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Education Tailor-Made for the Times

William Francis Herlehy III

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The computer in the classroom and computing in the curriculum are the impetus for major changes in higher education during the next decade. The changes needed in the curriculum and in the concepts and practices of instructional delivery, though accepted by most, will be considered radical and unorthodox by some and academic heresy by others. Prescribing a certain amount of contact time between the teacher and the learner as a requirement for the award of a corresponding number of academic credits will be reconsidered and redefined. The need for this artificial barrier to educational advancement no longer exists. The textbook no longer will be viewed as "the" source of knowledge on certain subjects, and going through the text from cover to cover at a certain pace no longer will be considered the only logical sequence for acquiring the requisite knowledge. Emerging concepts and complex subjects, along with multidimensional processes and systems, will be presented in forms that will achieve the greatest measure of clarity and understanding. Some of the needed forms do not currently exist. The major purpose of computing is going to be to provide insight through visualization. The instructor will need new skills and the traditional subject-matter expert will be inadequate. The teacher will facilitate the students' link to the deluge of words and images of every imaginable kind from literally around the world and will do it at all hours of the day and night. The teacher who thinks he or she is in the business of 50-minute lectures will still be in that business 10 years from now.

INTRODUCTION

When considering a list of the largest companies in America at the turn of the 20th century, one can see that 10 of the largest 12 were natural-resource companies. Our economy was a natural-resource economy. Wherever the most highly needed resources were found, job opportunities followed (Thurow, 1996).

To examine the equivalent list as we approach the turn of the next century, one now would see that the leaders are microelectronics, biotech, telecommunications, aircraft manufacturing, and computer hardware and software. All of them are brainpower industries that can be located anywhere in the world. Where they will actually locate and flourish depends on who organizes the brainpower to capture them. Who it is that will organize the brainpower most effectively and efficiently depends on who it is that educates best toward that objective.

A clear majority of the radical innovations of the last two decades have been by Americans, yet when it comes to sales, employment, and profits, all of these inventions have become Japanese products. The Japanese did not invent any of them. Radical innovation, if the innovator is not also the low-cost, quality producer, gives the inventor very little economic and/or competitive advantage. Of course, being the low-cost producer is partly a matter of wages. To a much greater extent, it is a matter of having the skills to do things better -- to make incremental innovation.

The global economy is a dynamic economy. It is always in transition. What is not changing is being passed by. The organizations that are and will continue to do best are those able to move from process to process and service to service within technological families so quickly that they can always keep up with and ahead of each new generation of technology.

If an organization wants to attain and stay at the leading edge of technology, it must be a participant and

partner in the evolutionary progress of brainpower. Knowledge clearly has become the only source of strategic sustainable competitive advantages. The rates of return for industries that invest in skills and knowledge are more than twice that of industries that concentrate on plant and equipment (Thurow, 1996). Industries' skills-and-knowledge investment will be made when and where they have been satisfied they will get the best return. If firms are to locate their top-skill, top-wage jobs in the United States, it will be because this nation offers them the lowest-cost, highest-quality opportunity to develop those skills and knowledge. If America's educational system is not competitive in this environment, the market will simply move on.

The skills and knowledge required in the global economy of the next century will be radically different from those required in the past. The people who do acquire those skills and knowledge may or may not be the young and/or the unskilled workers who currently live in this country. Equal to the ability to make anything anywhere in the world and to sell it anywhere else in the world, is going to become the ability to teach skills and knowledge to anyone, anywhere, and at anytime. Investment will be made in the process that provides the world-class graduate. Educational defects of the graduate are not the problem of industry, which will simply go with the process that gives it a graduate with the necessary market skills. The American worker will have no advantage at the turn of the century if it is not in the skills and knowledge needed to create radical and incremental innovations. If these are not provided by the educational institutions of this country, multinational companies will find them wherever it is in the world that best suits their economic needs.

Instruction and instructional technology need to create and organize the brainpower necessary to make us masters of new production and distribution technologies, radical and incremental innovation, and the strategic consequences of both. This is not going to happen by teaching the same things we have been. There are answers. We need to give them the appropriate priority.

Nothing has so *revolutionized the way we do things,* the academic way of life, more than the development of computers. Educational institutions, administrative functions aside, have been slow to use computers, computing, and the associate emerging technologies to their fullest advantage. Now that they are realizing the necessity of doing so, these academic institutions must make a serious attempt to catch up with advancing technology.

This is going to require the development of a new attitude throughout academia. A critical ingredient of this new attitude is an openness to and the acceptance of change. There are changes needed in the curriculum and in the concepts and practices of instructional delivery. These changes, though accepted by many, will be considered radical and unorthodox by some, and academic heresy by others. Nonetheless, what might prove to be an uphill battle will have to be fought. And it will be won by those who are committed to that vision of where it is that higher education needs to be in the decade. The teacher who thinks he or she is in the business of 50-minute lectures will still be in that business 10 years from now (Walker, 1996).

CONTACT TIME

One of the most firmly entrenched practices in today's higher education environment is that of directly equating a definitive amount of contact time between faculty and students with the specific number of academic credits (semester or quarter hours) to be awarded for a given course. This is, in essence, the Carnegie Unit.

When the Commission on Higher Education recommended the universal adoption of this system, the intended purpose was to standardize requirements for the award of academic credit (Nagel & Richman, 1992). Standardization, it was felt, was needed. At issue is the appropriateness of the particular response. It was argued decades ago; it is argued now; and I will argue against its appropriateness for the next decade.

Academic terms of specified lengths facilitate the administration of students, faculty, and learning resource support, but do they support teaching and learning outcomes? Is there even a meaningful relationship between the amount of time spent together by faculty and students and teaching/learning outcomes? Faculty members who think there is might be flattering themselves. Common knowledge suggests there is some relationship between the direction and focus provided by

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faculty and the student outcomes. However, there is a statistically significant relationship between student effort and measured outcomes that is independent of faculty/student contact time (Nagel & Richman, 1992). Isn't student competency what it is about? Dare I suggest that is the total of what it is about?

One change just starting to take place that will gain noticeable momentum in the next decade is the downsizing of direct contact time and the resurgence of competency-based instruction. All the pedagogical jargon aside, competency-based instruction is not much more than a high-sounding collection of words that simply means a flexible, individualized program that frees both the professor and the student to work at their own pace and to do so without the fear of failure (Nagel & Richman, 1992). Making use of specified performance objectives, or student outcomes, it is possible to take a text, a series of books, and a local or national curriculum and develop a program of instructional objectives that will meet the needs and desires of both the teacher and the students -- each *one* of the students.

Competency-based instruction (CBI) is not new. Developments of the next decade will, no doubt, pave the way for the computer to become the tool that proves CBI to be both effective and efficient. It will make its use practical for both the academician and the administrator. Competency-based instruction and computer-based instruction will become synonymous or, at the very least, interchangeable.

The administrative staff at the university of the next decade is going to have to accept replacing this time constraint that academia is tied to by nothing other than tradition and standardization. The only way an academic institution is going to be able to establish/enhance its reputation as a cutting-edge provider of technology education is to use those very technologies that are part of the curriculum and put them into practice in the administrative offices. Being able to process applications, registrations, and evaluations at a rate commensurate with the individual learning pace is the only acceptable response. The staff's need for specific start and stop dates as an administrative convenience will be replaced by the students' need to advance in their studies as their abilities allow. There is no need for artificial pedagogical or administrative barriers to educational advancement (Suchan & Crawford, 1995).

LEARNING-RESOURCE BASED INSTRUCTION

In the middle of the 15th century Gutenberg changed the course of educational history. With the invention of movable type he made it possible to print books accurately, efficiently, and automatically (Aukstakalnis & Mott, 1996). Within 25 years, books that were once only available to the nobility and the clergy could be had by anyone able to pay or trade for them. How-to books soon overshadowed the esoteric tomes and religious texts that once dominated the market. For the first time, skills and information were transmitted, on an ever-increasing scale, without personal contact, revolutionizing the spread of knowledge (Aukstakalnis & Mott, 1996).

As educators, we should remember that the potential of Gutenberg's technology, his invention, was only unleashed because of a shift in what students were taught. It was once considered sufficient for students to be apprenticed and learn a skill. Gutenberg's innovation made teachers realize students would not be considered educated unless they were able to read.

Like those teachers, today we must provide our students with the tools they need to use the learning resources currently available to them. It is interesting to note that introductory computer classes have not changed, but it is even more interesting to note how they have changed. The computer hardware is indeed different, but the basic cycle of input, process, output, and storage remains the same. The dramatic change is, and will continue to be, in how we have de-emphasized how the machine works and how we are significantly increasing the emphasis on what it does. We have already seen the shift in focus from the programming-technique classes of the late 1970's to classes on the use of productivity tools of the late 1980's (Thomas, 1996).

Education is a dynamic field. Our definition of computer literacy, what it really is to know how to use a computer, must be updated constantly to fit a rapidly changing world. During the next 10 years, the single most widely used function of the computer will be as an entrance to the rest of the world, the World Wide Web. Like Gutenberg's printing press, the Web is a

revolutionary advance in the transmission of knowledge. It allows access to learning resources on a scale never before dreamt of. This is evident in the large and quickly growing number of organizations and individuals who indicate "more information can be obtained at www.something."

Just as teachers acknowledged centuries ago the importance of reading to education, we must accept and pass on to our students that knowing how to access and use the Web is an essential component of computer literacy. Beyond this point, the ability to use Web browser software will be considered as much a part of literacy as knowing how to read a library card catalog is today (Tennant, 1996).

Through the next decade, the Web should go from being an exciting element of an introductory computer course to being "the" source of information for many courses and as a delivery tool for even more. The degree to which this can and should be done is open to discussion and debate. By the end of the next decade, it will be decided.

THE "LINEAR TYRANNY" OF THE TEXT

Other than those rare instances when it is essential to follow a very specific instructional sequence for an extended period, there will be little evidence at the end of the next decade of the illogical notion that teaching and learning have to follow some predetermined course. Just as there are individualized methods of instruction, there are idiosyncratic paths to optimum learning.

The key to what is going to happen in this area in the next decade is to liberate learning from the "linear tyranny" of a textbook where each chapter moves lockstep into the next (Herlehy, 1995, p. 204). The paradigm will be to have access to a "huge encyclopedic wall full of textbooks" and for the student to be able to go right to the information that is needed and to have it presented in multiple ways, with sound, with video, and with graphics or animation (Herlehy, 1993, p. 352). The on-line connection to learning-resource materials will change the textbook from being "the" source of knowledge to being, at the very most, a point of departure for the learning process.

The interactive capability of the on-line connection will be upgraded easily to provide instant feedback to a person's response to instruction. Because students respond independently, they will be given feedback independently.

Taking advantage of instructional technology of the next decade will allow students to zigzag through a course, taking a little bit from one section of a course outline and more from another in a fashion that allows them to customize a course, indeed a program, to accommodate their idiosyncratic learning needs. It will let the student have a cursory view or in-depth knowledge of a subject, depending on what the need is.

LEARNING THROUGH VISUALIZATION

The greatest challenge that has always faced the educator has been to present unknown theories and foreign concepts to students in ways that will achieve the greatest measure of clarity and understanding. This is going to be even more challenging in the next decade. Subjects and concepts studied will become increasingly complex and multidimensional. Multivariate processes, concurrent design and engineering activities, and biotechnic developments will necessitate a heretofore unheard-of degree of multidimensional computer simulation and visualization not only to be economically successful but also to be taught and learned.

Computer simulations and visualization techniques are being used, and will become increasingly sophisticated in their use, in higher education as the tools that best communicate complex subjects and foreign concepts to students in a form that enables greater insight, a clearer understanding, and longer retention.

This process is usually referred to as visual thinking and has foundation in accepted principles of cognitive psychology and visual-information processing. To create an accurate mental picture of some multidimensional concept or complex process, some form of input is needed with which to create a vision. If the input is highly symbolic and/or esoteric, a bottleneck forms (Aukstakalnis & Mott, 1996). The information-processing path to the brain is blocked because our preconscious must translate any input into some understandable form before it can be used by our conscious mind. It's only when information is presented in a recognizable form that it can be effectively studied and committed to conscious understanding (Aukstakalnis & Mott, 1996).

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With the development of hardware and software in the last decade and what will occur during the next decade, the ability to graphically represent highly complex processes or multidimensional concepts will dramatically enhance the educational process. A significant improvement in levels of understanding and awareness will be achieved.

Computers will be used in some capacity in almost all educational tracks. The development of the next decade will be visualization techniques. These techniques will expand well beyond the simulations of today into such things as the simulation of three-dimensional scenes on a standard, two-dimensional monitor and onto fully immersive, head-mounted and head-coupled displays (virtual reality) (Aukstakalnis & Mott, 1996).

The accurate interpretations of these visual representations certainly will depend on the interaction between teachers and learners. The process of arriving at solutions to visualization problems will be facilitated by the instructor. This will require specialized individuals using specialized hardware and software to achieve satisfying visualization results. The advantage of student involvement in the process is not inconsequential. Using visualization techniques in teaching encourages students to think in three dimensions when approaching a problem. They are not constrained by the visual parameters. They are more inclined to think "outside the box." Visualizations that can be created can be recreated again and again with differences in any variables that exist in either space or time (Aukstakalnis & Mott, 1996).

Simulations and visualizations will create an explosion in creativity. This new range of teaching tools will create truly new ways of looking at the world around us and new ways of thinking and problem solving -- transforming the educational process to one of insight through visualization.

THE "DIGITAL PROFESSOR"

The university instructor will need to acquire new skills. The traditional subject-matter specialist is going to be inadequate for the challenge. The called-for expertise will be in resource-based learning (Tennant, 1996). The teacher is going to facilitate the students' link to the deluge of words and images of every imaginable kind from literally around the world and do it at all hours of the day and night.

The tools necessary to make a transforming change are already available. We can surmise many things about technologies of the future and their effect on the teacher. However, if we have only a personal computer and access to the Internet, we have enough to begin revolutionizing higher education. We have the foundation in place for the building of the "digital professor."

We can create teaching tools interactive enough to let students seek them out and work with them at their own pace and when it is most convenient for them. Students can use an on-line service to review class sessions in as little as two- or three-minute segments instead of 50-minute lectures and also review them as many times as they want. It would be difficult to argue that to review in small segments directly from the professor's mouth is not better than attempting to decipher scribbled notes taken in one- to three-hour lectures (Tennant, 1996).

Some infrequently taught and low-enrollment courses are in danger of disappearing altogether. Many institutions have no qualified faculty to teach these courses (enrollments do not justify the position) and the department with the qualified faculty cannot give them the time to develop the courses in light of enrollments. If a college or university was willing to allow the initiative, a self-paced interactive instruction, with open discussions, recitations, and exercises, could be made available on-line worldwide (there is no obstacle to doing so right now), a highly qualified faculty member could start a student in a program of instruction, monitor his or her progress through it, and do an outcomes assessment upon completion, never having been face-to-face with the student (Finn & Manno, 1996). For the "nattering nabobs of negativism," it is being done right now and on more than a trial basis.

If the digital professor delivers high-quality instruction via the electronic network, we will do ourselves a favor by getting more students; we will do our students a favor by re-energizing and redirecting them; and we will have done the professor a needed favor by spreading education farther and deeper.

Technology manifested in the digital professor can

be dehumanizing and distancing. Our students are already subjected to huge lectures, novice teaching assistants, itinerant part-time lecturers, and other makeshifts. If and where the ideal exists, we should strengthen it, but with all of the information we have on the imperfection of our endeavors we have enough reason to seize the opportunity to use new tools.

The instructor is no longer what he or she was when the university taught all its students in one location. Each field of study had its "professor," the supreme local authority. That supremacy has steadily faded, as students increasingly discovered more ways to learn than to sit and listen to the local "guru."

The role of the professor in the next decade will not be to provide information on the subject but rather to guide and encourage students as they wade through the deep waters of the information deluge. Instructors will thrive as mentors. They will develop the skills needed to nudge students through the crucial tasks of gathering and processing information: problem solving, analysis, decision making, and synthesis (Finn & Manno, 1996).

The professor will be the point of entry to the world beyond the campus library. He or she will be a kind of "icon" on the computer monitor -- click on the professor and he or she will take you to, and through, the information world. If this seems absurd, remember that in part it already takes place with the Web.

We will sacrifice face-to-face intimacy for the sake of giving students the freedom and power to learn. Those who want to stay in the 50-minute-lecture business will find there will not be nearly as many of them and the lecture halls will be much quieter and far more tranquil -- not to say, empty -- places (Finn & Manno, 1996).□

William Francis Herlehy III earned a Ph.D. in Higher Education Administration from Kent State University, an M.B.A. from the University of Alaska, and a B.S. in Political Science from the University of Southern Mississippi. He is an associate professor of Business Administration with Embry-Riddle Aeronautical University.

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