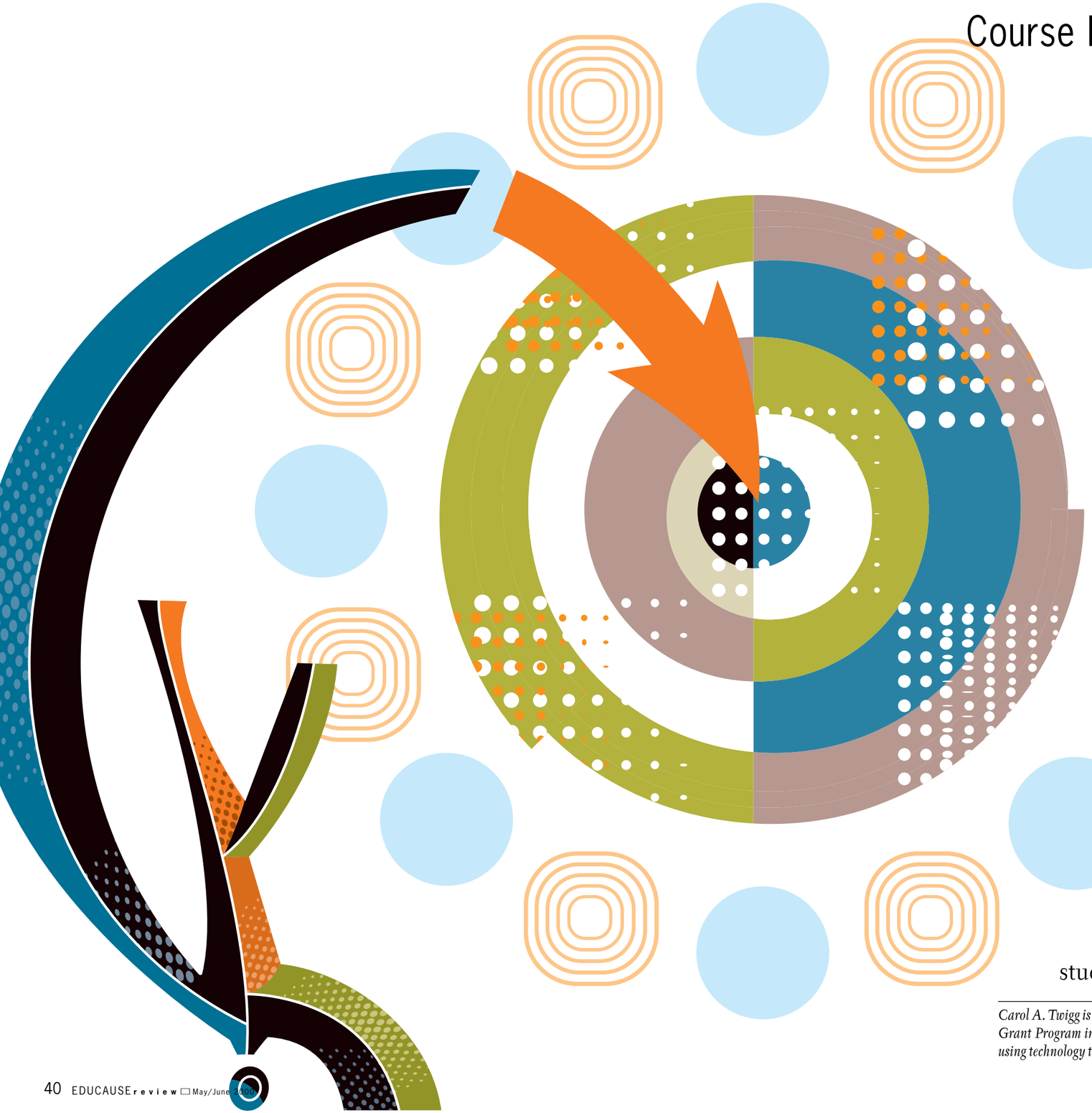
Course Readiness Criteria:

Identifying Targets of Opportunity for Large-Scale Redesign

By Carol A. Twigg



An increasing number of institutions are ready to use information technology (IT) to engage in large-scale course redesign in order to realize a return on their IT investments. Having made substantial financial commitments to create a computing-intensive campus and a set of mature IT support services, they are well on their way to developing a critical mass of faculty with experience in integrating IT into courses. They are now seeking ways to use IT more strategically in order to improve the quality of student learning and to increase academic productivity on their campuses.

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Illustration by Campbell Laird/Laughing Stock

Just as some institutions are more ready than others to engage in large-scale redesign, some courses are more ready than others to be the focus of that redesign effort. Because of prior experiences with technology-mediated teaching and learning, and because of numerous attitudinal factors, some faculty members are more ready to engage in course-redesign efforts. They have, in essence, a head start on the process. What follows is a list of preconditions—or readiness criteria—that can help a campus identify which courses are successful redesign candidates. Examples of the ways that institutions currently engaged in large-scale projects have met these criteria are included.

Improvements in the Course Must Have a Significant Impact on the Curriculum

Institutions are wise to concentrate on those courses that will generate a high return on their investment. There are several ways to identify courses whose redesign will have a significant impact. Is the course a large, introductory, high-enrollment course? Studies have shown that undergraduate enrollments are concentrated in relatively few academic areas. At the community college level, about 50 percent of student enrollment is concentrated in just twenty-five courses. These courses include introductory studies in English, mathematics, psychology, sociology, economics, accounting, biology, and chemistry. Those same twenty-five courses generate about 35 percent of enrollment at the baccalaureate level. By making improvements in a restricted number of courses, an institution can affect literally every student. At the University of Wisconsin-Madison, for example, the introductory chemistry course enrolls 50 percent of all freshmen. Penn State has discovered that redesigning just three courses will affect every member of the freshman class.

Is there a significant academic problem in the course, such as a substantial failure rate? Most of the weaknesses attributed to large, introductory, high-enrollment courses are generic in nature and have as their source the limitations of the predominant form of instruction in our nation's colleges and universities: the didactic lecture. An overwhelming body of research tells us that students do not learn effectively from lectures, and testimony from the field corroborates the literature. Although success rates vary by institutional type and by subject matter, Research I universities commonly cite a 15 percent rate of drops, D grades, and failures in lecture courses. Comprehensive universities report success rates (a grade of C or better) ranging from 78 percent down to 55 percent. Community colleges frequently experience retention rates of 60 percent or less. Clearly there is a great deal of room for increasing student achievement levels in these courses.

Even more important, those who pass often do not retain much of the material for future use in other courses. All institutions report students' inability to retain what they have learned in large lecture courses and, more specifically, their inability to apply the principles learned to other disciplines. Lee Shulman, president of the Carnegie Foundation, has described those learning problems as the "epidemiology of mislearning" or the "taxonomy of pedago-pathology." Students forget what they learned (amnesia); they don't understand that they misunderstand what they learned (fantasia); and they are unable to use what they learned (inertia).

Does the course face a serious resource problem, such as how to manage increased enrollment demand with no commensurate increase in resources? Introductory courses absorb a significant amount of resources. Despite the common wisdom that packed lecture halls and low-paid graduate teaching assistants constitute the most cost-effective way to deal with large numbers of students, those who have examined the matter know that lecture-based courses are not cheap. This is especially true when these courses are combined with discussion sections—used by most institutions to give students some opportunity for interaction—as well as laboratories. In many institutions, individual faculty members teach introductory courses in multiple-section models, quite costly given the large number of sections required. Controlling costs in those courses can result in a significant return to the institution.

The Course Must Offer the Possibility of Capital-for-Labor Substitution

Large size does not necessarily make a course a good candidate for redesign. The University of Illinois at Urbana-Champaign, for example, offers an introductory comparative literature course that enrolls about 250 students each semester. The course is writing-intensive and satisfies the campus composition requirement. In spite of the course size, the possibility for capital substitution is limited. Competent evaluators must assess the students' written work, which is contextually based, thus limiting the possibility of capital-for-labor substitution.

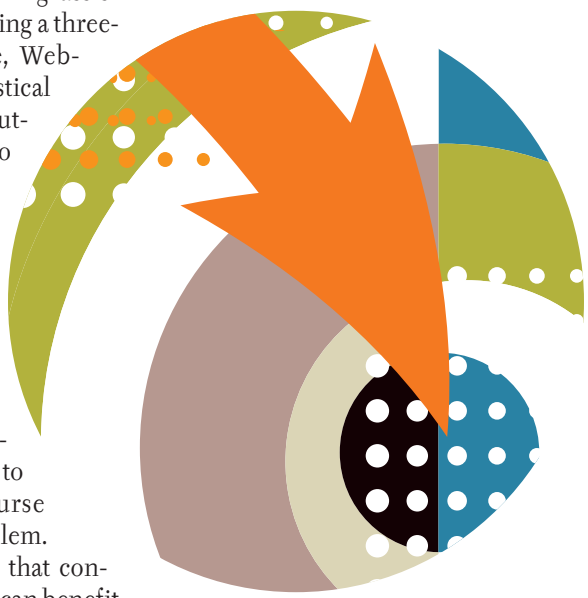
Some subjects are particularly well suited to computer-mediated techniques. Examples of good target subjects include remedial and basic math and other general education courses. A large part of the content of many introductory courses consists of codified knowledge that must be mastered before more complex systems can be understood. Introductory-level mathematics, for example, typically involves a modest conceptual core, underpinning a great deal of numerical and symbolic calculation. Interactive computer instruction is a natural way to provide examples and practice in implementing the mathematical ideas, especially when practice efforts and repetition count toward mastery of content. For these reasons, Virginia Tech has selected linear algebra as a natural target for redesign. Similarly, Rio Salado College offers distance learning using interactive pre-algebra and college algebra courseware developed by Academic Systems. Rio has found that the software presents course content so well that instructors no longer need to spend time doing so. Instead their time can be devoted to the necessary student intervention.

Those subjects that require hands-on experience with data analysis and collection—such as statistics and other research-based disciplines—can easily take advantage of available technologies

as a way of teaching concepts and techniques. Most statistical skills can be practiced and evaluated on the computer. As part of its redesign of introductory statistics, Penn State intends to reduce the number of teaching assistants from twelve to six by using a three-pronged model: interactive, Web-based materials to teach statistical concepts interactively; computerized, low-stakes quizzes to give students needed practice; and computer-graded midterm and final examinations to assess certain parts of the course. Since it is difficult for the department to identify such a large number of qualified assistants each semester, reducing the number required to teach the introductory course will address an ongoing problem.

Any portion of a course that concentrates on skill acquisition can benefit from an IT format. The University of Illinois at Urbana-Champaign has developed two products, CyberProf and Mallard, which allow students to self-teach; the products supply intelligent assessment of short-answer questions delivered through the Web. Used in such diverse fields as engineering, economics, and foreign languages, these products enable the faculty to put all homework on-line to be automatically graded. Rather than spending time on grading, the instructors can easily track and address problems that students may be having with the material.

Other subjects that are particularly well suited for technology-mediated learning include those that are visual in nature, since many of the concepts are illustrated by images. Biology, for example, is rich in graphics and uses many visual cues. Its many phenomena are good subjects for animation, which can capture essential or otherwise unobservable parts of the phenomena. Because many students at the introductory level are nonmajors, they have an especially great need to see the material that is taught. The University of Colorado-Boulder has selected its introductory astronomy course to redesign partly because of the visual nature of the course. Much of current astronomical research is carried out through analysis of images. The Web is already rich with astronomical images, animations, and Java applets to illustrate various concepts. With technology resources and a good road map, students can be given a high-quality exploratory experience using materials that are already available.



If an institution wants to make a change, the best chance of success involves not a single individual but rather a group of people who, working together, are committed to the project objectives.

Decisions about Curriculum in the Department, Program, or School Must Be Made Collectively

Decisions to engage in large-scale course redesign cannot be left to an individual faculty member. He or she may leave the institution, grow tired of the innovation, change his or her mind, and so on. If an institution wants to make a change, the best chance of success involves not a single individual but rather a group of people who, working together, are committed to the project objectives. This is even more important when it comes to sustaining the change.

Indicators that the faculty in a particular unit are ready to collaborate include the following: they may have engaged in joint conversations about the need for change; they may have decided to establish common learning objectives and processes for the course in question; and they may have instituted pieces of a common approach such as a shared final examination. Institutional support is important, but departmental ownership of the course-redesign idea is essential.

At Penn State, a group of statistics faculty has been meeting regularly for several years to discuss ways to improve instruction. Two years ago this group adopted the name "TAPS," which stands for Teachers at Penn State, giving the group a university-wide identity. The group meets weekly to share ideas about teaching statistical concepts and to discuss different approaches to teaching undergraduate statistics courses. Although the department also has an Undergraduate Service Course Committee to consider course revisions formally, TAPS provides a forum in which instructors can discuss the costs and benefits of curriculum revisions. The

members of TAPS presented their course-redesign proposal to the entire department, which unanimously approved the concept.

Indiana University–Purdue University at Indianapolis (IUPUI) is combining its introductory sociology course with its introductory writing course to strengthen both offerings. Both of these courses benefit from collective departmental decision-making, a direct result of an acknowledgment that these are high-impact courses on campus. The English Department's well-established writing program, which uses technology to enhance student learning, was developed collectively by those who teach the course. In the Sociology Department, a committee of full-time faculty members who regularly teach the introductory course was created in the fall of 1997. Its members, collectively and with the support of the chair of the Sociology Department, are collaborating on the redesign project.

At the State University of New York (SUNY) at Buffalo, the team that is redesigning the computer literacy course consists of faculty who have been involved in the design and teaching of the course in its traditional format. Decisions about the curriculum, textbooks, software, and lab setups are made by the course team. The university is planning to make the course a required general education course, at which time course ownership will move outside of the department. Decisions about updating and modifying the course will be made by a Computer Literacy Committee composed of the course team members and computer-literate faculty from throughout the university.

The Faculty Must Be Able and Willing to Incorporate Existing Curricular Materials in Order to Focus Work on Redesign Issues Rather Than Materials Creation

Ideally, faculty should have a head start in the redesign process. Disciplines with a comparatively large existing body of technology-based curricular materials and/or assessment instruments are especially appropriate targets. The studio-course model at Rensselaer Polytechnic Institute relied initially on materials created by the nationwide CUPLE project. The chemistry redesign project at UW-Madison builds on decades of collaborative work in chemistry software development.

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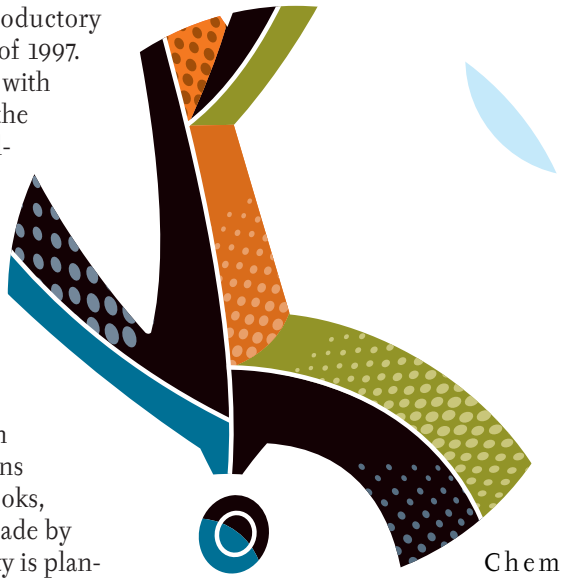

Chemistry has a broad range of available IT-based learning materials, many of which have been peer-reviewed and published by the *Journal of Chemical Education,* whose editorial offices are on the Madison campus.

Faculty who are willing to employ an appropriate blend of homegrown (created by local faculty) and purchased learning materials in a nondogmatic fashion will also have a head start. In its Math Emporium project, Virginia Tech first tries to locate existing materials to incorporate into its courses before turning to materials creation. The Astronomy Department at the University of Colorado-Boulder has developed a complete on-line hypertext, with many images, animations, and links to external sites and Java applets for constructive learning. It uses educational materials developed by NASA and by other universities such as Cornell, the University of Arizona, the University of Oregon, and UCLA. Colorado regards the collection of Web-based instructional materials not only as a resource for its own students but also as its contribution to an emerging worldwide infrastructure for astronomy education.

The University of Central Florida (UCF) has chosen to redesign its "American National Government" course, an ideal candidate due to the abundant copyright-free Web sites that deal with American politics: U.S. federal, state, and local government sites; newspapers, news periodicals, and television news sites; foreign government sites; U.S. and foreign-interest group sites; and transnational and international agency sites.

Many long-standing textbook publishers are producing technology-based materials that can be purchased by the student; the materials include supplementary Web-based assignments and exercises. Moreover, several new companies focused on electronic media are

developing tutorials and other kinds of educational materials. Companies are also producing Web-based packages to generate tests. Many styles of test questions are possible, including multiple choice, true/false, essay, short answer, fill-in-the-blank, and numerical responses. These products provide a mechanism for putting almost any test material on the Web and giving immediate feedback on student performance. The University of Southern Maine is taking advantage of existing commercial products in redesigning its introductory psychology course, recognizing that the quality of materials that already exist outside the department is far above what the university department could do itself. Southern Maine faculty are teachers, not programmers or educational technologists; they see the development of technology as something that someone else can do more efficiently and effectively. They have, in effect, outsourced their technology needs.

Faculty who are subject to the "not-invented-here syndrome"—that is, who believe that they must create everything themselves from scratch—will be consumed with materials development and will add large amounts of time to the redesign process. Those who are willing to partner with other content providers, whether commercial software producers or other universities that have developed technology-based materials, make better candidates for a large-scale redesign project.

The Project Participants Must Have the Requisite Skills

Successful projects build on an established skill set. For example, faculty who have some experience with computer-based instruction beyond putting syllabi on the Web are more likely to succeed than those without such experience. Previous work could include developing outlines and storyboards for pilot modules, developing computer-based tutorials and diagnostic quizzes and assignments keyed to questions in the quizzes, or using course-management systems that facilitate student-to-student and student-to-instructor communications.

Does the potential project have strong leadership? Champions or "heroes" frequently play a significant role in redesign projects. People need concrete evidence that an idea is doable, and having one person who can do something that others can see is important. The project leader of UW-Madison's redesign effort in chemistry has more than thirty years of experience in developing and using computer-based learning systems. He has authored half a dozen published programs and multimedia collections and served for eight years as the editor of *JCE Software*, which pioneered the distribution of peer-reviewed chemistry software in journal format. Several other members of the faculty and academic staff have written their own software as well. The Chemistry Department at UW-Madison has been at the center of development of new software and multimedia learning materials for the past decade.

Although a "hero" may be needed at first, the innovation will not grow and be sustained if the project continues to rely on heroism. Large-scale redesign efforts will almost always involve partnerships among faculty, IT staff, and others. At Virginia Tech, two senior faculty members in mathematics lead the redesign effort, with one handling software and database development and the other directing course administration and planning. The faculty and graduate student development group includes individuals with extensive experience in teaching linear algebra in a traditional setting as well as a broad array of experience in media and computer-based learning. Consultation with Virginia Tech's IT staff provides additional expertise, particularly in database management and Web server use. This strong collaborative effort has enabled the linear algebra project to move into full-scale operation within about one year.

In redesigning introductory statistics, Penn State has put together a project team with a diverse set of skills. All team members are excellent communicators; all have substantial experience in teaching elementary statistics; and all are intensely committed to the task of restructuring and redesigning the course and teaching approaches. Several members of the team possess a broad range of technical skills: they have coauthored a national, Web-based, interactive statistical course called "Visualizing Statistics"; have developed numerous multimedia demonstrations of basic statistical concepts; and have created collections of Web-based materials such as case studies and data-collection tools. Others are quite knowledgeable about learning theories and assessment and have a strong record of dissemination of research results involving collaboration with faculty in the College of Education. Still others have extensive experience with collaborative student research projects and in-class learning activities such as using small-group activities in a large lecture setting and student quality teams in continuous class monitoring. This combined set of skills and a strong track record help to ensure the success of the redesign effort.

The Course's Expected Learning Outcomes and a System for Measuring Their Achievement Must Be in Place

Successful large-scale course-redesign efforts begin by identifying the intended learning outcomes and developing methods other than the lecture-presentation model for achieving them. The curriculum is then built backward from the intended outcomes. As an example, the UW-Madison chemistry project team has developed both learning outcomes and the means to assess them as a result of a prior systemic curriculum project sponsored by the National Science Foundation (NSF). Outcomes are based partly on surveys of faculty in other disciplines, who are asked what content and process skills they expect students to gain from chemistry courses, and partly on the general consensus, across most of the chemistry departments in the United States, about introductory chemistry content.

Many redesign efforts take advantage of national standards and normed assessment instruments in their particular disciplines as a framework for structuring the project. SUNY-Buffalo will base its redesign on the learning out-

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David Halberstam

David Halberstam's landmark trilogy of books on power in America, *The Best and the Brightest, The Powers That Be*, and *The Reckoning*, have helped define the latter part of the century more than any journalistic works. David Halberstam was awarded The Pulitzer Prize in 1970 for his reporting on Vietnam.

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comes for computer literacy courses found in the April 1999 report "Be FIT: Fluency in Information Technology," sponsored by the NSF and the National Research Council (NRC). The report states that students need to learn three kinds of knowledge. The three components are interdependent and coequal: (1) *concepts* (understanding the foundations of information technology); (2) *skills* (knowing contemporary applications); and (3) *capabilities* (applying higher-level thinking to information technology). Within these knowledge components, the report specifies ten particular learning outcomes that will serve as a framework for redesign.

Similarly, UW-Madison has collaborated with experts at Catholic University and the American Chemical Society Examinations Institute at Clemson University. These experts have developed and tested new introductory chemistry content exams that involve traditional questions and related questions that determine whether students have developed conceptual understanding. UW-Madison has also developed systems for spot-testing students' understanding by interviewing a small number of students selected to represent a cross section of abilities. Having used these exams in the past, the university has comparative data to evaluate the success of the project.

Does the campus have assessment processes in place, such as the ability to collect data, the availability of baseline data, or the establishment of long-term measures? Many campuses have established an assessment culture, making it easier for them to assess the learning outcomes of innovative projects as well as of traditional courses and programs. IUPUI has a nationally recognized institutional research unit and is unusually capable of good longitudinal evaluative work. The Office of Institutional Management and Institutional Research (OIMIR) routinely collects information at both the class and the individual student levels. As part of its redesign project, the Sociology Department will administer its own questionnaires to assess student learning and will compare the results of a common examination (or examination modules) in both traditional and redesigned sections. Questionnaire results will be coordinated with data provided by OIMIR so that background variables that predict DWF status (e.g., being a parent) can be specifically identified as part of the course assessment.

Faculty Members Must Have a Good Understanding of Learning Theory

Sound pedagogy is the key to successful redesign projects. With sound pedagogy, technology becomes an enabler, rather than the driver, for good practice. Does the instructor seek to use technology to transform the teaching and learning environment to achieve learning improvements rather than merely to automate existing instructional practice? Has the instructor systematically thought about and investigated alternative methods for empowering students to learn? Faculty who already provide a range of options for achieving required learning outcomes are especially good candidates.

Members of the course-redesign team at SUNY-Buffalo have experience with learner-centered concepts. For example, lectures are punctuated with "Class Discussion Questions" ("CDQs"): students work in small groups on a challenging problem for a few minutes and then report their progress. In this process, students are placed in the position of assessing their own understanding of the concepts being discussed. Some members of the course-redesign team are also involved in a collaborative research project, "Learning Styles in a Virtual Environment," involving the university, the Hungarian Academy of Science, and ExecuTrain. The focus is to identify which of the various measures of learning style provide the best indicator of how successful a particular student will be with various types of computer-mediated learning materials. The team will then be able to customize materials for students with particular learning styles and to provide multiple means by which students can achieve the learning goals of the course.

Frequently, one assumes that university faculty members have an understanding of learning theory simply because they are teachers. In reality, many faculty are exposed to these ideas for the first time during faculty-development experiences. By working in partnership with instructional designers, faculty can become knowledgeable about learning theory and its relationship to course design. UCF, for example, offers a faculty-development course to prepare faculty to teach on-line. Participants learn from presentations by other faculty ("Web Vets") who are teaching on-line courses. Through the "live" and on-line portions of the course and the course-development work with their instructional designer, faculty members become knowledgeable about learning theory and its relationship to course design.

There Must Be a Business Plan to Sustain the Redesign in the Future

To be sustained, changes in instructional practice must be affordable for institutions and must be integrated into the institutional base funding practices. A wealth of experience shows that attempts to add on innovations with external support, and without internal structural change—especially without a commitment of resources in the institution's core budget—have been almost totally unsuccessful. When the grant funding runs out, the innovation ends. The best way to tell whether an innovation is real or artificial is to look at its funding. Unless an innovation is paid for directly by those who stand to benefit from it, its chances to flourish are dubious at best.

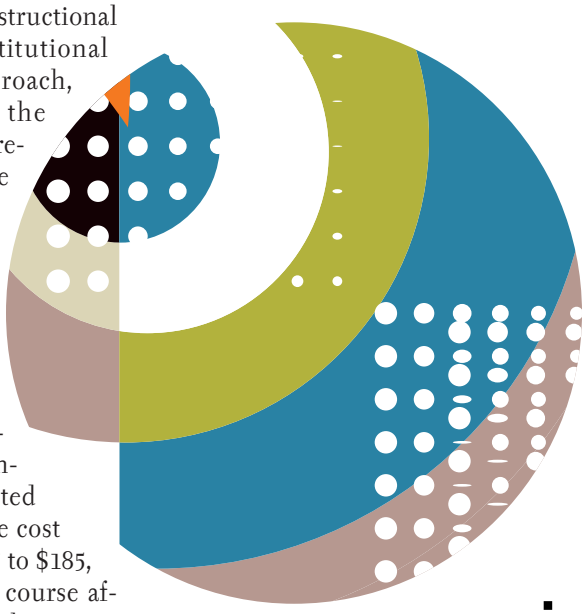
Since the major cost item in instruction is personnel, we know that reducing the time that faculty and other instructional personnel spend and transferring some tasks to technology-assisted activities constitute the key to cost savings in instruction. If we can reduce the number of hours spent by faculty and others while keeping credit hours constant with no diminution of learning results, we can reduce costs while maintaining quality. Of course, it is possible to reduce contact hours and save money, but without the use of IT and the redesign of the instructional process, quality would most certainly decline. With technology, an institution

can serve the same number of students at a lower cost—and serve them more effectively.

In redesigning large-enrollment courses, institutions have a variety of ways to reduce costs and, consequently, can develop a variety of instructional models depending on institutional circumstances. In one approach, student enrollments stay the same but the instructional resources devoted to the course (course expenditures) are reduced. This approach makes sense when the demand for the particular course is relatively stable. UW-Madison intends to maintain the same student enrollment in general chemistry while reducing the instructional resources devoted to the course, decreasing the cost per student from about $257 to $185, or 28 percent. Because this course affects 4,100 students per year, this saving translates to an annual saving of approximately $295,000. Penn State's redesign will result in a 30 percent reduction in the cost per student, from about $176 to $123. Because this course enrolls 2,200 students per year at the University Park campus alone, this translates to annual savings of at least $116,600.

Another approach is to increase enrollments with little or no change in expenditures. This technique is appealing to institutions that face greater student demand than can be met using conventional methods. The University of Illinois at Urbana-Champaign plans to increase enrollments with little or no change in expenditures, resulting in a reduction in the cost per student from $200 to $101. This technique is appropriate given the high student demand for Spanish courses. Without this redesign, the university would not be able to serve its students adequately. The University of Southern Maine's redesign of the introductory psychology course will increase the number of students per section from 75 to 125, resulting in a planned 49 percent cost-per student reduction, from $113 to $58. The university will redirect faculty resources to developing a distance learning program to increase service to the state's citizens.

A third way to decrease costs is to reduce the number of course repetitions required to pass a particular course. For example, in many community colleges 2.5 enrollments, on average, are needed to pass introductory mathematics courses. This means that the institution and the student must spend 2.5 times what it would cost to pass the course on the first try. Rio Salado College expects to increase enrollments in a distance-learning course while simultaneously reducing the number of repetitions required to pass its introductory mathematics course. The redesign will result in a projected cost-per-student reduction of 41 percent.



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Conclusion

Almost every college and university in the country provides some kind of support for faculty to integrate IT into teaching and learning. Most institutions, however, stop there. They do not consider the use of technology as a way to achieve particular academic goals, nor do they target specific elements of the curriculum for IT application. One way of thinking about these issues more strategically is to concentrate our efforts to integrate technology and new pedagogical techniques on those twenty to thirty courses that have a significant impact on the curriculum. If we do that, we can make a substantial contribution to controlling institutional costs while simultaneously creating more-effective learning experiences for students.

In higher education, we have traditionally assumed that high quality means low student-faculty ratios and that large lecture-presentation techniques are the only low-cost alternatives. Redesign using technology-based or learner-centered principles, however, can offer a way out of higher education's historical trade-off between cost and quality. New models show that it is possible to improve learning while simultaneously reducing the cost of instruction. We can indeed have our cake and eat it too.