thought, the latter in turn originating in the learning machine culture of Skinner's behavioristic learning theories. The intent here is to simulate with the computer a tutor as intelligent as possible for a specific realm of study so that with the computer's help given material can be taught as efficiently and completely as possible. From the pedagogical point of view the learning machine approach can be best circumscribed by the word "drill".

Whereas "computer assisted instruction", familiar in the form of programmed instruction, has as a point of departure an implicit student-teacher model, the new approaches of ITS attempt to represent the supposed thinking process of teacher and student explicitly. (Two publications by Sleeman and Brown [9] and O'Shea and Self [7] report on the current status of research on this approach.) By explicitly representing the knowledge to be transmitted and the methods of its acquisition the hope is to obtain operational didactic means of simulating the fine structure of the individual thought process. To be sure, the modelling attempts to date have shown how little explicit knowledge exists on the representation of problem-solving and learning processes of the student on the one hand, or on the didactic concepts of the teacher governing understanding and teacher-assistance on the other hand. The consequence is that today's models in very narrowly defined areas barely approximate the quality of individual human instruction.

Yet the quality of existing instructional programmes can certainly be improved by applying methods of ITS for some of the areas where CAI is currently utilized. Moreover, the successful experimental use of Anderson and Reiser's [1] LISP Tutor at Carnegie Mellon University has met with widespread acclaim. Reason enough for an impressive amount of subsidy monies to be made available through the defense budget in the USA last year, which in turn catalysed a boom in ITS research and development at various research centers.

But where exactly did the conflict lie which broke out between the two ideological positions? Cynthia Solomon formulated the reproach directed by LOGO-advocates at ITS-proponents in approximately the following manner: current ITS systems could by no means be described as intelligent and should not, therefore, be utilized for the instruction of children.

In defense, ITS-proponents maintained that current systems have by all means demonstrated proficiency in partial areas of achievement similar to achievements by human experts, and in addition, pointed out that other practical applications of artificial intelligence, for example the "expert systems", are not subjected to the claim of a profound, complete and adequate representation of human knowledge. Measured by the pragmatic standard also used for the "expert systems", ITS has its justifications in pedagogy, they contended.

Finally, several ITS proponents proposed in rejoinder to the LOGO group that no scientific proof of advantage of discovery learning *per se* exists and that LOGO's successes appear guaranteeable only in "instructor-rich" environments.

Happily the course of the conference was not ultimately defined by continuing controversy, for it soon became clear that a common theoretical interest in artificial intelligence and in the explication and representation of learning and instruction tied the participants together. The problems with which the designer of micro-worlds is confronted are similar to those facing the developer of ITS. Both need a profound epistemological analysis of their fields of study; for both, the problem presents itself of how to adapt their system to humans, give didactic assistance; and both have the same deficiency with respect to profound theoretical explanations of the learning and instructional process. Finally, the problems with respect to a programme of study and training for both areas of interest are almost identical.

This trend became clear especially in the following contributions:

Di Sessa, who comes from the LOGO camp and has developed a remarkable refinement of LOGO, called BOXER, at MIT along with Abelson [2], presented studies analysing the naive elements of student knowledge in the realm of physics. He called for a theory of naive common sense knowledge of physics which would serve as a constructive bridge to an analysis of formal scientific knowledge. It is interesting to note that in the ITS camp (as well as in the expert-system group) the topic of "naive physics" is also experiencing a boom.

Drescher (MIT) demonstrated a new theoretical approach to "Translating Piaget into LISP", an attempt to simulate the developmental processes of sensorimotor-development by a computer representation of a "schema mechanism" [3]. A change of paradigm is due here: Marvin Minsky has just completed his epoch-making book on the "Society of Mind", which he has been working on for over seven years [6] and his students, like Drescher, are attempting first realisations of the postulated genetic approach.

Feurzeig (BBN), who together with Papert developed the LOGO language, introduced his project of an algebra tool-box, which is ideally suited to bridge the gap between the two camps in a concrete way: Feurzeig's algebra tool-box is an attempt to integrate the micro-world *and* ITS approaches in the form of an "intelligent microworld". This mixture promises an initial clarification of how functional both approaches are, it now being possible to perform practical experiments and gather concrete experience.

Several new trends in ITS also became clear in the course of the conference:

The development of ITS-Shells, analogous to the development in the expert-system field, is in full swing at different research sites; especially, however, in the US. Whereas LISP machines with their excellent graphic capabilities and the programming environment for "rapid prototyping" can meanwhile be taken for granted at the US centers, the Europeans, even when highly qualified, still have difficulty in obtaining financing for their research projects and can but dream of equipment which is standard fare for their American colleagues.

Due to a non-existent research and development policy, many European researchers have, in frustration, since turned to other areas of artificial intelligence research or followed calls to the US. This is especially true for England, a few years ago at the forefront in this area of research and now having had to forfeit its lead to the US. Researchers in other continental European countries who were concerned with both artificial intelligence and education have been and remain an exception. At the moment improvements such as supra-regional research centres on the Common Market level do not appear in sight, as subsidies are currently available only for industry and merely the introduction of hardware into schools and universities has been taken as a measure in the educational sector. Software and an infrastructure are not (as yet) a point in discussion. The omissions of the past explain the dearth of qualified experts who could serve as "multiplying agents". And certainly one would be hard put to produce these experts at will, as the interdisciplinary nature of the field (artificial intelligence, cognitive science, pedagogy and an area of special interest, e.g. mathematics) necessitates many years of study and training.

The interesting contributions of the conference which ranged from programming environments to the question of how to teach artificial intelligence will be published in a book by the organizers of the conference: Lawler and Yazdani [5]. And the dynamics of that new research domain in education is marked by the intent to held this conference every second year: The next event will take place in 1987 at the "Learning Research and Development Center" at the University of Pittsburgh.

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