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Re-Engineering the Learning Process with Information Technology

By Steven Sliwa

In business organizations, effective use of information technology is a cornerstone of re-engineering and Total Quality Management (TQM). Higher education is a service-sector business enterprise, but its core academic mission has features unlike any other business, and these features offer special challenges and unique opportunities to use evolving information technologies.

Most people expect information technology to improve the productivity and effectiveness of student services and administrative aspects of higher education. We cannot, however, take for granted that information technology will enhance the learning environment. Since the Industrial Revolution there has been a commercial inclination to use technology to increase productivity first and to hope that improvements in quality will follow. Now is the time to take the initiative and establish an appropriate set of goals for the improvement of learning in higher education.

Mass Production versus Mass Customization

The emphasis on productivity through greater and more efficient mass production in the Industrial Revolution appears in the example of the "straight pin." Traditionally, each pin had been handmade by a single craftsman until that process was replaced by a system in which each part of the operation was broken out for a different expert and each task was specialized to increase the speed of production and the uniformity of the pins. Henry Ford, likewise, emphasized speed of production when he mass produced Model T automobiles "...in any color that the customer wanted as long as it was black." Black paint dried faster than other colors, so the assembly line could work quickly and cheaply.

THE GRANGER COLLECTION, NEW YORK

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Education has followed a similar path. Formal education outside the home began in one-on-one interactions between tutors and students. Socrates, meeting with his students individually or in small groups, examined the rationale of known concepts and theories while developing the minds of budding scholars for future discoveries.

For centuries, societies have struggled to improve the speed and consistency of teaching (and presumably learning) while helping to develop social systems and personal human attributes. Innovations in material structures and organization occurred to support this quest: chalk boards, semesters, course schedules, prerequisites, credit hours, majors, minors, areas of teaching specialty, lecture halls, overhead projectors, syllabi, standardized testings, report cards, GPAs, etc. Did these innovations occur to augment the quality of learning, or did they rather come about to accommodate mass education and to assure consistency of teaching? Socrates did not need these artifacts or organizational structures to produce scholars.

In the manufacturing and service sectors of the economy, some major shifts in paradigms are becoming evident. As the standard of living improves, consumers are less concerned about the producers' economy of scale and uniformity of production which yield the cheapest and most consistent options. Instead, consumers increasingly prefer to have many choices in order to reflect their individuality. This trend is causing a major restructuring (sometimes called "re-engineering") of existing business enterprise. Information technologies permit movement away from *mass production,* which reduces the cost of inputs while increasing the consistency of output, toward *mass customization,* with more options for the consumer at the point of sale.

Higher education is at a similar crossroad. Colleges and universities are already following other service-oriented businesses in adapting technologies to improve effectiveness and to

increase personalization of services in accounting, record keeping, registration, and financial counseling. However, we should give careful thought to the potential of information technologies for improving learning before we simply automate current teaching practices, as many so-called *virtual classrooms* do. This approach through simple automization seems logical enough, but when it is coupled with our historical tendency to look for economic gain from increased productivity, such automization may eventually undermine our higher academic goals. On the other hand, if we follow the example of the business sector's mass customization, we can aspire instead to reach the goal of a Socratic individualization of learning and teaching.

SINCE THE TIME OF SOCRATES, OF course, the teacher's role has gone through many changes. Several of these have hampered the teacher's ability to devote his or her creative attention to teaching and to helping students fully develop their individual abilities. Perhaps these changes have been prompted by the need to increase productivity for the higher education enterprise. In view of the potential of today's information technologies, we should resist the temptation to reach for simple economic advantage and instead focus on improvement of quality of education. Educational leadership needs to understand that the integration of information technology into academia should not be motivated by faculty management optimization, but should emerge as a result of a new conceptualization of learning.

We are familiar with typical attempts to maximize the use of faculty. In some cases, faculty members spend less time using their creative talents and abilities to motivate individual students and more time preparing lectures in formats for large class settings that do not permit much interaction. Consequently, the professor devotes more time to computing grades, completing paperwork, and attending committee meetings. As we bring technology to bear on this time-management problem, one educational goal should not be lost: to increase the number and quality of one-on-one interactions or one-on-few interactions between faculty and students.

Interactions during which faculty members motivate students, encourage the acquisition of knowledge, and develop skills and reasoning abilities cannot easily be replaced by technology. At the very least, technology can be targeted at the routine and repetitive tasks in edu-

cation, relying on faculty members to inspire and nurture the intellectual development of students. Faculty members should *pull* technology in for these repetitive tasks, freeing up time to prepare units of instruction and participate in more direct interactions with students.

Since many students learn better from model-based reasoning, in which visualizing or experiencing a trend or movement in a system is clearer than talking about it, faculty need to incorporate these simulations, as well as devise other learning environments such as virtual reality, adaptive testing, and electronic labs. Computer technologies have been used to create learning opportunities that are not possible otherwise. For example, computer simulations can model the behavior of complex systems showing the influence of individual variables or the interactions of multiple variables.

Technology also can assist faculty members in stimulating reasoning and cognitive skills. For instance, Groupware Software can facilitate dialogue between students and experts in the field. The Internet (and the so-called information highway technologies) are providing numerous opportunities for students to develop scholarship in ways that were not possible one year ago.

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A key aspect of re-engineering in the business sector involves redefining chronology by shrinking the time it takes to respond to consumer needs. Yet for decades, credit hours, course requirements, and semesters have not declined but have been static or growing. Planners of courses customarily presume that all units of material should be covered on a common schedule, effectively stretching degrees from four years to five years and more. If higher education is to remain viable over the long haul, it must devise ways to deliver education as it is needed by the individual, not as tradition had dictated.

Perhaps information technology will help higher education implement devices through which the students can measure their own mastery of skills. Higher education has been assailed for dictating the time allowed to learn each item and then merely assessing success or failure. If adaptive tests can be developed which fairly evaluate a student's capabilities, professors can refocus on the task of helping individual students demonstrate their mastery as rapidly as possible. This has the potential of reducing the time needed to reach the educational level required for an academic degree.

Such a drastic redesign of the educational process has additional benefits. It permits students to take an active rather than a passive role in learning. It helps to combat the harmful effects of competition while enhancing collaboration. It also encourages students to appreciate their instructors as coaches rather than as gatekeepers.

THERE WILL BE NO SINGLE technology that fits all educational situations. Each university or college needs to develop a variety of options, as certain subject matters lend themselves to a subset of approaches. The teaching style of individual faculty members may lead toward alternate technological approaches. There should also be a variety of options taking into account the individual learning preferences of students.

At Embry-Riddle, whenever we offer the students options for learning some specific subject matter—ranging from independent study to classical chalk board instruction—the students perform better in each segment than they statistically do otherwise. It seems that just offering the choice itself helps the student to maintain motivation and confidence.

Many theoretically good ideas for enhancing learning with technology have not lived up to their promise. Evaluation committees must do more than just read the literature and attend product demonstrations. An environment must be built in which experiments are performed on a regular basis to determine whether the technology is maturing smoothly and can be adapted for the academic culture at which we aim. Key players in this process must be willing to appreciate and admit failures, as well as be willing to change multi-year acquisition plans if the results do not warrant continued investment. Those favoring the status quo will fight many new ideas and look for disappointments in technology to strengthen their case against change. Nonetheless, learning technologies must be tested within the intended environment in order to be properly evaluated. Considerable leadership, discipline, and tolerance are needed to implement and continuously remodel a technological path.

Technology is maturing at a pace that exceeds most organizations' abilities to adapt. Many information technologies are eclipsed by others within months and, by most standards, are obsolete within five years. We must devise strategies to respond to continuous change. Academic leaders should reinforce a climate in which faculty members have options for developing the learning and teaching environment. It is likely that institutions which are unsuccessful at creating this environment will be at a severe competitive disadvantage within a decade. Catching up will be virtually impossible.

No new technology will be useful unless

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both faculty and students have training and learning time. With current tight budgets and schedules, such on-the-job training is hard to afford, yet it is essential for wise investment and true change.

One of the most controversial opportunities of communication technologies is distance education. Audio and television/video links have been used in a limited fashion for decades, yet many faculty members and universities have been reluctant to accept this approach fully. This reluctance is surprising, since studies have consistently shown that students who graduate from these programs do so with equal or higher performances than do those completing their education on the campus. Such good performances may, in reality, be due to the quality of the students and the limitations of our measurement systems, rather than to the quality of the delivery mechanisms.

Will these "virtual classrooms" make universities as we know them obsolete? Fewer funds may be spent on brick and mortar infrastructures as more investments are made in expertise (knowledge workers) and information technology. These investments do have the advantage of linking the local community with the global community, but we must not forget that the hub of the educational experience and the definition of the learning environment still remain in the university. Here students acquire the interpersonal skills they will subsequently need, for face-to-face meetings dominate the business and political deliberations of our society.

Yet there are many benefits of the virtual classroom beyond economic efficiency. Faculty members at various locations can be called on to assist in the university's mission. Similarly, students in remote locations are often working adults with significant life experiences. The synergy that results from students on the residential campus interacting with those in the field has the promise of increasing the learning opportunities for all. We must learn to profit from this interaction around the university hub while resolving significant problems in distance learning such as differences in time zones and the lower percentage of course completions by off-campus students.

We should, moreover, not overlook the possibilities that "distance education" technologies offer professors and students on the same campus. Is it necessary for faculty members to be physically present in the room with the students? Can students work productively on problems, labs, homework, and so forth in resource labs under the electronic guidance of teachers? Instructors could "peek" in on students from the comfort of their offices using computers and multi-media technologies and assist learning through real-time guidance or through a variety of computer tools, videotapes, and other materials to which the students have access. Clearly, not all classes need to be taught via stand-up lectures or in seminar formats. There could be new, on-campus teaching paradigms that make use of the same distance technologies developed for connecting off-campus students and faculty.

MANY INSTITUTIONS ARE TRYING to introduce more *real-world* problem solving, more collaboration skills, and more decision making under uncertain conditions into their curricula. Employers of university graduates expect their employees to acclimate faster to their new roles in the workforce and to adapt as their jobs grow or as they advance. Distance education should play a role there as well.

Few tasks in today's competitive and global environment can be performed entirely in one location. Companies are using more telecommunication technologies (e-mail, fax, teleconferencing, and videoconferencing) to augment their face-to-face interactions. Although telecommunications technologies will never completely supplant direct interpersonal interactions, their importance is growing rapidly.

Yet many of the study groups and capstone projects that are assigned to students at their institutions emphasize the way business interactions used to be conducted. If academic exercises should mimic real world commerce, then which participants are talking to the vendors in the Pacific Rim or to buyers in Central America? Who is coordinating with the multiple corporate headquarters? Who is talking to the public relations and finance groups in New York? Who is negotiating with the customers in Europe? In fact, voice mail, e-mail, shared data bases, and videoconferencing are all growing factors in enterprises outside of academia. If higher education is not exposing students to these communications technologies, it is short-changing them, and this places higher education in further danger of becoming irrelevant.

Information technology and telecommunications present a substantial opportunity for universities to take the initiative. Leaders in almost all business endeavors say that telecommunications and transportation are becoming greater factors in the effective accomplishment of their work. Yet when these same leaders are asked how well their organizations use distance technologies for telecommunications, many will respond that theirs are fairly ad-hoc ap-

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proaches. As faculty members experiment with new information systems and learn how to exploit the associated technologies, they will pass on to their students skills and approaches to share with their future employers.

Faculty members who are developing new teaching methods and direct class projects using telecommunications are conducting relevant research. If an approach to sharing information via electronic networks improves a company's productivity by 1 percent, it may be more valuable than any single invention that a scientist or engineer might contribute. As professors concentrate more on the mission of teaching, relevant research results may accrue that are as valuable as other scholarship efforts.

Higher education obviously has a responsibility to serve residential campus students, but our institutions also have a responsibility to serve other segments of society and the community. Colleges and universities should, in particular, be taking a leading role in supporting K–12 educational opportunities. Likewise, working professionals need access to educational opportunities within their restricted daily schedules. The U.S. workforce of the future will emphasize "knowledge workers," who quickly adapt to the changing environment. The promise of the virtual classroom technologies offers real opportunities to serve both these nontraditional clients and residential students. Whether in classical credit-bearing curricula or in non-credit short-courses, subjects can be electronically offered by connecting our campuses with the world.

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Today's theme in business seems to be the "just-in-time" delivery of materials, products, or services. By recasting its mission, "just-in-time" higher education could be delivered as desired by the educator, to the student, parent or employer with electronic connections and enabling technologies. Trying to establish brick and mortar edifices to support similar opportunities in the field merely drains resources from this recast academic mission.

MUCH HAS BEEN WRITTEN ON how electronic document storage and retrieval will change campus libraries. It is probable that the central role of libraries and librarians will increase since effective distance education is impossible without linkages to library resources. Students are growing up with expectations of acquiring greater access to digital libraries, bulletin boards, gophers, and Internet information in multimedia formats via the information highway. Universities and colleges must endeavor to learn which approaches for using the technology will be most effective while insuring that these formats remain cost effective. It is likely that by focusing resources, specialists who prepare and maintain the new digital libraries will diminish the overhead of the brick and mortar growth pattern. Positive, appropriate relationships with partner institutions, coupled with increased networking should help to minimize the duplication that currently exists within institutional libraries.

Leadership will be required to make the transition to digitized portions of library collections that are available for scholars and students. In fact, these changes may require a greater investment in media and personnel than current business models dictate. But, if they are developed correctly, institutional libraries will have increased significance.

RATHER THAN IMPROVING productivity through mass production, the higher education of the future should embrace new information technologies which significantly improve the quality of learning. Faculty members should be freed from repetitive teaching and administrative tasks and given time for quality contacts with individual students or small groups of students. New technology should be used to enable faculty to pursue creative teaching methods and to provide opportunities for improved learning experiences.

No single information or telecommunication technology for teaching will serve all faculty or all students in all contexts. We need to find a broad spectrum of solutions that can be customized to subject material, faculty desires, and student preferences. Time and resources for training are needed for the teacher and the student to maximize the relevancy of higher education.

The model environment for learning may be the classroom, the virtual classroom, the resource center, or the electronic library. Adopting a re-engineering process described in this overview involves continuous experimentation and change. As the teaching and learning environment evolves, attitude modifications by faculty, librarians, students, and administrations become necessary. In all cases where change is an important cultural requirement, many of those involved will make the transition successfully. Unfortunately, those who resist these critical changes may prevent higher education from adapting and improving at an appropriate pace. With the cooperation of all individuals in the system, institutions of higher learning will have faculty, librarians, staff and students in increasing numbers participating at a higher level of learning and research and inquiry.