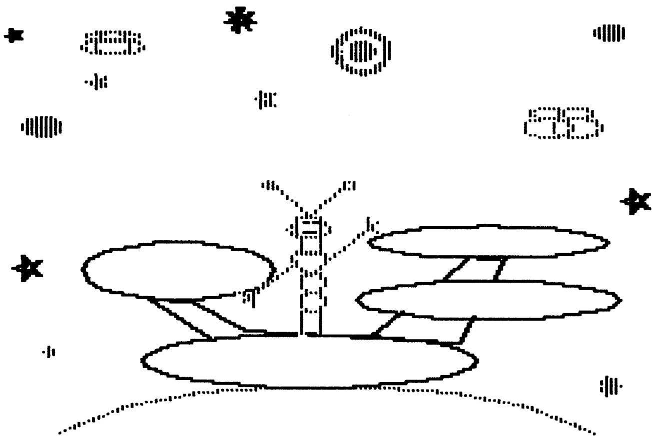


"Without Logo My Ship Won't Gogo"
Janneke Baan and Maria Sarai

Steve Hunka

Some problems of computer assisted instruction

Grasping the scope and consequences of change in the classroom signaled by the advent of the computer has become urgent for any thinking professional. It is easy to magnify the image of that change when the glass of the future is not clear. Hunka does not minimise the scale of changes impending, but as an experienced researcher into the underlying practical issues of educational enterprise he is able to bring to bear an instrumentality of certain considerations that gets us down to earth. After presenting us with an unexpected reminder of the richness of the state of the art in computer-assisted instruction that existed in 1968, he moves to current problems and poses a number of searching but answerable questions about such matters as the role of the teacher and the achievement of quality in instruction. His discussion of these problems, and his concluding part on problems yet to be resolved, is conducted with what one might call horse-sense systematically applied, in a manner that only research experience could supply but that gives teachers a firm grasp on concerns they can recognize as their own. The computer is thus brought into perspective in the landscape of the future.

There are still many problems for which solutions must be found before computers can make an appreciable contribution to the instruction of each student in our massive system of public education. During the last five years, the basic role of CAI (computer-assisted instruction) and the concepts associated with its use have not been enlarged upon to any great extent. However, technological advances have forced most teachers to recognize that at least some of their instructional activities are no longer uniquely human.

A richness in the early systems

Many early developments in equipment, software, and courseware, and in the integration of these to make a substantial contribution to instruction, began as early as 1968. For example, there is no commercial CAI system today which has the richness of the student terminal hardware which was available with IBM's 1500 system, a version of which was initially used by Patrick Suppes. The IBM 1500 CAI system provided each student with a monochrom cathode ray tube, a light pen, an audio play and record system, as well as a film projector, all under control of the courseware. Even the Plato system, as marketed today by Control Data Corporation, does not provide such facilities for the student and the courseware author, nor does any commercial microcomputer.

The richness of the IBM 1500 CAI system allowed for a number of exciting and creative developments during the mid-seventies. At Pennsylvania State University, two mobile vans housing IBM 1500 systems were used to bring the special education Computer Aided Remedial Education (CARE) series of courses to rural teachers, and at the same time more traditional subject matter to students. The CARE courses were designed to be the primary source of instruction, and upon successful completion led to university credit. One of these vans was located for a time at the Mayo Clinic and again in Montreal for purposes of demonstrating a cardiology course developed at the University of Alberta, where over 26,000 student hours of CAI instruction per year were being delivered. The cardiology course made full use of all the audio-visual capabilities of the IBM 1500 system.

In addition to teaching cardiology by CAI to all undergraduate medical students at the University of Alberta, the Royal College of Physicians and Surgeons developed a large number of patient-management simulations which were, during one examination year, used across Canada for evaluating candidates for the RCPA specialist degree. These simulations included access to laboratory and radiological results, and to a physical examination and the historical facts of the patient. Simulations of emergency cases provided a real-time assessment of such vital signs as heart rate, blood pressure, and respiration. During the same period, Fairfield University in Connecticut was making available to students a newly developed language called APL, while in Chicago IBM's subsidiary, Science Research Associates, was producing courseware using APL.

CAI activities were not all directed towards post-secondary instruction. In the same period the Chicago and Philadelphia school systems were operating very extensive instructional programs using large computers. For example, Chicago had approximately one thousand computer terminals located in its elementary schools.

Not all CAI installations however were as dynamic and creative as those which have been noted. Some installations were not staffed with computer technicians competent to handle the programming and hardware required to incorporate the needs of students and the demands of the courseware authors. In some instances, negative results of research could be attributed to poor selection of equipment and a naive understanding of computing concepts.

The early years of CAI did have their problems. Equipment was less reliable than today, computers operated at much slower speeds, and the memory capacities were substantially less. Programming a CAI course required that a program code be efficient in speed of execution and in use of memory; otherwise it could be rendered useless because of the system's lengthy response times to the student. On those computers which had special audio and film projection devices, the costs of preparing curriculum for these media were heavy. Facilities for editing large segments of text were slow in operation and tedious to use compared with the text-processing capabilities of the microcomputers of today.

The late seventies brought constrained financial resources upon educational institutions, with the result that many CAI installations, and particularly those operating on research grants, were forced to close before many innovative advances could be properly documented and adequately evaluated.

Some current problems in CAI

As with any rapid and major introduction of change because of technological advances, severe adjustments are usually required on the part of the work force. Frequently, the introduction has been delayed or decelerated by collective action. This tends to produce an even more traumatic effect when the introduction is made, because of increased resentfulness in the work force and the further enhancements made in the interim to the technology. The development of the computer's ability to simulate human efforts ensures that almost every work place as currently known will be affected, resulting in readjustments in varying degrees required of the work force. The teaching force is not immune to the dynamics of adjustment due to technological change.

As computer capabilities are enhanced by large memory systems, faster speeds, more versatile software, and highly adaptive systems particularly, computers will encroach upon many instructional activities regardless of the subject matter area. To some extent this has already occurred, as shown by instructional courseware being frequently given using the same descriptors of instructional strategies as those employed with traditional instruction. In addition, courseware has been so developed as to be the primary source of instruction in a number of post-secondary institutions.

When CAI courseware becomes a primary source of instruction, and acceptable for academic credit, then a number of important problems arise:

1. What role should the teacher play in support of CAI? Should the teacher act as a resource person, tutor, diagnostician, or critic of the courseware? Should these roles be allocated among different teachers? Should some teachers take on a special role, to develop in students appropriate social behaviour, while other teachers concern themselves with academic achievement? How important is it for teachers to evaluate operational courseware qualitatively, and to provide this information to authors as one source for courseware improvement?

2. To what extent should continuous progress be instituted? Continuous progress implies that a very large amount of quality courseware must be continuously available for students to use.

3. If CAI courseware in a subject is not extensive, then how best can it be integrated with existing classroom practice? Perhaps CAI should only be used for those functions which cannot be handled by the teacher, such as exploration of number systems, or for topics for which the teacher has had little training?

4. Should the computer take on specialized roles such as diagnosis and remediation, with the teacher playing the primary role in instruction? If this is done, is the computer simply being used to recover from the errors or failures of the traditional modes of instruction?

5. How should the effectiveness of CAI programs be evaluated in the context of the classroom? If individual teachers are not formally evaluated, why should CAI courseware be evaluated? Is it any more or less valid to compare traditional instruction with CAI instruction, than to compare one teacher with another?

The roles of a teacher

CAI courseware is generally 'bounded'; that is, the domains of content and of student interactions are structured and controlled to a large degree by the nature of the program code. This characteristic limits the degree to which students can explore ideas on their own while using CAI courseware. Although a highly structured instructional strategy may have its merits for a wide range of students, it can hardly be recommended as the only instructional approach. Conversely, the use of highly unstructured instructional strategies cannot be fully supported either. It would seem then, that the problem of defining the appropriate mix of approaches needs to be solved.

In addition, this problem most probably requires consideration of the role that strategies generated by the teacher are to play in this mix.

This problem is not trivial, as in some subject matter areas there may be a very fine distinction between creativity and chaos. At present one way of providing the student with an unstructured and potentially creative environment is to allow the student access to a variety of programming languages, which can be used by students to explore the frontiers of their own ideas. The role of the teacher in providing guidance to the student in this exploration is quite different from the role required in support of courseware having precisely defined boundaries. In the former case guidance is required to ensure that fruitful avenues are being explored with elegance rather than brute force, while in the latter case the teacher's role is to be supportive of the specific objectives of the courseware. Supporting the objectives of the courseware requires the teacher to intervene as a diagnostician and tutor, and to report any deficiencies of the courseware to the authors.

In the case where students are desired to explore the frontiers of their own ideas, the programming language which provides the vehicle of communication with the computing system is very important. What programming languages should be used or are best suited for this purpose? Although some languages may be better suited to exploring ideas in mathematics, few if any languages are available for such subject areas as the language arts, social studies, music, and art. Although definitions of software for new languages will continue to evolve, it is likely that those suited for commercial and scientific environments will continue to receive the greater attention of computer scientists and computer manufacturers. However, there is likely to be some spin-off from commercial and scientific program development, as might be expected for example from the development of symbolic manipulation programs developed for scientific purposes.

The only alternative to this situation is for educators themselves to take a role in specifying at least the functional characteristics of the computer languages they require. Unfortunately, teachers at present seem to rely solely on such languages as Basic, which have very limited potential for the easy exploration of concepts outside the arithmetic field. Teachers have an important role to play in guiding the development of CAI, by specifying at least the functional characteristics of CAI systems required for effective instruction.

Obtaining quality in instruction

The problem of obtaining instructional quality is not unique to CAI, as it has existed in the more traditional areas in which audio-visual devices have been used, such as educational television. Indeed, the problem of ensuring instructional quality also plagues the classroom teacher on a daily basis.

In CAI the problem of instructional quality is accentuated, for a number of reasons. Firstly, computer-based instruction tends to be much more public, and therefore is more open to scrutiny and criticism. Secondly, CAI processes are reproducible to a much greater extent than traditional instruction; and thirdly, the interaction of the courseware with each student can be closely monitored and evaluated.

The development of courseware requires many of the same processes and components as the development of a good traditional classroom lesson. There are additional requirements based on the hardware and software characteristics of the computing system, which do not have close parallels in the traditional setting. These factors include the following:

a. Subject matter must be organized with regard to the internal logic and complexity of the basic concepts, and yet be tempered by the psychological needs and characteristics of the students.

b. The instructional strategies must be well suited to the instructional task at hand. For courseware of any importane the variety of instructional strategies will be quite extensive, and will include effective introductions to new content, diagnostic and remedial sequences in addition to tutorial sequences, drills, testing, reviews, and even simulations where appropriate. All those factors which enhance learning in the traditional classroom are equally important in CAI.

c. The adequacy of the computing system in supporting the presentation of content - through the availability of such capabilities as graphics, audio, animation, a variety of character fonts, a light pen or other device for making a pointing response, and true video - is also important, as such capabilities may individually or collectively be indispensable for some areas of instruction. For example, many aspects of foreign language instruction must have an audio component.

d. Since the content and instructional stragegies, with their references to peripheral computer devices such as audio, must be represented within the computer by sequences of program code, the flexibility and power of this code may determine to a large extent the feasibility of developing a CAI course. Highly interactive authoring systems are required, using the best software developed in such specialized computing fields as word processing, graphics, digitalized audio, artificial intelligence, information retrieval, and numerical computation.

e. Once a CAI course becomes operational, attention centers more upon the administrative support systems than upon the course content and the instructional strategies. For example, an instructor wishes to know what parts of the course each student has completed, which students are falling behind, which students should be identified for assistance, and what are the examination marks for each student - as well as more general class statistics. Such information is easily collected in the traditional classroom, but it requires special software systems, usually independent of the authoring language, in the case of CAI.

Each of the factors noted above raises a number of questions and related problems. The interaction of content and instructional strategies defines not only the main path through the course most students are likely to take, but also any secondary paths, their content and instructional strategies, as well as the conditions under which these other paths should be assigned. The assignment problem is not at all well defined by the research literature even for the traditional modes of instruction. In all likelihood, this problem requires solutions specific to the subject matter and background of the students. It is likely that there is more than one combination of curricular organization and instructional strategies that will produce similar amounts of learning.

Problems yet to be resolved

Instructional strategies, ideally, should be generated by learning theory, but it is unlikely that a single instructional strategy generated by a specific learning theory can be applied throughout a course of major size. Different learning strategies are required for different learning situations, and in addition consideration must be given to such factors as motivation, visual perception, and the background and level of maturation of the learner. The combining of these factors is today as much an art as it is a science, frequently requiring extensive evaluations in non-laboratory settings. For extensive CAI courses, this approach is expensive, although a greater level of success, and eventually lower costs, can be attained by careful and deliberate planning - in the course design phase - to incorporate those procedures which are predicted to enhance learning. Even for the simpler instructional strategies employed in CAI such as drill and practice, one should not assume that an optimum combination of factors has currently been achieved.

The use of special peripheral computing devices such as audio, graphics, light pens, and photographic-like visuals is available on very few CAI systems. Thus many factors related to their use individually and collectively are yet to be explored. For example, research has provided little guidance regarding the size of the target area to be used when young children are required to use a light pen to make a pointing response.

Similarly, research has provided little guidance as to the amount of and need for repetition of audio instructions with children who are unable to read. For example, it is not necessarily reasonable to follow the high degree of audio repetition in giving instructions frequently used in some methods of reading instruction, since young children recognize quickly from the screen-display configuration the task to be carried out. In addition, many instructional paradigms used in the classroom assume an attentiveness on the part of the learner because of the central role played by the teacher. In the application of CAI, such a central role cannot be assumed to be inherent in the equipment, and other attention-getting procedures are probably necessary. These procedures must also be sufficiently varied to ensure that their impact is not lost by repetitive use. The problems of using CAI with young children present many unique problems which are yet to be resolved.

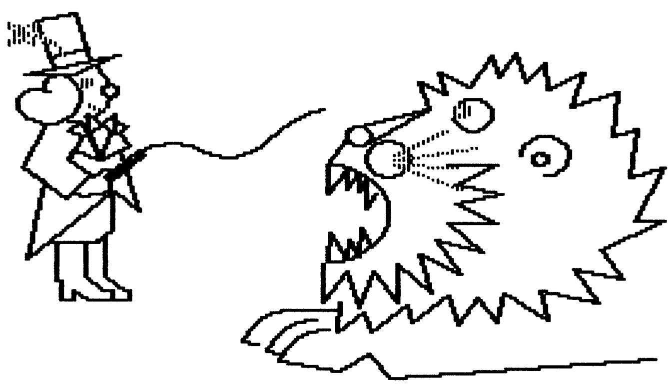
An extensive CAI course which becomes a primary source of instruction may have as many as one hundred thousand computer instructions. Although this number may seem very large, it is not large when one considers the amount of textual information which must be displayed. The human time demanded and the associated costs in writing courseware are rapidly becoming prohibitive, and therefore some method other than writing computer instructions must be developed. However, the development of authoring systems rather than authoring languages is no minor technical task, since so many features currently considered specialized must be made available to the author. For example, course authors desire to have the power of word processors in developing formats for screen displays of text; the capabilities of computer-aided design systems for the creation of graphics; the deciphering power of language translation systems; and the audio capabilities of a language laboratory or a high fidelity music system. Each area noted currently forms a highly technical and specialized field of research and development. The problem of bringing such specialized fields together in a sufficiently integrated and simple-to-use manner remains a major challenge in the development of CAI. Clearly, the provision of such systems must evolve, as they are too complex to be created by a single major effort.

The evaluation of the effectiveness of CAI courseware is not a simple or inexpensive procedure. Several levels of evaluation are required, the first level being to determine whether the program instructions operate correctly, and the second level being to decide whether the instructional objectives are being met. For a large CAI course containing tens of thousands of computer instructions, the number of different paths through which students may pass is so large that verification of each by an author is practically impossible. In such a case, specialized software is required so that the computer may provide evidence for the functionality of each path. However, even if a CAI course operates correctly, this does not guarantee that learning will take place. Extensive testing in the field is required in which both quantitative and qualitative information is collected. During this phase the courseware requires modifications to optimize its instructional effectiveness, and this may require rewriting parts of the program to effect better instructional strategies, reordering the sequence of topics, the addition or improvement of graphics, an improved analysis of responses, and the introduction of additional monitoring procedures. Only after courseware has been optimized should it be subjected to an evaluation. However, comparative evaluations raise the traditional problem of validity, which is most problematic when CAI is to be compared with traditional modes of instruction.

A certainty, but also uncertainty

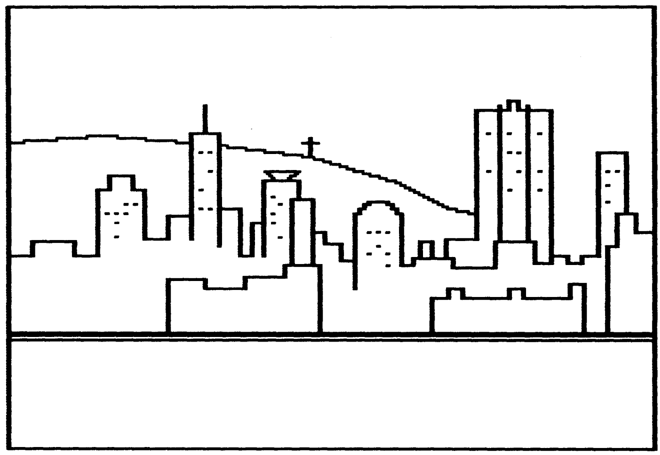
The escalating demands for greater author and student support capabilities can only lead to the evolution of CAI towards the simulation and eventual surpassing of many of the human capabilities required to carry out the complex process of instruction and to maintain the associated support systems. Hopefully, as this evolution takes place, uniquely human contributions to the processes of instruction will not be attenuated. There is, however, no guarantee that this will not happen.

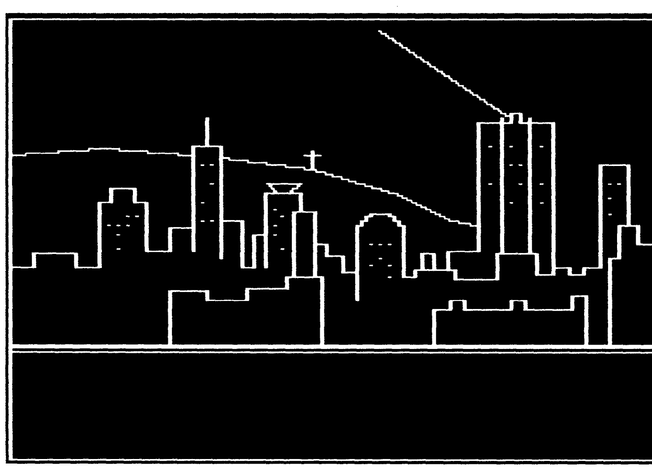
Steve Hunka has been actively involved with computers since 1956. Currently he is a Professor at the University of Alberta, and coordinator of the Division of Educational Research Services in the Faculty of Education, where his work involves both numerical and instructional uses of computers.



"Fearless Patricia"
Mellie Francisco and Shirley Soma

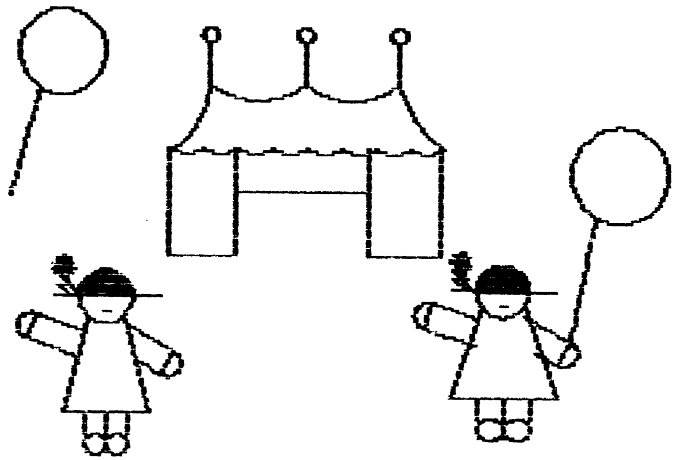
The smaller graphics in this issue were done by teachers as a part of an introductory course on computers in education at McGill, to demonstrate their control of the Logo "turtle". This exercise was only one of several aspects of the course, and was done after about 20 hours of experience on the microcomputer.



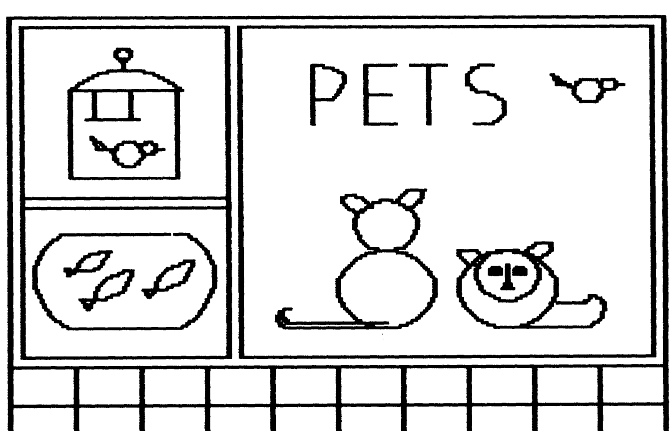


"Montreal By Day"
Gordon Norris

"Montreal By Night"
Gordon Norris



"Bye Circus, Bye Balloon"
Linda A. Carter and Gloria Labrecque



"Petshop"
Helen Guay and Thelma Hunter