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As an academic who has had a long term interest in Artificial Intelligence, it is hard to disagree with the call from some "AI types" for more attention in education to such things as general concepts, thinking skills, transfer and creativity. And, as a cognitive instructional theorist deeply involved in microcomputer-based instruction (CBI), their current anticipation of a bright future for the field could hardly fall on more ready ears.

Nonetheless, my views on the proper mix of CBI and more traditional approaches to education differ by 180 degrees from those of the more extreme proponents of "micro-worlds" and such education-oriented programming languages as LOGO. While most would agree that micro-worlds, etc., can have significant educational value, some, unfortunately, have gone so far as to imply that artificial intelligence will soon make obsolete the need for teaching information and specific skills and, hence, that computers should be used exclusively to teach thinking and all those other good things. There are four problems with this suggestion.

First, the definitions of conceptual learning, thinking and so on, where offered at all, have been at best ambiguous. Indeed, there is often a direct correlation between the grandiosity of the educational goals espoused and the inability to demonstrate that these goals can be achieved by the means proposed. Perhaps the primary advantage of CBI is that such instruction is highly replicable, that one can, in fact, reliably demonstrate educational improvements - as long as the goals are reasonably clear and measurable. It is not true, in this regard, that teaching information is incompatible with teaching concepts, meaning, or even "thinking." In a well-constructed curriculum, one tries to do all of these things in an integrated fashion.

Second, irrespective of rapid advances in cognitive and instructional theory generally, and in artificial intelligence specifically, it will be a very long time, if ever, before it will be feasible or desirable to dispense with information and specific skills in education. If western societies are to continue to advance,
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we clearly need people who can think independently and comprehensively and must encourage such capabilities in our youth. But, the fact remains, elitists aside, that society will always need “Indians” with specific skills as well as the “Chiefs.” It is here. I believe, that computer-based instruction, especially that involving cost-effective and practicable micro-computers, can and will play its most important role in the education of MOST students. Clearly, CBI can usefully be used to impart new information and skills as well as to provide drill and practice of previously taught materials (although most current systems are less than optimal in this respect). But that is a far cry from viewing CBI as “merely” an automated drill instructor, as some have done.

Third, there is no a priori reason for believing that computer-based instruction, or the use of computers for problem solving and/or as an object to be controlled by programming, are the only, or the best, means of teaching people how to think. Indeed, there is strong reason to believe that traditional agents (e.g., teachers, books, internships, etc.) will in the foreseeable future continue to play a major role in teaching the complexities of real thinking in the real world, where complex interactions abound among symbol manipulation (at which computers excel) and perception and physical actions (at which computer systems are obviously primitive compared to man).

Finally, the importance of the above observations is by no means diminished by the assertion, commonly made by those to whom I refer, to the effect that educational goals which can be formulated operationally are not worth teaching. Indeed, if my own research in structural learning over the past two decades shows anything at all it is that creativity, thinking skills, transfer potential or whatever, and not just facts and low-level skills, can be represented in operational terms. To wit, I would challenge: If one wants to develop a “micro-world” with educational value then one must also accept the responsibility of specifying what a child studying (i.e., “exploring”) that micro-world might be expected to learn. While a good deal of work might be required to do this, our research demonstrates that it can be done (e.g., in such disparate fields as algebraic proofs, Scandura, 1977, and Piagetian conservation, Scandura & Scandura, 1980). Moreover, the responsibility for doing so cannot be sloughed off by claiming lack of interest. To disclaim interest in educational goals is to forfeit one’s right to educational influence.

My point is that, while we have learned a great deal about how students learn and how to teach effectively and efficiently, while we are learning and must continue to learn more about higher mental processes, a major role of CBI for some time to come will and should be directed toward teaching information (including conceptual information) and specifiable cognitive skills—and, yes, even drill and practice where this is justified by the importance of the skills involved. Not only is this an area where we can expect major improvements at the present time, but it also is the area in CBI where we can expect greatest acceptance from the educational establishment.

Footnote

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References


In addition to his research, he has organized an ongoing series of interdisciplinary conferences and a new international society on structural learning, including a NATO Advanced Study Institute, "Structural/Process Theories of Complex Human Behavior." He is currently director of Structural Learning, Instructional Systems Design and Computer-Based Instruction at the University of Pennsylvania and president, Instructional Micro Systems, a company specializing in the development of advanced instructional systems for use on microcomputers.

Dr. Scandura received his B.A. and M.A. degrees from the University of Michigan and his Ph.D. degree from Syracuse University in 1962. He has also taught at the State University of New York, Buffalo, Syracuse University, and Florida State University, and has been a post-doctoral research fellow or scholar in residence in experimental, mathematical, and educational psychology and artificial intelligence at Indiana University, University of Michigan, E. T. S., Stanford University, and M. I. T., respectively. He completed a one-year U. S. O. E. senior post-doctoral fellowship at the Institute for Mathematical Studies in the Social Sciences at Stanford University during 1968–69 and won Fulbright Awards to West Germany in 1975 and 1976.

_**Structural (Cognitive Task) Analysis: A Method for Analyzing Content**_

_**PART I: BACKGROUND AND EMPIRICAL RESEARCH**_

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Having decided on the topic to be taught, the first step in designing effective instruction is to specify precisely what the student is to learn and in what order. In the former regard, behavioral objectives are the most commonly used means for identifying what is to be learned. In comparison to course outlines and general lesson plans, behavioral objectives have the distinct advantage of being operationally precise. It is relatively easy to measure whether or not students have mastered the required material.

Nonetheless, behavioral objectives have two major disadvantages (e.g., Scandura, 1971; Ehrenpreis & Scandura, 1974). First, while behavioral objectives specify what the learner is to be able to do after instruction, they leave open the question of exactly what processes must be learned in order to do that. This is an important intrinsic limitation because it can be proven (e.g., in computer science) that if there is even one process for performing successfully on a class of tasks, then there must be an infinite number of other processes for doing the same thing. As a concrete illustration consider the different possible paths one might follow in moving from location to location. From an instructional perspective, of course, not all of these different processes may be equally desirable or feasible. The second major disadvantage of behavioral objectives is that they do not allow the instructional designer to make provision for the unexpected, in the sense of building into a curriculum the potential for solving unanticipated kinds of tasks. Since the sheer bulk of what might be taught is so vast, it is impossible to teach directly everything that one might need to know. Indeed, our whole educational system is based implicitly on the assumption that learners can evidence some degree of creativity.

The technique used most commonly by designers to sequence instruction is based on task analysis. As with behavioral objectives, traditional task analysis has the major advantage of being relatively easy to apply. Its essentials are well summarized by (repeatedly asking and answering) the familiar question, "What would a learner have to be able to do in order to perform that task?"