PRESENT AND FUTURES USES OF COMPUTERS IN EDUCATION: SOME QUOTES AND BRIEF COMMENTS

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A long time ago I learned that I was not a good predictor of future developments in technology. While a graduate student in the 1950's, I remember discussing manned space flights and landing on the moon. I did not believe a lunar mission was possible much before the beginning of the next century. In less than ten years manned space flight had occurred and within fifteen years a lunar landing had been made. Several decades later in the era of mainframes, I remember predictions that within a decade or so there would be portable hand-held computers as powerful as the computers we were then using. Again I was skeptical.

Recently, in flying across the country I was surprised to see several passengers working with lap tops during the flight. Announcements are made on planes these days asking those with lap tops to turn off their computers just prior to take off and landing. It is amazing to see how far we have come in such a short time.

A number of future developments are certain to have profound effects upon computing in general and educational computing in particular. For example, advances in interactive multimedia (hypermedia), artificial intelligence and expert systems, virtual reality, networking, information transfer, hardware and software will impact on how and what we teach and how students learn. Rather than making my own predictions, let me quote from some recent literature which indicates where we are and what is in the future. I have added some personal comments bracketed by asterisks (*).

WHERE WE ARE AND SOME PROBLEMS

"The national student:computer ratio is now 16:1. Over half the schools in the country use computers in almost every discipline. . . . Cable, satellite, and modems are in half to three-quarters of all *school* districts."

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"The United States leads the world in the number of computers in its schools. Ninety-nine percent of all elementary and secondary schools in the U.S. have installed computers and 93 percent of the students use them during the school year. . . . Despite all that equipment, American students are less computer-knowledgeable than students in Austria, Germany, and the Netherlands. In addition, their teachers get less computer training than their counterparts in Europe and Japan. Those are just two of the findings of "Computers in American Schools, 1992: An Overview", a report sponsored by the International Association for the Evaluation of Education Achievement, and the Council of Chief State School Officers."

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"In a world often over-enamored of change for change's sake - and thus technology for technology's sake - advocates of technology in our schools should have a compelling answer to the question: "Technology for what?" . . . "Educational technology will continue to advance whether we like it or not. As educators, it is our job to make sure that technology is planned for and implemented in ways that are best . . ."

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". . . the body of knowledge will have doubled four times between 1988 and 2000, and college freshmen in 2000 will be exposed to more information in one year of study than their grandparents were in a lifetime. How can the existing instructional infrastructure in higher education handle this sheer volume of information without widespread utilization of CBT *Computer-Based Training*? More importantly, how can higher education provide students with the experiential basis for lifelong independent learning without the adoption of sophisticated intelligent simulations? In the final analysis, it is not a question of whether higher education will adopt CBT, but how effectively and efficiently it will do so."

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" School districts are . . . exploring new ways to integrate technology into new ways of thinking about schools and instruction. As education moves into the 1990s, educators, parents and society in general appear to have made a longterm commitment to technology's role in education. What has contributed to this advancement of technology into the classroom? . . . four general reasons are proposed. First, there is a growing body of research on the positive effects of technology assisted instruction on student performance and attitudes. . . . science teachers have found that students can learn as much or more and with less risk from technology based simulations as from more costly lab experiments. Students who have been taught to use word processing systems write more and produce higher quality work than when using more traditional paper and pencil practices. . . . A second reason . . . is that technology has expanded beyond the early capabilities of the microcomputer and the videotape. . . . Linking videodiscs and microcomputers can access data heretofore unavailable to most students. CD ROMS now make available entire reference libraries . . . Students and teachers alike are able to learn in an information rich environment.

A third reason . . . is teachers' acceptance of the technology as tools to help them perform multiple tasks more efficiently. Technology tools, such as word processing and graphic programs, allow teachers to create higher quality instructional materials more quickly than in the past. Electronic gradebooks help teachers manage student scores and grades. Sophisticated simulations permit teachers to use models that were once too difficult to manage with a group of students. . . . offer greater capacity to rationalize the notion of individualized instruction by monitoring student progress, diagnosing student competence, and assigning specific instructional tasks. . . . The fourth reason . . . is that more teachers are being prepared to use advanced technologies for instruction. While the commitment to better prepare teachers has been significant, the number of teachers who need training remains high. . . The lack of preparation of teachers to use technology effectively and to integrate it into instruction is a serious problem . . . To better meet the demands of improved technology education colleges and universities must make some significant changes. . . . faculty development must become a central issue."

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LONG DISTANCE LEARNING

"Although computer science and technology have undergone tremendous changes in recent years, teaching methods in our colleges have hardly changed at all. Our colleges still operate under the assumption that a large group of students will sit in a lecture hall, take notes while the instructor drones on, and then regurgitate the facts at exam time. . . . established patterns of work and study are breaking down. Many people need continuing access to education throughout their lives. Our educational system needs to be more creative in how it conducts its business, while at the same time the consumer requires greater flexibility in managing the conflicting demands of family, work, and study. Our educational system has the opportunity to develop more efficient and cost-effective means to do business while filling a rapidly growing public need. . . . I believe it is time to offer a full range of college courses entirely by internet-working. Physically attending class is inefficient at best and impossible for many working people. The interpersonal benefits of class attendance have been overstated and, in any case, have their equivalent in Cyberspace."

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"The technology explosion coupled with the information explosion has provided us with unimaginable possibilities. . . . Institutions of higher education have been integrating electronic capabilities for two or more decades. Some of the basic systems include electronic mail, telephone registration, and information storage and retrieval. Extensions of such systems allow for computer conferencing, access to library holdings and services, instructional management, and communications between students and faculty. Making use of such systems, colleges and universities have tapped into national and international networks which allow them new avenues for marketing, distance learning, and information sharing."

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COMPUTERS IN THE LABORATORY

"Technology drives major changes in science. . . . Technology has not driven major changes in education. In "Intelligent Teaching Machines", Larry Cuban . . has documented the lack of impact of such heralded and truly wonderous technologies as the camera, the radio and TV in the classroom. Microcomputer-based labs (MBL) is an emerging technology that provides learners with new ways of seeing - and thinking about -scientific phenomena. In MBL, STUDENTS connect up all sorts of probes -temperature, pH, motion - to a personal computer through a d/a converter. The data from a probe is pumped straight into a spreadsheet and graphically displayed on the screen in real-time. MBL technology IS making a difference in education. . . . the students are engaged and thinking . . . students . . come to understand how to manipulate and interpret graphs, and come to develop deep understandings of the science underlying their experiments. . . . enable students to see scientific phenomena in new ways and ask new questions - questions that don't have answers at the end of the book. Why have TV and radio not impacted education? . . . TV has been used to deliver instruction . . Learning . . amounts to knowledge transfer: the expert knows something the student does not, and if the expert talks about the material well enough . . students come to know. This unfortunately, isn't necessarily true. On your job you learn all the time. How much of that learning takes place listening to a lecture? . . lectures are not a good way to learn; . . one learns through direct experience, through doing. . . lectures might well have a (small) place in the school day. . . as the dominant-instructional strategy (lectures) are overused and overrated. Just ask any student . . . what is the value in replicating experiments to which answers are already known? . . we learn through doing; we learn through constructing artifacts; we learn through engaging in genuine dialogue and conversation; we learn through the use of technological tools such as MBL. F. James Rutherford, former U.S. Secretary for Education (New York Times, October 25, 1993): ". . . existing curriculums try to cover too much (and) do not teach enough practical applications of science . . . curriculums should delve more deeply into scientific skills, and methods that have broader use, like devising and testing theories, or drawing conclusions from experimental data."

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***ARTIFICIAL INTELLIGENCE AND**

EXPERT SYSTEMS*

"'*Computers* will be capable of conversing with their users in their natural languages, preparing documents by voice-activated typewriter, and providing expert advisory services. . . . expert systems on chips embedded within equipment for diagnostic applications and enhanced user interfaces featuring voice dialog options."

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". . . vision systems and speech recognition in order to create the "intelligent" talking, listening, thinking machines of the future. Tom Forester, "High-Tech Society", MIT Press, Cambridge MA 1987, p. 42.

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* This book (9) contains a bibliography on Education, Instruction, Tutoring - p. 49 - 52; Modeling and Simulation - p. 67; Robotics - p. 69; Science - p. 70; and Hypertext - p. 78 - 89. *

" . . . development of strategic problem-solving capability is a critical educational goal that can be speeded and enhanced substantially through the application of artificial intelligence to the design of computer-assisted instruction. Specifically, we see the need for intelligent tutoring systems that not only design and present problem-solving tasks compatible with a student's prior knowledge, motivational history, and current instructional goals, but that also can analyze task performance online while the student is solving problems, providing maximally effective guidance, correction, and encouragements directed at improving the problem solving process. In order . . . to operate in this sophisticated manner, it must, in some sense, possess all of the following subsystems: 1. An intelligent problem-solving expert that recognizes all feasible plans and strategies possible for any given problem. 2. A sophisticated problem-generation system that can create whatever type of problem the system needs to tutor the student and that matches the student on characteristics such as age, world knowledge, gender, and interests. 3. A multipurpose interface that provides concept-enhancing problem-solving tools for the student to use in solving problems and that also helps make explicit the student's strategies, plans, and misunderstandings. 4. A coaching expert that can recognize and respond not only to correct moves, but also to errors and indicators of motivational breakdowns. 5. A lesson planner that selects problems and instructional routines and assembles them into lessons designed to accomplish instructional goals. 6. A sophisticated student record system for developing and storing student knowledge models and for establishing instructional goals for students. Machine-based intelligent tutoring systems might eventually achieve remarkable power through integration of these capabilities. . . . . . vary the difficulty of its problem and tutoring routines to meet the instructional need of students ranging from grade 4 through remedial college level. . . . the intelligent machine-based tutor will be capable of many different instructional strategies and routines known to enhance learning."

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HYPERMEDIA AND VIRTUAL REALITY

"Hypermedia -A hypertext consisting of different kinds of information (e.g. text, photographs, sound/speech, video)."

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"Hypertext is . . . the nonlinear viewing of information. "Nonlinear means that you can examine information in any order you wish by selecting the topic you want to see next."

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"Hypermedia technology can revolutionize a student's view of learning. The educational environment will advance beyond lectures, taking notes, computer-assisted instruction, and other forms of teaching. Students will be able to access unlimited amounts of information from a universal library and enter computer-based worlds that imitate reality. . . . By integrating text, audio, graphics and video, hypermedia presentations both entertain and educate. . . . Hypermedia systems will become common in homes. Future home and school hypermedia systems will access information from databases located throughout the world. Students will have the world's data at their fingertips by having ready access to magazines, audio and video, journals, and other reports in electronic form. . . . One of the most talked about extensions of hypermedia is virtual reality. . . . Students . . . will choose from numerous virtual realities to match their educational needs. From the inside of an atom to the edge of the universe, students will be able to experience whatever environment they require. When microcomputers were first introduced in the schools, many teachers were concerned that they would be replaced by a machine. Instead of superseding the classroom teacher, computers illustrated the need for competent teachers who could design meaningful learning environments. Research demonstrated that incorporating technology into the classroom could both increase and decrease the amount of learning. Only when the classroom teacher evaluated the technology and rationally incorporated well-designed computer applications into the curriculum did learning increase. . . . Educators claim that one of their goals is to provide students with the best-possible learning environment. By continually assessing technology and its implications for learning, teachers will be able to design curricula today that will best prepare their students for the future. By incorporating hypermedia into the curriculum, teachers allow students to control access to information. This gives them a sense of ownership in the ideas and concepts that are represented, thus advancing the learning process."

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TECHNOLOGY AND COLLEGES OF EDUCATION

Alan November: "We currently have enough technology to automate every menial task in the country, from making autos to wiping out middle management. . . . Whether we like it or not, technology has/will forever change the way we learn and work. It is not a question of applying technology to improve current reality. We have a new reality." David Thornburg: "Technology is the response, not the cause. Overall, technology has helped change and shape culture, but only because certain human beings applied technology in certain ways to bring about these changes. . . ." "How should we educate future teachers?" Alan: "This may be the first time in history that teachers do not have a clue about the kinds of jobs students will have. Eighty percent of the jobs that today's kindergarten kids will apply for do not exist today. If this is true, how do we know what content to teach? . . . We have to let go of curriculum and teacher training that are based on confined content and move toward helping students apply their knowledge to solve problems that have not yet been solved. And to do that, we have to see technology as more than a tool. It represents a new medium, a new culture, as sure as the Industrial Age represented a new culture." David: "Technology should play a role in redefining teacher preparation . . . As everything becomes digital, and as bandwidth explodes through the roof, universal access to information through homes, offices and (someday) schools will allow education to acquire a new face. Teachers need to see their roles differently in that technology allows much of the "content" to be acquired online . . . Also, educators need authoring skills in the new media so they can evaluate student work submitted in that form." Can undergraduate education schools provide what either of you are talking about? Alan: NO! David: YES! Alan: "This country has to commit itself to a massive overhaul of teacher preparation, and the last people I would put in charge are the current professors of education. We need the equivalent of the Manhattan Project." David: "If the schools of education are isolated from the needs of society, it is because we allowed that to happen." Alan: "David, do you think ed. schools as a group have the organizational incentive to change?" David: "Of course not, but we should provide it. They are not just arbitrary structures imposed by some alien force, they are part of society and should respond accordingly."

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INFORMATION RETRIEVAL - NEW TOOLS VS. OLD METHODS

"The object you hold in your hands has three centuries of tradition behind it as a medium of communication in the sciences. . . . But printed periodicals will not remain the scientist's medium of choice for another three centuries, or even another three decades.. Their future beyond the next three years is somewhat cloudy. Already, much of the day-to-day discourse of science flows over computer networks, and dozens of electronically distributed journals have sprung up. Sooner or later, ink on paper will be superfluous. The new schemes of electronic publication have an irresistible appeal. Information is delivered in minutes instead of days or weeks. . . . Computer-based methods of searching and indexing make it easier to find what you want. . . . (documents) can be enriched with large data sets, sounds, video clips, animations or simulations. In the right computing environment they could become active documents, which invite the reader to participate as well as to peruse . . . Computers will be standardized, portable, lighter than an average book, with wireless links to a universal network. . . . The time will come when the printing press will be a computer peripheral device not much different from what the laser printer is today. . . . By the time the printed version of a paper appears - often years after it was written - workers have long since read it in preprint form."

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SOME CONCLUSIONS

* The future as predicted by many of these individuals is both challenging an exciting. The prospect of an expert hypermedia system which could interact with students and individualize instruction for an ENTIRE course is mind boggling. Such a system needs to be carefully designed by a team with expertise in diverse disciplines. What a boon for distance learning and large general chemistry courses containing students with diverse backgrounds and abilities! I wonder how long it will be before a really successful chemical system of this kind will come along? Because chemistry is so dynamic, a chemistry system will be difficult to design and maintain. One point made by David Brooks in the recent Computer Conference (17) is that, if computers are able to guide students in solving general-type problems, then computers should be able to solve such problems by themselves. Perhaps it is no longer necessary to teach students how to solve such problems. Perhaps all that is needed is for students to be able to ask computers the appropriate questions. (Such asking will eventually be done by voice in our natural language!) This will affect what we teach students. That is, we need to consider what computers know, and what problems computers are capable of solving before deciding what we should be teaching our students! *

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