Knowledge-Building Technologies

Beyond Information Access

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The Royal Commission's recommendations on technology are sane and sensible — and ten years ago they would have been considered forward-looking. For, ten years ago the software available to schools consisted of lots of programs for doing this and that — programs of highly variable quality, calling for Circular 14-type screening — plus business productivity software adapted for student use. That is still mostly what is in use in schools. In the hands of creative teachers, it's possible to do great things with it. But we have also seen it used in some of the worst teaching we have observed.

The irony is that ten years ago a Royal Commission would have noted that Ontario was a leader in educational technology. Somehow that lead was lost. There is no suggestion in the current report of regaining leadership or of a guiding vision. There is more the feel of Ontario as a discriminating consumer, not a creator of mainstream technology. To the Royal Commission, it seems, innovation consists of model-school projects using off-the-shelf technology. That, too, was a forward-looking idea ten years ago. It was the idea behind the Apple Classrooms of Tomorrow program. It is interesting to note, however, that Apple's first venture into advanced educational software did not come out of their model classrooms. It came, in fact, from Huron Street Public School in Ontario, and CSILE (Computer-Supported Intentional Learning Environments) is a technology developed at OISE. In its press release of CSILE (termed Collaborative Learning Product by Apple), Apple Inc. states:

> **Apple Introduces Ground-Breaking Product For Collaborative Learning**
> During a meeting of key education press at Apple headquarters today, the company introduced [the] Collaborative Learning Product, an integrated, research-based product and the first collaborative learning offering available for the K-12 education market. The Collaborative Learning Product allows students to build their understanding of a topic by working in discussion groups while sitting at personal computers. Using the specially designed collaboration software, students are able to send electronic notes to one another to discuss events, examine factual information and raise and address questions. Once they have entered their responses to one another in a shared database housed on a workgroup server, they can hone their ideas as they add comments to the growing discussion.
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> Unlike bulletin-board services or electronic mail, the network-based product provides a structure for student-centered inquiry that extends the learning process beyond the traditional boundaries of fact presentation and recall. Classrooms using this product will be able to engage in

"knowledge construction" through a process that entails problem statement, theory presentation, comment and the introduction of new information.

"We've been using collaborative learning for a long time," notes June Fuji, a teacher at the Ohlone School in Palo Alto, Calif. "What this product adds is a structure for writing and knowledge building. It's designed so that many students — even in different classes — can work together. And because it permits students 'think time,' it provides a more even playing field."

This product is the result of years of education research...and directly addresses the education reform recommendations detailed in the SCANS (Secretary's Commission on Achieving Necessary Skills) Report, published in July, 1991 by the U.S. Dept. of Labor. This report highlighted the need for students to learn a set of skills critical to success in the workplace of the 21st century. These skills include the ability to organize resources, to work with others, to learn a variety of technologies, as well as the ability to acquire, understand, and evaluate information.

As the Apple release suggests, the CSILE technology invented at OISE represents a new generation of educational technology. It is not business software retooled for children; it is technology specifically designed to support knowledge construction. It provides more than a set of tools. It provides an environment to support the kinds of inquiry, information search, and discussion that go on in research teams and knowledge-building groups of all kinds. Accordingly, we call it "knowledge-building technology." We have been working on the development of knowledge-building technology for nine years, and are happy to see this work influencing technology developments elsewhere. The Schools for Thought project, centered in St. Louis, is probably the most deeply innovative educational development project of its scale anywhere. And it not only uses Ontario-based technology, but its project director, Mary Lamon, is a Canadian, living in Toronto.

CSILE was built originally on the Ontario-invented and developed ICON computer, which was far enough in advance of the field to give us a substantial lead with networked architectures. Only years later, with support from IBM and Apple, was CSILE exported to IBM then Macintosh platforms. Ironically, it is now claimed as an Apple invention, addressing learning guidelines put out by the U.S. Department of Labor. Andrew Nikiforuk, writing for the *Globe and Mail* in 1992, suggested this sort of thing would happen, that if Canadians do not seize opportunities for leadership they will have to settle for the branch plant status that the Royal Commission seems to take for granted.

Ontario has the potential to lead, and should be taking steps to realize that potential. A first step will be rethinking the recommendations set out by the Royal Commission.

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Contrasting Recommendations: Learning, Teaching, and Information Technology

To give a sense of the way the Royal Commission has approached educational technology, I have abstracted from their recommendations phrases that indicate the action they propose. The first thing to note is that virtually all the actions are to be carried out by the Ministry of Education and Training. Beyond this, however, the action phrases themselves strikingly reveal the kind of thinking represented in the Report.

Key Technology-Related Actions Recommended by the Royal Commission

Actions to be carried out by the Ministry of Education and Training:

- tabulate available resources
- create a clearinghouse
- facilitate alliances
- develop standards
- develop licensing protocols
- support high-profile and diverse projects
- approach other ministries
- co-ordinate efforts to distribute surplus computers
- increase the budget for purchasing
- ensure Circular 14 assessment of electronic materials
- identify priority areas in which Canadian content and perspective are lacking
- promote production
- support projects to extend access
- upgrade Contact North from audio to interactive video

Other actions, not necessarily carried out by the Ministry:

- make educational use of information technology part of the curriculum for teachers
- promote professional development for "appropriate use of information technology in the classroom"

Summary: Themes Underlying Royal Commission Recommendations

Three themes are evident in these recommendations: (a) access, (b) centralized control, and (c) implementation. Overall, the recommendations are a blueprint for bureaucratization, not innovation.

Conceptual Framework for an Alternative Set of Recommendations

At the same time that the Royal Commission was conducting its interviews, Carl Bereiter and I were conducting a special project on school reform as fellows at the Center for Advanced Study in the Behavioural Sciences in California. In this capacity, and subsequently as Scholars-in-Residence at the American Institutes for Research, we conducted an international study of school reform projects, focussing on those that are yielding substantial educational gains. These studies were conducted over the same time period as the Royal Commission investigations. A summary review of trends that we found to be associated with significant educational initiatives follows.

1. *Constructivism as the dominant view of learning espoused by contemporary educators* (Duffy & Jonassen, 1991). According to this view, subject-matter learning arises from students' own

efforts to understand the world, driven by their own perceived knowledge needs, with books and other information sources serving as tools in knowledge construction rather than as direct sources of knowledge.

2. *Increasing concerns about reconciling the constructivist view with individual students' needs and with societal goals*, as expressed in curriculum standards and the like. An entire issue of the *Journal of Special Education* (Harris & Graham, 1994) was devoted to such concerns.
3. *The shift in educational computing from single-user instructional software to networked software* to support collaborative inquiry (Pea, 1994).
4. *Increasing focus on understanding as the central goal of instruction* and as the goal driving educational reform (Perkins, 1992).
5. *The "rhetorical turn" in education and epistemology*, viewing knowledge as something constructed primarily through social discourse (Bruner, 1990).
6. *An increasing concern with establishing and enforcing standards* in elementary and secondary education.
7. *An enlarged conception of education, which sees it as a function of the whole society*, with schools playing an important role but one deeply imbedded in a dynamically structured "learning society" (Keating, in press).

All these issues are recognized in the Report of the Royal Commission on Learning (1994). However, the means of dealing with them coherently, at either a conceptual or a programmatic level, are left unspecified. With due regard for the very large scope of the Royal Commissioners' inquiry, we may note that they largely overlooked the potential of information technology to play an integrative role in their vision of a society committed to learning. The computer was treated primarily as a classroom tool. This is understandable. As the Commissioners noted (Vol. IV, p. 5), widespread attention to the "information highway" and its implications was just emerging during the period of the inquiry and would not have figured prominently in consultations.

A fundamental part of the "learning society" concept is embodied in the Royal Commission's treatment of "community education." It is that the stakeholders should also be contributors. Thus, the proposed school-community councils have the dual role of representing the stakeholders — segments of the community to which the school is accountable — and at the same time enlisting them in contributing in various ways to the educational process. The same reasoning, however, applies to other kinds of connections. Secondary schools have a stake in the outcomes of elementary education, and post secondary institutions have a stake in the outcomes of secondary. Should they not, accordingly, be contributing? And are there not possibilities of contributions flowing in the reverse direction — from elementary school students to secondary or postsecondary students, from school students to teachers and teachers in training, and from any of these to the formulators of curriculum guidelines and standards? Carried to its logical limit, community education may be envisaged as a fully interacting network of people in all parts of the community who are simultaneously learners and contributors to the learning of others.

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But how could such a complex network actually function? This is where computer-based communication networks may enter the picture. The Internet already serves to link a great diversity of people, although organizing this diversity in functional ways remains a challenge for technology and social design. The following are some observations on educationally-relevant linkages. (These are undocumented, based on direct observation or informal reports of colleagues.)

- There are many network conferences dealing with education, which are successful in that there are active participants who appear to profit from their involvement; but active participants usually represent only a small fraction of those eligible to participate.
- The most successful classroom uses of wide-area networks have been for cross-school research projects, such as ones organized by the National Geographic Society. These are typically designed on an opportunistic basis, however, rather than on the basis of curriculum requirements. They pursue topics such as climate and dialect differences, which lend themselves to comparing information that students collect in different localities. Basic topics in science, which typically pertain to phenomena that do not vary geographically (physiology, electricity, etc.), thus tend to be neglected.
- Electronic mail links have been used as a way for scientists and other subject-matter experts to contribute to classroom learning. Serious problems with this approach have appeared, however:
  - The workload for volunteers is very high, raising doubts about sustainability.
  - One classroom seems to be about all a single volunteer can handle, raising doubts about scalability (there are far more classrooms than there are prospective knowledgeable volunteers in most subject-matter areas).
  - Volunteers often have trouble responding to questions at the appropriate level or in educationally desirable ways; some educators talk of providing training for volunteer subject-matter experts.
  - Students may not make good use of experts' time and knowledge, asking questions to which they should be able to find answers themselves. Hence, teacher management may be required.
  - At a deeper level, many educators have misgivings about the whole process, because it seems contrary to constructivist principles. It implies that knowledge is "out there" in the minds of experts, not something to be constructed through the students' own efforts to make sense.

The problems noted are not peculiar to

the network medium. The same problems with volunteer subject-matter experts could occur, and might even be intensified, in a program that called for their personal presence in the classroom.[2] An advantage of the network medium, however, is that the technology can be redesigned in an effort to remedy the problems.

An important agenda for school reform is experimentation with alternatives to the technologies currently in use for educational networking. Virtually all educational uses of networks are based on e-mail or file transfer.[3] Although these are immensely valuable technologies in their own ways, neither one lends itself very well to collective activity or to the sustained build-up of knowledge. These purposes are more directly served by a shared database, which participants may use and contribute to in various ways. In the business world, Lotus Notes™ is the prime example of such an approach, and it is being widely adopted by businesses setting out to become "learning organizations." Notes, and the approach it embodies, is perceived to be so important to the future of business computing that it was the primary motivation for IBM's recent three billion dollar buyout of Lotus Development. In the education world, CSILE™ is the prime example, antedating Lotus Notes by several years (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989). The head of collaborative research for Lotus Development Corporation referred to CSILE as "probably the leading example of groupware technology used in classroom settings." It has directly influenced components of other groundbreaking projects, for example, the Collaboratory Notebook of Northwestern's CoVis project and Georgia Tech's CaMILE.

An Alternative Set of Recommendations

Based on socio-constructivist epistemologies, analysis of school reform initiatives worldwide, and our own experimentation and evaluation with new knowledge media, we suggest the following sorts of recommendations.

- **Reinvent schooling in the context of a knowledge-building society**

Create models for knowledge advancement extensible to all sectors of society, with schools integral to cross-sectorial communities for learning and knowledge creation, not a world apart. The Royal Commission proposes a model for "Community Education" that is consonant with such a model, but its recommendations for information technology read as a different mission altogether.

- **Create novel funding structures and alliances that favour education-first technologies**

At present, our school technologies are vendor-dominated, favoring productivity and presentation software designed for business use and a wide variety of educational applications that lead to fragmentation of curriculum. The Integrated Learning Systems designed to produce coherent packaging of educational materials are proving disappointing. Alternatives that put knowledge-building at the heart of the design challenge are needed.

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- **Democratize processes of invention and society's knowledge resources**

New technologies provide new opportunities, as well as dangers. We must use educational technologies in ways that turn diversity into a strength rather than creating underclasses. The system we have been developing is distinctive for demonstrating the *absence* of significant differences in participation between males and females and between those who, measured by standardized achievement tests, are at the lower-and higher-ends of the ability spectrum. More importantly, diverse contributions help to lift the whole process. We need to take as a design challenge the creation of technologies that benefit all users.

- **Explore the power of distributed versus centralized processes**

The most effective research and innovation efforts demonstrate the power of distributed versus centralized processes, and suggest potential conflict between centralized curriculum initiatives and student-driven inquiry, and between mandated assessments and self-initiated efforts at educational advancement. As suggested below, new programmes of research are needed to provide creative solutions.

- **Encourage research and invention to channel opportunities of new knowledge media for more effective education and the creation of a knowledge economy**

New opportunities include:
  - virtual job opportunities, practica for professional development, and meeting grounds for those working on parallel problems
  - novel uses of volunteers and retirees
  - special facilities for inclusion of all members of the populace
  - administrators, experts, and curriculum writers as on-line knowledge workers, not distant figureheads
  - student creativity used in the service of a knowledge economy

- **Replace outmoded curriculum and evaluation processes with systems for local autonomy with global relevance**

New technologies make it possible for teachers and students to be at the heart of curriculum and assessment processes. In the past, a delivery model for curriculum and standards may have been needed — with experts establishing content guidelines, curriculum writers translating these into forms deliverable to teachers, and students treated as the end-of-the-line consumers. With new knowledge media, teachers and students are positioned to contribute creatively to curriculum designs and resources, with curriculum experts and evaluators participating in the process, not standing outside and above it. Such initiatives will occur on a global scale, so Circular 14 type screening is well off the mark. New systems

are needed to support fast-paced, global processes for continual improvement, as opposed to outmoded and lengthy cycles of curriculum publication.

- Demonstrate superior educational achievements

Rather than investing in schools to show off technology, we need to invest in schools that demonstrate new possibilities for educational achievement. This does not mean, primarily, improved test scores — although successful technologies produce those as well (Scardamalia et al, 1992). It means levels of knowledge and thinking that go beyond the modest expectations of mass assessments and that would give Ontario graduates a privileged position in the global knowledge-based economy. Will such schools also function to demonstrate educational technology? If not, something is wrong with the technology.

Comparison Between the Royal Commission and Alternative Recommendations

The Royal Commission's recommendations, summarized above, are concerned almost entirely with measures to *promote* and *regulate* the use of computer technology. They are consistent with other recommendations of the Commission, relating to centralized curriculum planning and evaluation. All in all, they represent a bureaucratic, top-down managerial approach to educational reform. As is characteristic of such an approach, it is cautious and short on vision. I personally do not think it is an approach that can keep Ontario in the running during the next decade. It is aimed at enabling Ontario students to do the kinds of work that schooled people all over the world are now able to do, and usually for less money. The alternative recommendations are based on the view that there have, in fact, been major breakthroughs in technologies for education and that the leading countries in the next decades will be the ones that are most successful in taking advantage of and further advancing those technologies. These are technologies for building and working with knowledge.

Possibilities exist, however, not only for harmonizing centralized curriculum planning and evaluation with student-driven collaborative inquiry but also for coordinating these objectives with two others arising from Royal Commission recommendations: greater community involvement in school-level education and better connections across different levels of education and between education and work. These intriguing possibilities arise from the greatly expanded opportunities that wide-area network communication affords for interaction among previously separated individuals, groups, and spheres of activity. Research is essential for determining the feasibility of the following:

- Engaging students in implementing the curriculum guidelines and standards that apply to them.
- Creating overlapping communities of inquiry involving elementary, secondary, and university students, their teachers, working scientists, and interested parents and others, all working within the same general problem area.

Educational policies adequate for the 21st century cannot be created simply by analyzing current needs, studying projections for the future, and trying to balance the two. The result will be cautious compromise. That, more or less, is what has come to us from the Royal Commission. But the 21st century is being created right now. It is being created by innovative industries around the world, in poor nations as well as rich, and by governments trying to regulate and at the same time spur on the development of knowledge-based enterprises. The question for us is whether education will have an active role in creating the future or whether it will just be a "resource provider." In order for education to have an active role, I believe, it has to be reconceived as part of a society-wide effort aimed at advancing the creation, distribution, and utilization of knowledge.

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Where to Next?

In 1992, a *Globe and Mail* report warned that another Canadian invention was heading South. Writing about CSILE, Nikiforuk said "Although U.S. school reformers hail it as a novel program that could well shape the schools of tomorrow, CSILE remains an almost unknown pedagogical tool among Canadian educators." It is now three years later, and the problem is more extreme. Ontario is the one place where the proposals and the technologies that afford them have failed to engender significant involvement. In contrast, educators on four continents are working with us to advance on projects of the sort suggested above and to use the technologies built here. Many are additionally providing financial support as Founding Members for a new CSILE initiative aimed at having educators take charge of their own technologies.

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Ontario could be in a uniquely advantageous position to focus on the problems of maximizing knowledge construction through networked, multimedia technologies. Other Ontario development projects of significance in this context include First Class™, Telepresence, the Dynamic Graphics Project's collaborative multimedia tools, and the CARATS research project. Knowledge-building technologies of the sort we describe fall in the networked solution/multimedia categories projected as a billion dollar curriculum industry by next year. The

potential for significant economic as well as educational gains from backing knowledge-building technology is high. We suggest Ontario put in place recommendations that support invention and that channel research to make today's educational visions a vital part of tomorrow's reality.

NOTES

1 The conceptual framework and research reported in this analysis are based on writings co-authored with Carl Bereiter. I would like to acknowledge the efforts of the entire CSILE team, without whose contributions the work reported here would not have been possible.

2 Incidentally, we do not question the value of personal visits to classrooms, especially for establishing rapport and for role modeling purposes. We see these, however, as supplementary to some more sustained kind of involvement in the educational process.

3 Conferencing software is essentially e-mail with 'threads' connecting sequentially related messages. Bulletin boards are different, but their use in education has been incidental.

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