Improving quality and reducing costs:

The case for redesign

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Executive summary

The need to increase access, improve student learning and control or reduce rising costs continues to challenge American higher education. These issues are, of course, interrelated. As tuition costs continue to rise, access is curtailed. However, promises to increase access ring hollow when high percentages of students fail to graduate. The solutions to these challenges are also interrelated. Historically, improving quality or increasing access has meant increasing costs; reducing costs has meant reducing both quality and/or access. To sustain its vitality while serving a growing and increasingly diverse student body, higher education must find a way to resolve the familiar trade-off between cost and quality.

Unlike higher education, most industries have taken advantage of information technology to increase productivity, thus improving the quality of service while reducing costs. The introduction of information technology to the U.S. economy in general—with the notable exceptions of education, health care and law—contributes to the disparity between the general rate of inflation and higher education's cost increases.

Few colleges and universities have begun to fully realize the promise of technology to improve the quality of student learning, increase retention and reduce the costs of instruction. In contrast, the National Center for Academic Transformation (NCAT) has completed a five-year national project, the Program in Course Redesign, which annually involves 50,000 students at 30 institutions. The program has shown how technology can enhance quality *and* reduce cost. Results show improved student learning in 25 of the 30 projects; the remaining five show learning equal to that found in traditional formats. All 30 institutions reduced their costs by 37 percent on average (from 20 percent to 77 percent) and produced a collective annual savings of $3.1 million. Of the 24 that measured retention, 18 showed noticeable increases. Other qualitative outcomes include better student attitudes toward the subject matter and increased student satisfaction with the mode of instruction.

This paper argues that an outmoded, labor-intensive delivery model and outdated assumptions about the relationship between cost and quality are important contributors to the rising cost of higher education. It also argues that improving student learning while reducing instructional costs is possible if we redesign collegiate instruction. The Program in Course Redesign offers persuasive data about how to achieve this goal. In addition to offering a broad solution to the cost/quality tradeoff, the program's redesign methodology offers many specific solutions that all colleges and universities can adapt.

The National Center for Academic Transformation has established a solid record of success that demonstrates that technology can improve student learning while reducing instructional costs. Each participating institution has found that successfully implementing the redesign methodology involves a partnership between faculty members, professional staff and administrators. NCAT's redesign methodology offers a well-considered, practical alternative to the current postsecondary dilemma facing the nation, especially if it is scaled appropriately to each institution. The paper concludes with a number of recommendations for scaling up the solutions offered by the redesign methodology, which could reduce the annual cost of instruction by at least 16 percent.

Introduction

Many people have observed that both the cost and the price of higher education continue to outpace the rate of inflation. As a U.S. House Education and the Workforce Committee report notes, "While some point to state budget cuts or a poor economy as the source of rising tuition, the fact is that college costs have been steadily and relentlessly increasing for more than a decade—even during the '90s economic boom—and that tuition increases have persisted regardless of circumstances and have far outpaced inflation year after year, whether the economy has been stumbling or thriving." The need to increase access, improve student learning and control or reduce rising costs continues to challenge American higher education. These issues are, of course, interrelated. As tuition costs continue to rise, access is curtailed. However, promises to increase access ring hollow when high percentages of students fail to graduate. The solutions to these challenges are also interrelated. Historically, improving quality or increasing access has meant increasing costs; reducing costs has meant reducing both quality and/or access. To sustain its vitality while serving a growing and increasingly diverse student body, higher education must find a way to resolve the familiar trade-off between cost and quality.

The problem is not that higher education has avoided information technology. Indeed, every college and university in the United States is discovering exciting new ways of using technology to enhance teaching and learning and to extend access to new populations of students. For most institutions, however, new technologies represent a large additional expense rather than an investment in increased productivity. Most campuses have simply bolted new technologies onto a fixed plant, a fixed faculty and a fixed notion of classroom instruction. Under these circumstances, technology contributes to the problem of rising costs rather than helping solve it. Moreover, comparative research studies show that most technology-based courses produce learning simply "as good as" their traditional counterparts—in other words, they produce "no significant difference." By and large, colleges and universities have not yet begun to realize the promise of technology to improve the quality of student learning and reduce the costs of instruction.

We at the National Center for Academic Transformation (NCAT) believe that an outmoded, labor-intensive delivery model and outdated assumptions about the relationship between cost and quality are important contributors to the rising cost of higher education. This paper argues that improving student learning while reducing instructional costs is possible with redesigned collegiate instruction. The Program in Course Redesign (PCR) offers persuasive data about how to achieve this goal. In addition to offering a broad solution to the cost/quality tradeoff, the program's redesign methodology offers many specific solutions that all colleges and universities can adapt.

Program in Course Redesign

Supported by an $8.8 million grant from the Pew Charitable Trusts, NCAT created the PCR in April 1999. Formerly housed at Rensselaer Polytechnic Institute, NCAT sought to demonstrate how colleges and universities can redesign their instructional approaches by using technology to enhance quality and save money. Selected from hundreds of applicants in a national competition, 30 institutions received grants of $200,000 each. The grants were awarded in three rounds of 10. The 30 institutions included research universities, comprehensive universities, private colleges and community colleges in all regions of the United States.

The PCR followed a unique three-stage proposal process that required applicants to assess their readiness to participate in the program, develop a plan to improve learning and analyze both the cost of traditional instruction and of new methods of technology-based instruction. A series of invitational workshops taught institutional teams these assessment and planning methodologies, and NCAT staff consulted individually with prospective grant recipients.

NCAT required each institution to evaluate student performance and achievement rigorously. National experts provided consultation and oversight regarding learning assessment to ensure reliable and valid results. The results were astounding. Twenty-five institutions showed significant increases in student learning, and the remaining five showed learning equal to that associated with traditional formats. Of the 24 that measured retention, 18 showed noticeable increases. Other qualitative outcomes include better student attitudes toward the subject matter and increased student satisfaction with the mode of instruction.

The course-redesign projects focus on large-enrollment, introductory courses, which can affect significant student numbers.

The PCR's basic assessment concern was the degree to which improved learning occurred at reduced cost. Answering this question required comparisons between the learning outcomes of a given course delivered in its traditional and in its redesigned format. Therefore, costs and outcomes were compared for courses in both formats—some held simultaneously and others held in different terms.

Student mastery of course content was the bottom line. Techniques for assessing student learning included comparisons of common final examinations, embedded common questions or items in examinations or assignments and samples of student work (papers, lab assignments, problems). Outcomes were assessed according to agreed-upon common faculty standards for scoring or grading. Assessment also included tracking student records after they completed redesigned courses. Tracking examined a) percentage satisfactorily completing a downstream course; b) percentage continuing to a second course in the discipline; and c) grade performances in later courses.

"Before and after" course costs were analyzed and documented with activity-based costing. NCAT developed a spreadsheet-based course planning tool (CPT) for institutions to do the following: 1) determine all personnel (faculty, adjunct instructors, teaching assistants, peer tutors and professional staff) costs expressed as an hourly rate; 2) identify the tasks associated with preparing and offering the course in a traditional format; 3) determine how much time each person involved in preparing and offering the course in a traditional format spends on each of the tasks; 4) repeat steps one through three for the redesigned format; 5) enter the data in the CPT. The CPT then automatically calculates the cost of both formats and converts the data to a comparable cost-per-student measure. At the beginning of each project, baseline cost data (traditional course costs and projected redesigned course costs) were collected, and actual redesigned course costs were collected at the end.

All 30 institutions reduced costs by an average of 37 percent, with a range of 15 percent to 77 percent. Collectively, the 30 redesigned courses affect more than 50,000 students nationwide and produce a savings of $3.1 million in operating expenses each year.

The course-redesign projects focus on large-enrollment, introductory courses, which can affect significant student numbers and thus generate substantial cost savings. Why focus on such courses? Simply put, undergraduate enrollments in the United States are concentrated heavily in only a few academic areas. In fact, just 25 courses generate about half of community college enrollment and about 35 percent four-year college enrollment.

The topics of these courses are no surprise. They include introductory studies in English, mathematics, psychology, sociology, economics, accounting, biology and chemistry. Successful completion of these courses is critical for student progress toward a degree. However, their high typical failure rates—15 percent at research universities, 30 percent to 40 percent at comprehensive universities, and 50 percent to 60 percent at community colleges—significantly influence dropout between the first and second year.

The lesson in these figures is simple and compelling: To have a significant impact on large numbers of students, an institution should concentrate on redesigning the 25 most popular courses. By improving a restricted number of large-enrollment prerequisite or introductory courses, a college or university can affect literally every one of its students.

A variety of models

The PCR has produced many different models of how to restructure such courses to improve learning and cut costs. The program has demonstrated that many approaches can achieve positive results in many types of institutions and in many disciplines. The 30 participating institutions and the curricular area of their redesigned courses are the following:

Quantitative (13)

Mathematics: Iowa State University; Northern Arizona University; Rio Salado College; Riverside Community College; University of Alabama; University of Idaho; Virginia Polytechnic Institute and State University.

Statistics: Carnegie Mellon University; Ohio State University; Pennsylvania State University; University of Illinois at Urbana-Champaign.

Computer Programming: Drexel University; University of Buffalo.

Social science (6)

Psychology: California State Polytechnic University-Pomona; University of Dayton; University of New Mexico; University of Southern Maine.

Sociology: Indiana University-Purdue University-Indianapolis.

American government: University of Central Florida.

Humanities (6)

English composition: Brigham Young University; Tallahassee Community College.

Spanish: Portland State University; University of Tennessee-Knoxville.

Fine Arts: Florida Gulf Coast University.

World literature: University of Southern Mississippi.

Science (5)

Biology: Fairfield University; University of Massachusetts-Amherst.

Chemistry: University of Iowa; University of Wisconsin-Madison.

Astronomy: University of Colorado-Boulder.

What do these projects have in common? To one degree or another, all 30 share the following six characteristics:

1. Whole course redesign. In each case, the whole course—rather than a single class or section—is redesigned. Faculty members begin by analyzing the time that each person involved in the course spends on each kind of activity. This analysis often reveals duplication of effort. By sharing responsibility for both course development and course delivery, faculty members save substantial time and achieve greater course consistency.

2. Active learning. All of the redesign projects make the teaching-learning enterprise significantly more active and learner-centered. Lectures are replaced with a variety of learning resources that move students from a passive, note-taking role to active learning. As one math professor put it, "Students learn math by doing math, not by listening to someone talk about doing math."

3. Computer-based learning resources. Instructional software and other Web-based learning resources assume an important role in engaging students with course content. Resources include tutorials, exercises and low-stakes quizzes that provide frequent practice, feedback and reinforcement of course concepts.

4. Mastery learning. The redesign projects offer students more flexibility, but the redesigned courses are not self-paced. Student pace and progress are organized by the need to master specific learning objectives—often in a modular format, according to scheduled milestones for completion—rather than by class meeting times.

5. On-demand help. An expanded support system enables students to receive assistance from a variety of people. Helping students feel that they are a part of a learning community is critical to persistence, learning and satisfaction. Many projects replace lecture time with individual and small-group activities that take place in computer labs—staffed by faculty, graduate teaching assistants (GTAs) and/or peer tutors—or online, thus providing students more one-on-one assistance.

6. Alternative staffing. Various instructional personnel—in addition to highly trained, expert faculty—constitute the student's support system. Not all tasks associated with a course require a faculty member's time. By replacing expensive labor (faculty and graduate students) with relatively inexpensive labor (undergraduate peer mentors and course assistants) where appropriate, the projects increase the number of hours during which students can get help and free faculty to concentrate on academic rather than logistical tasks.

Strategies and successes for improving student learning

The redesign projects have changed teaching and learning. Lectures are replaced with a wide variety of learning resources, all of which involve more active forms of student learning or more individualized assistance. Moving from an entirely lecture-based format to a student-engagement approach makes learning less dependent on words uttered by instructors and more dependent on active reading, exploring and problem-solving.

Most of the projects show statistically significant improvements in overall student understanding of course content, as measured by assessments that examine key course concepts before and after the course. For example, at the University of Central Florida, students in a traditional political science course posted a 1.6-point improvement on a content examination, whereas students in the redesigned course nearly doubled that improvement, with an average gain of 2.9 points. At Penn State, students in a redesigned course in statistics outperformed traditional students on a content-knowledge test. Scores for those in the traditional format averaged 60 percent; for those in the redesigned course, the average was 68 percent.

Other projects demonstrate statistically significant improvements in student understanding of course content, as shown in students' performance on commonly administered examinations. At Carnegie Mellon University, for example, student performance in redesigned courses increased by 22.8 percent on tests of skills and concepts. At Florida Gulf Coast University, the average score on a commonly administered standardized test for students in a traditional fine arts course was 72 percent; in the redesigned course, it was 85 percent. At the University of Iowa, students in a redesigned introductory chemistry course outscored traditional students on 29 of 30 items on a common exam. Students in the redesigned course also outperformed the comparison group on two forms of an American Chemical Society standard exam (65.4 vs. 58.4 on the first and 61.0 vs. 52.4 on the second).

In several of the projects, exam questions in the redesigned courses shifted to testing higher-level cognitive skills. At the University of Massachusetts-Amherst, for example, most exam questions in the traditional biology course were designed to test recall of factual material or definitions; only 23 percent required reasoning or problem-solving skills. In the redesigned course, 67 percent of the questions required problem-solving skills. Similar shifts were observed in Fairfield University's redesigned biology exams. At Carnegie Mellon, final exam questions asking students to choose an appropriate statistical test were added in the redesign. These questions had not been posed to students previously because they had been deemed too difficult. Likewise, because midterm scores in a redesigned programming course at Drexel University were significantly higher than those in the traditional version, instructors created a more difficult final exam for subsequent offerings of the redesigned course.

Many of the projects also reported significant improvements in their drop-failure-withdrawal (DFW) rates. At the University of Southern Maine, a smaller percentage of introductory psychology students dropped the redesigned course or received failing grades, thus moving the DFW rate from 28 percent in traditional sections to 19 percent in the redesigned course. At Virginia Tech, the percentage of students achieving grades of D- or better in a redesigned linear algebra course improved from 80 percent to 87 percent. At the University of Idaho, the percentage of students earning a D or F was cut by more than half. Drexel University reduced its DFW rate in computer programming from 49 percent to 38 percent; Florida Gulf Coast from 45 percent to 11 percent in fine arts; Indiana University-Purdue University-Indianapolis from 39 percent to 25 percent in introductory sociology; and the University of New Mexico from 42 percent to 25 percent in psychology.

What techniques have proven most effective in improving student learning and increasing student success? The most prominent techniques are the following:

- **Continuous assessment and feedback.** It is essential to shift the traditional assessment approach in large introductory courses toward continuous assessment—and away from midterm and final examinations only; research consistently has proven that doing so enhances learning. Many of the redesigned courses include computer-based assessments that give students instantaneous feedback on their performances and enable repeated practice.

  Regular quizzes on assigned readings and homework probe students' preparedness and conceptual understanding. These low-stakes quizzes motivate students to keep on top of the course material, structure how they study and encourage them to spend more time on task. Online quizzing encourages a "do it until you get it right" approach; students are allowed to take quizzes as many times as they want to until they master the material. Students receive detailed diagnostic feedback that points out why an incorrect response is inappropriate and directs them to material that needs to be reviewed.

Faculty who teach the redesigned courses use quizzes from commercial sources as well as their own. Iowa, for example, heavily relies on *ChemSkillBuilder Online*, a homework software program that helps students practice problem-solving in an active learning environment. At the University of Tennessee-Knoxville and Portland State University, Spanish grammar presentation, grammar drills, listening comprehension and reading comprehension exercises are delivered online, allowing class interaction to focus on student-to-student oral communication. The electronic activities provide consistent, automated grading across sections and instant feedback when students are concentrating on the task.

Quizzes also provide powerful formative feedback to faculty members, who therefore quickly can detect areas in which students are not grasping key concepts. This feature enables timely corrective intervention. Because students must complete quizzes before class, they are better prepared for higher-level activities when they arrive. Consequently, the instructor's role shifts from introducing basic material to reviewing and expanding what students already have been doing.

- **Increased interaction between students.** Many redesign projects use the Internet's ability to support useful and convenient opportunities for student discussion. Students in large lecture classes tend to be passive recipients of information, and class size inhibits student-to-student interaction. Through smaller online discussion forums, students can participate actively. The University of Central Florida and Indiana University-Purdue University-Indianapolis have created groups such as these for their redesigned American government and introductory sociology courses. Students benefit from participating in the informal learning communities, and software allows instructors to monitor the frequency and quality of student contributions to these discussions more readily and carefully than would be the case in a crowded classroom.

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At Florida Gulf Coast, fine arts students complete online analyses of sample short essays in preparation for writing their own short essays. Working in peer-learning teams of six students each, students determine the relative merits and weaknesses of each essay and explain why. The online discussions increase interaction between students and develop their critical thinking skills. At Drexel, a dedicated computer laboratory facilitates group work, allowing students to project shared work and annotations onto white board "wallpaper." Groups mix students with different levels of previous programming experience, thus providing novice students with help in overcoming the initial obstacles to learning programming. The more experienced students can demonstrate the computer and/or software tools to the less experienced in their groups, preventing the latter from falling behind.

- **Individualized, on-demand support.** A support system, available around the clock, enables students to receive help from a variety of sources. Helping students feel part of a learning community is critical to persistence, learning and satisfaction. Active mentorship of this kind can come from a variety of sources, thus allowing the student to interact with the person who can provide the best help for his or her specific problem.

Tallahassee Community College (TCC) English composition students submit rough drafts to tutors at SMARTHINKING, a commercial online tutoring service, and/or to TCC e-responders. These "round-the-clock" services provide students with prompt, constructive feedback on writing assignments. The fast feedback and online assistance allow students to make appropriate changes in their drafts and thus improve their writing. Ohio State has established a help room that allows statistics students to collaborate on difficult problems or concepts. The help room is staffed with faculty members, graduate teaching assistants (GTAs) and adjunct instructors who hold their office hours there. This arrangement makes help available to students throughout the day.

Rather than supplementing class time with help, many of the redesigned courses replace lecture time with individual and small-group activities in computer labs staffed by faculty, GTAs and/or peer tutors. In several instances, increased lab hours have provided students access to further one-on-one assistance. Virginia Tech and the universities of Alabama and Idaho have moved away from the norm of three contact hours per week and have significantly expanded the amount of instructional assistance available to students. Virginia Tech's Math Emporium is open 24 hours a day, seven days a week; Alabama's Math Technology Learning Center (MTLC) is open 71 hours per week; and Idaho's Polya center is open 86 hours per week.

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- **Online tutorials**. In redesigned courses, instructional software and other Web-based resources that support greater student engagement with the material replace standard presentation formats. Such resources may include interactive tutorials and exercises that give students needed practice, computerized or digitally recorded presentations and demonstrations, reading materials developed by instructors or in assigned textbooks, examples and exercises in the student's field of interest, links to other relevant online materials and individual and group laboratory assignments.

  Some institutions create their own materials; others use materials available from commercial sources. Virginia Tech uses a variety of Web-based course-delivery techniques, such as tutorials, streaming video lectures and lecture notes as tools for presenting materials in a linear algebra course. Consisting of concrete exercises with solutions explained through built-in video clips, such tutorials are available to students from home or at a campus lab. The University of Wisconsin-Madison has produced more than 37 Web-based chemistry instructional modules. Each module leads a student through a particular topic in six to 10 interactive pages. When the student completes the tutorial, a set of debriefing questions tests whether the student has mastered the module's content. Students especially like the ability to link directly from a difficult problem to a tutorial that helps them learn the concepts needed to solve it.

  The universities of Alabama and Idaho, Northern Arizona University and Riverside Community College base their redesigned mathematics courses on *MyMathLab*, a commercial software package. Commercial software allows institutions to avoid spending on software development and to direct all of their resources toward supporting student learning. Using instructional software allows much of the time previously spent on instruction about math concepts to be transferred to the technology and eliminates lecture time previously used to review homework. The software supports verbal, visual and discovery-based learning styles and can be reached at any time from home or a computer lab. *MyMathLab* allows instructors to see what work students are actually doing and to easily monitor their progress.

- **Undergraduate learning assistants (ULAs).** Several universities are employing ULAs in lieu of GTAs. They have found that ULAs better assist their peers because of their understanding of the course content, superior communication skills, and awareness—based on their own recent experience—of the many misconceptions that undergraduates often hold. At both Idaho and the University of Colorado-Boulder, course faculty members meet weekly with the ULAs to detail what is working and where students are struggling. Feedback from these weekly meetings gives the instructors a much better sense of the class as a whole and of the individual students than would otherwise be possible with classes of more than 200 students.

- **Structural supports that ensure student engagement and progress.** Each redesigned model adds flexibility in the times and places of student engagement with the course. However, this flexibility does not mean that the redesign projects are self-paced. Student pace and progress are organized by requiring students to master specific learning objectives—often in a modular format, according to scheduled milestones for completion—rather than by class meeting times. Although some institutions initially conceived of their redesigned courses as self-paced, they quickly discovered that students need structure—especially first-year students and especially in disciplines that may be required rather than chosen. Most students simply will not succeed in a totally self-paced environment. Students need a concrete learning plan with specific mastery components and milestones of achievement, especially in more flexible learning environments.

  To ensure that students spend sufficient time on task, the universities of Alabama and Idaho and Riverside Community College require students to spend a minimum amount of time in their learning labs and to attend group meetings. Despite these attendance requirements, some students do not spend enough time in the lab to meet learning objectives. Technology helps remedy this problem. At Alabama, for example, student hours are tabulated weekly to ensure that students invest adequate time in the course. An automated e-mail system is used to reward students who are meeting requirements and to encourage those who are falling behind. In response to student requests for more structure, the Idaho team created a weekly task list, a step-by-step breakdown of the week's assignments that shows the student precisely where to find the information that pertains to each problem. Instructors can use the task list to help each student devise a detailed study plan for the upcoming week. The task lists are Web-based, with links to all of the necessary online lectures and to hints and other supplemental material.

Although some institutions initially conceived of their redesigned courses as self-paced, they quickly discovered that students need structure.

People who are knowledgeable about proven pedagogies will find nothing surprising in the aforementioned list. Among the well-accepted *Seven Principles for Good Practice in Undergraduate Education*, developed by Arthur W. Chickering and Zelda F. Gamson in 1987, are such items as "encourage active learning," "give prompt feedback," "encourage cooperation among students" and "emphasize time on task." Good pedagogy in itself has nothing to do with technology, and higher education has known about good pedagogy for years. The significance of the redesigned courses is that faculty members incorporated good pedagogical practice into courses *with very large numbers of students*—a task that would have been impossible without technology.

In the traditional general chemistry course at the University of Iowa, for example, four GTAs previously were responsible for grading more than 16,000 homework assignments each term. Because of the many assignments, GTAs could only spot-grade and return a composite score to students. By automating the homework process through redesign, every problem is graded, and students receive specific feedback on their performance. This process leads to more time on task and to higher levels of learning. Moreover, the GTAs are freed to perform other duties. Applying technology is not beneficial without good pedagogy. However, technology is essential to scale good pedagogical practice to large numbers of students.

Strategies and successes for reducing instructional costs

A variety of ways exist to reduce instructional costs. Thus, a variety of strategies for redesign also exist, depending on institutional circumstances. For instance, an institution may want to maintain enrollment while reducing the total amount of resources devoted to the course. By using technology effectively and engaging faculty members only where their expertise is essential, an institution can decrease costs per student without affecting enrollment. This approach makes sense when student demand for the course is relatively stable.

However, if an institution is growing or has more demand than it can meet through existing strategies, it may seek to maintain the same level of investment while serving more students. Many institutions cannot meet increased demand for particular subjects such as Spanish or information technology because of a shortage of faculty. Redesign allows them to increase the number of students in such courses without changing associated costs. The University of Tennessee-Knoxville, for example, has increased by one-third the number of students served by the same instructional staff in introductory Spanish.

Another way to reduce costs is to minimize course repetitions due to failure or withdrawal, so that the overall number of students enrolled each term and the required number of sections (and the faculty members to teach them) are reduced. At many community colleges, for example, students take 2.5 tries, on average, to pass introductory math courses. Moving students more quickly through introductory classes will generate considerable savings—both in terms of institutional resources and student time and tuition.

As noted earlier, 18 of the 24 projects that measured retention have reported a noticeable decrease in DFW rates. To illustrate how much can be saved, the universities of Central Florida and Iowa have calculated the savings resulting from increases in course retention. In its American government course, the University of Central Florida increased retention by 7 percent. Applying this rate to 25 redesigned sections results in a reduction of one course section—a savings of $28,064 each time the course is offered. Iowa's reduction in its DFW rate from 24.6 percent to 13.1 percent has meant that 90 students per semester need not repeat the course. These students constitute three discussion sections and four laboratory sections. The personnel needed to cover these sections equates to 1.5 GTAs who are no longer necessary—a savings of $7,022. Not surprisingly, most of the redesigned courses attempt to reduce course repetitions while saving resources from one of the other two approaches.

What are the most effective cost-reduction techniques used by the redesigned projects? Because the major cost item in instruction is personnel, reducing the time that faculty and other instructional personnel invest in the course and transferring some of these tasks to technology-assisted activities is the key strategy. Some of the more predominant cost-reduction techniques include the following:

- **Online course-management systems**: Course-management systems—software packages designed to help faculty members transfer course content to an online environment and assist them in administering various aspects of course delivery—play a central role in most of the redesigned courses. Some projects use commercial products such as WebCT and Blackboard; others use homegrown systems created centrally for campus-wide use or specifically for the redesigned course. Still others use instructional software that includes an integrated course-management system. Sophisticated course-management software packages enable faculty members to monitor student progress and performance, track their time on task and intervene on an individualized basis when necessary.

  Course-management systems can automatically generate many kinds of tailored messages that provide needed information to students. They can communicate automatically with students to suggest additional activities based on homework and quiz performance or to encourage greater participation in online discussions. Using course-management systems radically reduces the amount of time that faculty members typically spend on nonacademic tasks, such as calculating and recording grades, photocopying course materials, posting changes in schedules and course syllabi and sending out special announcements to students. The course-management systems also preserve syllabi, assignments and examinations so that they can be reused in later terms.

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- **Automated assessment of exercises, quizzes and tests.** Automated grading of homework exercises and problems, of low-stakes quizzes and of examinations for subjects that can be assessed through standardized formats not only increases the level of student feedback but also offloads these rote activities from faculty members and other instructional personnel. Some institutions use the quizzing features of commercial products such as WebCT. Others use specially developed grading systems such as Mallard at the University of Illinois. Still others take advantage of the online test banks available from textbook publishers.

  Online quizzing sharply reduces the amount of time instructors need to spend on the laborious process of preparing quizzes, grading them and recording the results. Automated testing systems that contain large numbers of questions in a database format enable individualized tests to be generated easily and then quickly graded and returned.

- **Online tutorials.** Modular tutorials lead a student through a particular topic presented through interactive Web- or CD-ROM-based materials. When students have completed the tutorial, they are presented questions that test whether they have mastered the content of the module. Virginia Tech's online linear algebra course delivery has reduced teaching staff radically. Individual faculty members are no longer required to duplicate content. Interactive tutorials can replace part—and, in some cases, all—of the "teaching" portions of the course. Similarly, at Riverside Community College, lecture time has been reduced from four to two hours per week. Class meetings have been reorganized and targeted to topics that students find particularly difficult. Faculty members spend more time interacting with students about questions and problems rather than repeating math concepts.

Access to Web-based resources has reduced labor costs at Tallahassee Community College by decreasing the amount of time faculty members devote to diagnostics, lecture preparation, grammar instruction, progress monitoring, grading and class announcements. Faculty logs kept during the Spring 2003 semester indicate a 33 percent decrease in time spent on course activities associated with these tasks. At Iowa State, salary savings in the redesigned course are directly attributable to online instruction and testing. Because instructors do not meet students in the classroom and do not need to design several exams per term, each instructor can handle between 500 and 600 students, rather than 150 in the traditional format.

By replacing expensive faculty members and graduate students with relatively inexpensive labor, an institution can increase the person-hours devoted to the course while cutting costs.

- **Shared resources.** When an entire course (or more than one section of a course) is redesigned, faculty must begin by analyzing the time each person involved in the course spends doing each activity. This highly specific task analysis often uncovers instances of duplicated effort. This discovery can lead to more efficient shared approaches to course development. The time that individual faculty members spend developing and revising course materials and preparing for classes can be reduced considerably by eliminating such duplications.

For example, Penn State has constructed an easy-to-navigate Web site for its introductory statistics course. The site contains not only material on managing the course but also a large number of student aids and resources, including solutions to problems, study guides, supplemental reading materials for topics not otherwise treated in the text and student self-assessment activities. Putting assignments, quizzes, exams and other course materials on a community Web site can save considerable instructional time because instructors share responsibility for improving and updating the materials, thus reducing each individual faculty member's workload.

Another benefit of sharing course resources is the opportunity for continuous improvement of those resources. During each phase of implementation, redesign teams can modify learning activities based on what works well and what does not. Student feedback on the clarity and number of assignments and on the need for better explanations and models provides multiple indicators of what needs to change. The online environment permits flexible and timely design and expansion where needed. In addition, many teams have found that once the course resources have been developed, only minimal additional labor has been necessary to improve and update the course content. The shared course materials not only save the original instructors' preparation and maintenance time, they also allow new instructors to benefit from previous course preparation and refinements.

- **Staffing substitutions**. Constructing a support system that comprises various kinds of instructional personnel allows the institution to intervene appropriately for particular kinds of student problems. Employing ULAs in lieu of GTAs, for example, not only improves the quality of assistance available to students, it also saves money. By replacing expensive faculty members and graduate students with relatively inexpensive labor, an institution can increase the person-hours devoted to the course while cutting costs.

At Alabama, the initial redesign plan was to staff the Math Technology Learning Center primarily with instructors and to use graduate students and upper-level undergraduate students for tutorial support. In the first semester, however, undergraduate students proved equally effective as the graduate students in providing tutorial support, thus allowing Alabama to replace the graduate students with less expensive undergraduate labor. Data on student use of instructional staff collected during the first semester of operation were refined each semester. That data suggested that Alabama could reduce the number of instructors and undergraduate tutors assigned to the learning center by matching staffing levels to trends in student use.

Because the course is offered entirely online, it uses no classroom space.

Another solution, implemented by Rio Salado College, is to employ a "course assistant" to address the many nonacademic questions that arise as any course is delivered—questions that can characterize up to 90 percent of staff interactions with students. This frees the instructor to handle more students and to concentrate on academic interactions rather than logistics.

Only full-time faculty teach Florida Gulf Coast's redesigned course. However, a new role—the preceptor—was created to support faculty members. Preceptors interact with students via e-mail to monitor their progress, lead online discussions and grade critical analysis essays. Each preceptor works with 10 peer learning teams, a total of 60 students. Hiring a preceptor at a rate of $1,800 per 60 students was more cost-effective than using adjunct instructors, who were paid $2,200 to teach 30-student sections. This approach has allowed Florida Gulf Coast to accommodate ongoing enrollment growth at a reduced per-student cost.

- **Reduced space requirements.** Using the Web to deliver particular parts of a course enables institutions to use classroom space more efficiently. Because one of the goals of its redesign was to reduce the need for rented space, the University of Central Florida delivers portions of its American government course online. Two or three course sections can be scheduled in the same classroom where only one could be scheduled before.

  Delivering parts of Portland State University's Spanish course online saves significant space on its urban campus—an especially important consideration because of its rapidly increasing enrollment. Online discussions in Spanish allow practice beyond the classroom while maintaining student-to-student contact and instructional supervision. Likewise, Florida Gulf Coast's redesign helps the university manage a space crisis caused by rapidly growing enrollment. Because the course is offered entirely online, it uses no classroom space.

- **Consolidation of sections and courses.** Redesigning the whole course rather than a single section creates significant cost savings because multiple sections can be consolidated. In the emporium model used at the universities of Alabama and Idaho, multiple sections of a course are combined into one large class, replacing duplicate lectures, homework and tests with collaboratively developed online materials. Alabama combined 44 intermediate algebra sections of about 35 students each into one 1,500-student section; Idaho moved two pre-calculus courses—previously organized in 60 sections of approximately 40 students each—into its Polya learning center, treating each course as a single entity. By teaching multiple math courses in one facility, each university can share instructional person-power, thus cutting teaching costs.

  At Fairfield, the redesigned biology course consolidated four sections into one, reducing the faculty by almost half. This change used technology to create dynamic learning environments to compensate for the larger class size. Because of the success of the chemistry redesign at Iowa, the department could combine the general chemistry sequence with a separate chemical sciences sequence, previously required by the College of Engineering. The institution thereby decreased the number of faculty members needed to teach those courses. Now the special sequence is no longer needed, and 1.5 faculty members per term are available for other assignments.

With regard to cost savings, the redesign methodology is an unqualified success. Redesigned courses are reducing costs by an average of 37 percent, with specific savings ranging from 15 percent to 77 percent. Collectively, the 30 courses initially projected annual savings of about $3.6 million. Final results show that the 30 courses annually saved about $3.1 million. Some saved more than they expected; others less.

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Producing a savings in excess of $3 million for 30 courses is impressive, but the real savings produced by the redesigns is actually even higher. The $3 million figure is calculated by multiplying the differences in the per-student costs for the traditional and redesigned formats by the number of students enrolled in the course. However, the cost-per-student calculation does not include the following important considerations:

- **Savings accrued through increased retention.** Eighteen of the 30 projects have increased retention. Only the University of Central Florida's savings accrued through increased retention, which were used to demonstrate the calculation, are counted in the $3 million figure.

- **Savings in campus space.** Twenty-four of the 30 projects have substantial space savings because of reduced seat time. Only the University of Central Florida's space savings, which were used to demonstrate the calculation, are counted in the $3 million figure.

- **Serendipitous savings.** Unplanned savings also were not counted. For example, at Fairfield University, laboratory costs in general biology decreased by nearly 73 percent (from $2,470 to $680) by replacing dissection labs with computer-based activities. By putting course materials online, the University of Tennessee-Knoxville has reduced the cost of students' materials. In the traditional format, students paid a total of $182 for the textbook, a CD-ROM, two workbooks and audio CDs. In the redesigned course, students pay only $96 for a customized version of the textbook and an access card for the online material. At Iowa, the combination of the general chemistry sequence with a separate chemical sciences sequence, described earlier, produced an additional cost savings of $25,959 (1.5 faculty members per semester) that is not included in Iowa's cost-per-student calculation.

Perhaps most important, the cost-per-student savings calculation includes only one year of operating expenses. A more accurate picture would calculate the savings over the life of the course. Because introductory courses have a relatively long shelf life—somewhere between five and 10 years, on average—calculating the savings over the same period would mean that the total savings for the 30 courses is, in fact, *five to ten times higher* than reported.

The discrepancies in savings between the institutions directly relate to the different design decisions made by the project teams, especially with respect to how to allocate expensive faculty members. Redesigns with lower savings tended to redirect, not reallocate, saved faculty time. They keep the total amount of faculty time devoted to the course constant but change how faculty members actually spend their time (for example, lecturing rather than interacting with students).

Other institutions substantially reduced the time that non-faculty personnel, such as GTAs, devoted to the course but maintained the amount of regular faculty time. Such decisions minimize total cost savings. By radically reallocating faculty time to other courses and activities, in contrast, Virginia Tech saved 77 percent in its redesigned linear algebra course—the most substantial cost savings among the 30 projects. Most of the other projects could have saved more without reducing quality if they had made different design decisions.

By using technology-based approaches and learner-centered principles to redesign their courses, these 30 institutions have shown a way out of higher education's historical tradeoff between cost and quality. Some of them rely on asynchronous, self-paced learning modes; others use traditional, synchronous classroom settings but with reduced student/faculty contact hours. Both approaches start with a careful look at how best to deploy all available instructional resources to achieve the desired learning objectives. Questioning the current credit-for-contact paradigm of instruction and thinking systematically about how to produce more effective and efficient learning are fundamental conditions for success.

What's next? Scaling up

The National Center for Academic Transformation has established a solid track record of success in using technology to improve student learning while reducing instructional costs. Each participating institution has found that the redesign depends on a partnership among faculty members, professional staff and administrators. If it is scaled appropriately, NCAT's redesign methodology offers a well-considered, practical alternative to the current postsecondary dilemma facing the nation.

However, not every redesign project needs a grant of $200,000 as NCAT provided in the Pew-funded PCR. NCAT is currently working with the University of Hawaii system and the Ohio Learning Network to create statewide redesign programs. In each case, the sponsors are offering incentive grants in the $40,000 range. NCAT is also managing a new program, the Roadmap to Redesign, with support from the Fund for the Improvement of Postsecondary Education (FIPSE) to demonstrate how to redesign large-enrollment courses without providing direct grants. Twenty-two new redesign projects are under way. Each relies on a combination of internal resources and technical support from NCAT.

Can NCAT's redesign methodology be applied to parts of the curriculum other than the top 25 courses? Absolutely. Any course that is taught by more than one faculty member is a potential target for redesign. The University of Hawaii-Manoa, for example, recently analyzed its campus enrollment patterns and found more than 120 courses with enrollments exceeding 100 students and taught by more than one faculty member. Redesigning these courses would affect 34,534 students. Any of these courses could improve learning and reduce cost with NCAT's redesign methodology.

Even courses taught by single faculty members can benefit from many of the redesign approaches. Some of the automation techniques and differentiated personnel strategies discussed earlier, for example, would enable faculty members to increase their course loads without increasing their workloads. Employing a course assistant to manage the nonacademic aspects of courses—with or without the addition of instructional software, where available—would allow each faculty member to teach an additional course. Applying those same strategies would also permit an increased class size in high-demand, bottleneck courses—again, without increasing faculty workload.

If all institutions of higher education in the United States adopted NCAT's methodology to redesign their top 25 courses, the cost of instruction would be reduced *annually* by approximately 16 percent—while improving student learning and retention.

That figure was calculated in the following manner:

- Fifty percent of community college enrollments and 35 percent of four-year enrollments are in the top 25 courses.
- Half of all higher education enrollment is at community colleges, and half is at four-year institutions.
- Given the proportion of two-year vs. four-year colleges in the U.S., 42.5 percent of all higher education enrollments are in the top 25 courses.
- The average cost reduction of the 30 projects that use NCAT's redesign methodology is 37 percent.
- Thirty-seven percent of 42.5 percent is 16 percent.

Arriving at an exact dollar value of the savings is difficult because estimates of total higher education expenditures—and the "Education and General" portion of those expenditures (those that support an institution's primary missions: instruction, research and public service)—seem to vary, depending on the source.

One way of estimating the impact of all higher education spending is the following:

- The National Center for Education Statistics (NCES) says that total higher education expenditures are 2.3 percent of the U.S. gross domestic product (GDP), which was about $10 trillion in 2002.
- If 2.3 percent of the U.S. GDP is spent on higher education, total higher education expenditures in the U.S. equal $230 billion.
- If the portion devoted to instruction averages 35 percent, the cost of instruction is $80.5 billion.
- Sixteen percent of $80.5 billion is $12.9 billion per year.
- $12.9 billion is 5.6 percent of the overall cost of higher education.

Whatever the right number, as Everett Dirksen once observed about the federal budget, "A billion here, a billion there, and first thing you know you're talking about real money."

What should those concerned about the future affordability of higher education—particularly those in leadership positions—do with the knowledge that they *can* reduce costs and improve student learning by redesigning traditional methods of instruction? First, we need to change the national conversation about what is possible. Once we break the higher quality/more money connection, we can unleash the creative energies of hundreds—indeed thousands—of faculty, professional staff and administrators in higher education to work on redesigning courses. Second, we need to establish redesign programs in states, in higher education systems, in community college districts and in institutions to provide a framework and incentives for institutions to begin the process. Third, we need to build incentives into the ways in which we fund higher education—at the national, state and local levels—to accelerate an ongoing redesign process. This new process must emphasize the importance of measuring learning outcomes and instructional costs, reward those who make constructive changes and penalize those who do not.

Perhaps the most significant contributor to the success of the PCR has been NCAT's effort to teach institutions its redesign methodology, especially its rigorous approach to understanding cost savings. Faculty members and administrators rarely understand the full instructional costs of a course, especially the personnel costs that are often viewed as "sunk." Clarifying these costs clarifies the framework for achieving savings with technology. Faculty members and administrators involved with the PCR have repeatedly indicated that learning the methodology is central to the effectiveness of the process, yet once it is mastered, the methodology is easily transferable to other courses and disciplines. An initial partnership with NCAT can allow states, systems, districts and individual institutions independently to support this process on an ongoing basis.

The biggest challenge higher education faces in the coming decade is providing a cost-effective, high-quality education for all Americans who can benefit. As Russ Edgerton, president emeritus of the American Association of Higher Education, has said, "For many Americans, what is at stake is nothing less than the continued viability of the American dream."

The solution is *not* to throw money at the problem. The solution is to work together to rethink the ways we teach and students learn. Higher education has traditionally assumed that high quality means low student-faculty ratios and that large lecture-presentation techniques are the only low-cost alternatives. But course redesign using technology-based, learner-centered principles can offer us a way out of its historical trade-off between cost and quality. By building on those principles, we can create a 21st-century higher education system that will serve our nation well. ■