The National Center for Academic Transformation

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Mr. Chairman and Members of the Commission:

Thank you for inviting me to testify. I am President and CEO of the National Center for Academic Transformation, a non-profit organization whose goal is to demonstrate how effective use of information technology can improve student learning and reduce instructional costs.

American higher education continues to be challenged by the need to increase access, to improve the quality of student learning, and to control or reduce rising costs. These issues are, of course, inter-related. As tuition costs continue to rise, access is curtailed. If the quality of the curriculum fails to enable successful student completion of courses and programs, promises of increased access become hollow. Furthermore, the solutions to these challenges appear to be inter-related as well. Historically, improving quality or increasing access has meant increasing costs; reducing costs has meant reducing both quality and/or access. In order 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.

Many 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 90's 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." In contrast to higher education, most industries have been able to take advantage of the capabilities of information technology to increase productivity–and in doing so, increase quality of service while reducing costs. The injection of information technology into the U.S. economy in general—with the notable exceptions of education, health care and the legal profession—is a major contributor to the disparity between relationship between the general rate of inflation and higher education's cost increases.

It's not that higher education has avoided information technology. Every college and university in the United States is discovering exciting new ways of using technology to enhance the process of teaching and learning and to extend access to new populations of students. For most institutions, however, new technologies represent a black hole of additional expense rather than an investment that leads to 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 becomes part of the problem of rising costs rather than part of the solution. In addition, comparative research studies show that rather than improving quality, most technology-based courses produce learning outcomes that are simply "as good as" their traditional counterparts—in what is often referred to as the "no significant difference" phenomenon. 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.

A premise of this paper is that an important contributor to the rising cost of higher education—perhaps the key contributor--is an outmoded, labor intensive delivery model coupled with an outmoded set of assumptions about the relationship between cost and quality. A second premise is that it *is* possible to improve student learning while reducing instructional costs by *redesigning* the way in which we organize collegiate instruction. The

Program in Course Redesign (PCR) described below offers persuasive data showing how this can be done. In addition to offering a broad solution to the cost/quality trade-off in its redesign methodology, the program offers numerous specific solutions that can be adapted by colleges and universities across the board.

<u>Program in Course Redesign (PCR)</u>

Supported by an $8.8 million grant from the Pew Charitable Trusts, the PCR was created in April 1999 by the National Center for Academic Transformation (NCAT), formerly housed at Rensselaer Polytechnic Institute, to address these issues. Its purpose was to demonstrate how colleges and universities can redesign their instructional approaches using technology to achieve quality enhancements as well as cost savings. Selected from hundreds of applicants in a national competition, 30 institutions received a grant of $200,000 each, with the grants awarded in three rounds of ten. The 30 institutions include 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 for improved learning outcomes, and analyze the cost of traditional methods of instruction as well as new methods of instruction utilizing technology. Prospective grant recipients were supported in this process through a series of invitational workshops that taught institutional teams these assessment and planning methodologies and through individual consultations with NCAT staff.

The NCAT required each institution to conduct a rigorous evaluation focused on learning outcomes as measured by student performance and achievement. National experts provided consultation and oversight regarding the assessment of learning outcomes to ensure that the results were reliable and valid. The results were astounding. Twenty-five institutions showed significant increases in student learning with the remaining five showing learning equivalent to 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 basic assessment question associated with the PCR was the degree to which improved learning was achieved at lowered cost. Answering this question required comparisons between the learning outcomes of a given course delivered in its traditional and in its redesigned format. This comparison was accomplished by running parallel sections of the course in traditional and redesigned formats or by comparing baseline information from a traditional course to a later offering of the course in redesigned format, looking at whether there were any differences in costs and outcomes.

The degree to which students actually mastered course content was the bottom line. Techniques used to assess student learning included comparing the results of common final examinations; comparing the results of embedded common questions or items in examinations or assignments; collecting samples of student work (papers, lab assignments, problems) and comparing their outcomes according to agreed-upon common faculty standards for scoring or grading; tracking student records after they completed redesigned courses, looking at a) proportions satisfactorily completing a downstream course, b) proportions going on to a second course in the discipline, and c) grade performances in "post-requisite" courses.

“Before and after” course costs were analyzed and documented using activity-based costing. The Center developed a spreadsheet-based course planning tool (CPT) that supported institutions in this process, which involved the following steps: 1) determine all personnel (faculty, adjuncts, teaching assistants, peer tutors, professional staff) costs expressed as an hourly rate; 2) identify the tasks associated with preparing and offering the course in a traditional format and the personnel involved; 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 37 percent on average, 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 about $3 million in operating expenses each year.

The course-redesign projects focus on large-enrollment, introductory courses, which have the potential of impacting significant student numbers and generating substantial cost savings. Why focus on such courses? Because undergraduate enrollments in the United States are concentrated heavily in only a few academic areas. In fact, just 25 courses generate about 50 percent of student enrollment at the community college level and about 35 percent of enrollment at the baccalaureate level.

The topics of these courses are no surprise and include introductory studies in disciplines such as English, mathematics, psychology, sociology, economics, accounting, biology, and chemistry. Successful completion of these courses is critical for student progress toward a degree. But typical failure rates in many of these courses—15 percent at research universities, 30 to 40 percent at comprehensive universities, and 50 to 60 percent at community colleges—contribute heavily to overall institutional drop-out rates between the first and second year.

The insight that these figures point to is simple and compelling: In order to have a significant impact on large numbers of students, an institution should concentrate on redesigning the 25 courses in which most students are enrolled instead of putting a lot of energy into improving quality or cutting costs in disparate small-enrollment courses. By making improvements in a restricted number of large-enrollment prerequisite or introductory courses, a college or university can literally affect every student who attends.

<u>A Variety of Models</u>

The PCR has produced many different models of how to restructure such courses to improve learning as well as to effect cost savings. In contrast to the contention that only certain kinds of institutions can accomplish these goals, and in only one way, the program has demonstrated that many approaches can achieve positive results. And to counter the belief that only courses in a restricted subset of disciplines—science or math, for instance—can be effectively redesigned, the program contains successful examples in many disciplines. Here is a breakdown of the 30 participating institutions by curricular area:

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 at 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 at Boulder

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

1. *Whole course redesign*. In each case, the whole course—rather than a single class or section—is the target of redesign. Faculty begin the design process by analyzing the amount of time that each person involved in the course spends on each kind of activity, a process that often reveals duplication of effort among faculty members. By sharing responsibility for both course development and course delivery, faculty members save substantial amounts of time while achieving 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 an active, learning orientation. 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 add greater flexibility for when students can engage with a course, but the redesigned courses are not self-paced. Rather than depending on class meetings, student pacing and progress are organized by the need to master specific learning objectives, which are frequently in modular format, according to scheduled milestones for completion.

5. *On-demand help*. An expanded support system enables students to receive assistance from a variety of different 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 either in computer labs—staffed by faculty, graduate teaching assistants (GTAs), and/or peer tutors—or online, enabling students to have more one-on-one assistance.

6. *Alternative staffing*. By constructing support systems consisting of various kinds of instructional personnel, the projects apply the right level of human intervention to particular student problems. Not all tasks associated with a course require highly trained, expert faculty. By replacing expensive labor (faculty and graduate students) with relatively inexpensive labor (undergraduate peer mentors and course assistants) where appropriate, the projects increase the person-hours devoted to the course and free faculty to concentrate on academic rather than logistical tasks.

<u>Strategies and Successes for Improving Student Learning</u>

The redesign projects have effected significant changes in the teaching and learning process. Lectures are replaced with a wide variety of learning resources, all of which involve more active forms of student learning or more individualized assistance. In moving from an entirely lecture-based to a student-engagement approach, learning is less dependent on words uttered by instructors and more dependent on reading, exploring, and problem-solving undertaken actively by students.

Most of the projects show statistically significant improvements in overall student understanding of course content as measured by pre- and post- assessments that examine key course concepts. For example, at the University of Central Florida (UCF), students enrolled in a traditional political science course posted a 1.6-point improvement on a content examination, while the average gain of 2.9 points for students in the re-designed course was almost double that amount. Redesign-course statistics students at Penn State, outperformed traditional students on a content-knowledge test, with 60 percent correct answers in the traditional format and 68 percent correct in the redesign.

Other projects demonstrate statistically significant improvements in student understanding of course content by comparing the performance of students enrolled in traditional and redesigned courses on commonly administered examinations. At Carnegie Mellon University (CMU), for example, the performance of redesign-course students in statistics increased by 22.8 percent on tests of skills and concepts. At Florida Gulf Coast University (FGCU), the average score achieved on a commonly administered standardized test by students enrolled in the traditional fine arts course was 72 percent; in the redesigned course it was a significantly higher 85 percent. At the University of Iowa, redesign students in introductory chemistry outperformed traditional students and outscored them on 29 of 30 items on a common exam. In addition, redesign students 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 have shifted to testing higher-level cognitive skills. At the University of Massachusetts—Amherst (UMass), for example, the vast majority of exam questions in the traditional biology course were designed to test recall of factual material or definitions of terms, and 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 CMU, final exam questions asking students to choose an appropriate statistical test were added in the redesign. Previously, these questions were not posed to students because they were deemed too difficult. 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 examination to assess student learning in 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 (USM), a smaller percentage of introductory psychology students dropped the redesigned course or received failing grades, moving the DFW rate from 28 percent in traditional sections to 19 percent in the redesigned course. At Virginia Tech (VT), the percentage of students achieving grades of D- or better in a redesigned linear algebra course improved from an average of 80 percent to an average of 87 percent. At the University of Idaho, the percentage of students earning a D or failing was cut by more than half. Drexel reduced its DFW rate in computer programming from 49 to 38 percent, FGCU from 45 percent to 11 percent in fine arts, Indiana University-Purdue University Indianapolis (IUPUI) from 39 to 25 percent in introductory sociology, and the University of New Mexico from 42 percent to 25 percent in psychology.

What techniques have been found to be the most effective in improving student learning and increasing student success? The most prominent are the following:

- *Continuous Assessment and Feedback*: Shifting the traditional assessment approach in large introductory courses, which typically employ only midterm and final examinations, toward continuous assessment is an essential pedagogical strategy, one that research consistently has proven to enhance learning. Many of the redesigns include numerous computer-based assessments that give students instantaneous feedback on their performance and enable repeated practice.

  Students are regularly tested on assigned readings and homework using short quizzes that probe their 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 till 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 review.

  The redesign projects take advantage of quizzes from commercial sources as well as those they create themselves. Iowa, for example, makes heavy use of *ChemSkillBuilder On-Line*, a homework software program that helps students practice problem-solving in an active learning environment. At both the University of Tennessee, Knoxville (UTK) and Portland State University (PSU), Spanish grammar presentation, grammar drills, listening comprehension and reading comprehension exercises are delivered online, allowing class interaction to focus on student-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. Faculty can quickly detect areas where students are not grasping key concepts, enabling timely corrective intervention. Since students are required to complete quizzes before class, they are better prepared for higher-level activities once they get there. Consequently, the role of the instructor shifts from one of introducing basic material to reviewing and expanding what students have already been doing.

- *Increased Interaction among Students*: Many redesign projects take advantage of the Internet's ability to support useful and convenient opportunities for discussion among students. Students in large lecture classes tend to be passive recipients of information, and student-to-student interaction is inhibited by class size. Through smaller discussion forums established online, students can participate actively. UCF and IUPUI create small online discussion groups in which students can easily contact one another in their redesigned American government and introductory sociology courses. Students benefit from participating in the informal learning communities that are created in this manner. 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.

  At FGCU, fine arts students complete online discussions where they analyze sample short essays in preparation for writing their own short essays. Working in peer learning teams of six students each, students have to determine which essays are strong and which are weak and explain why. The online discussions increase interaction among students and develop students' 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, providing less experienced students with help over the initial obstacles in learning to program. The more experienced students can demonstrate the use of 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 that they are a part of a learning community is critical to persistence, learning, and satisfaction. Active mentorship of this kind can come from a variety of sources, allowing students to interact with the person who can provide the best help for the specific problem they have encountered.

  Tallahassee Community College (TCC) English composition students are able to submit mid-stage drafts to tutors at SMARTHINKING, a commercial, online tutoring service, and/or to TCC e-responders. These 24x7 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, improving the quality of student writing. Ohio State has established a

Help Room that allows students in statistics to work collaboratively on problems or concepts that present difficulty. The Help Room is staffed with faculty, graduate teaching assistants (GTAs) and adjuncts who hold their office hours there, thus making help available to students throughout the day.

Rather than supplementing class time with help, many of the redesign projects *replace* lecture time with individual and small-group activities that take place in computer labs staffed by faculty, GTAs and/or peer tutors. In several instances, increasing lab hours has enabled students to get access to more one-on-one assistance. VT and the Universities of Alabama and Idaho have moved away from the three-contact-hours-per-week norm and significantly expanded the amount of instructional assistance available to students: VT's Math Emporium is open 24x7; Alabama's Math Technology Learning Center (MTLC) is open 71 hours per week, and Idaho's Polya center is open 86 hours per week.

- *Online Tutorials*: In redesign 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 projects use resources created by the institution and some use materials available from commercial sources. VT uses a variety of Web-based course-delivery techniques like tutorials, streaming video lectures, and lecture notes as tools for presenting materials in a linear algebra course. Consisting of concrete exercises with solutions that are explained through built-in video clips, such tutorials can be accessed at home or at a campus lab. The University of Wisconsin at Madison (UW) has produced more than 37 Web-based instructional modules in chemistry. Each module leads a student through a particular topic in six to 10 interactive pages. When the student completes the tutorial, a debriefing set of questions tests whether the student has mastered the module's content. Students especially like the ability to link from a problem they have difficulty with directly to a tutorial that helps them learn the concepts needed to solve it.

  The Universities of Alabama and Idaho, Northern Arizona University and RCC base their redesigned mathematics courses on *MyMathLab*, a commercial software package. The availability of this software has allowed each institution to avoid spending funds 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 accessed anytime at home or in a lab. *MyMathLab* allows instructors to see what work students are actually doing and to easily monitor their progress.

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

- *Structural Supports that Ensure Student Engagement and Progress*: Each redesign model adds greater flexibility in the times and places of student engagement with the course. This does not mean, however, that the redesign projects are "self-paced." Rather than depending on class meetings, the redesigns ensure student pacing and progress by requiring students to master specific learning objectives, frequently in modular format, according to scheduled milestones for completion. Although some projects initially thought of their designs 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) and that most students simply will not make it 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.

  Alabama, Idaho and RCC require students to spend a minimum amount of time in their learning labs and to attend group meetings in order to ensure that students spend sufficient time on task. In spite of such attendance requirements, some students do not spend enough time in the lab to meet learning objectives. 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 assignment that shows the student precisely where to find the information that pertains to each specific problem. Instructors are able to 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 providing more instruction.

People who are knowledgeable about proven pedagogies that improve student learning will find nothing surprising in the above 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 we’ve known about good pedagogy for years. What is significant about the faculty involved in these redesigns is that they were able to incorporate 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 used to be responsible for grading more than 16,000 homework assignments each term. Because of the large number of 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, in turn, leads to more time on task and higher levels of learning and releases the GTAs to perform other duties. Applying technology is not beneficial without good pedagogy. But technology is essential to move good pedagogical practice to scale, where it can affect large numbers of students.

Strategies and Successes for Reducing Instructional Costs

There are a variety of ways to reduce instructional costs. As a result, there are also a variety of strategies for redesign, depending upon institutional circumstances. For instance, an institution may want to maintain constant enrollments while reducing the total amount of resources devoted to the course. By using technology for those aspects of the course where it would be more effective and by engaging faculty only in tasks that require faculty expertise while transferring other tasks that are less academically challenging to those with a lower level of education, an institution can decrease costs per student even though the number of students enrolled in the course remains unchanged. This approach makes sense when student demand for the course is relatively stable.

But if an institution is in a growth mode or has more demand than it can meet through existing course delivery, it may seek to increase enrollments while maintaining the same level of investment. Many institutions have escalating demand for particular subjects like Spanish or information technology that they cannot meet because they cannot hire enough faculty members. By using redesign techniques, they can increase the number of students they enroll in such courses and relieve these academic bottlenecks without changing associated costs. UTK, for example, has been able to increase by one-third the number of students served by the same instructional staff in introductory Spanish.

Another way to reduce costs is to decrease the number of course repetitions due to failure or withdrawal, so that the overall number of students enrolled each term is lowered and the required number of sections (and the faculty members to teach them) are reduced. At many community colleges, for example, it takes students about two-and-a-half tries to pass introductory math courses. If an institution can move students through in a more expeditious fashion by enabling them to pass key courses in fewer attempts, this will generate considerable savings--both in terms of institutional resources and in terms of student time and tuition.

As noted earlier, 18 of the 24 projects that measured retention have reported a noticeable decrease in DFW rates. As examples of the levels of resources that can be saved, UCF and Iowa have calculated the savings resulting from increases in course retention. In its American government course, UCF increased retention by seven percent Applying this rate to 25 redesigned sections results in a one-course-section reduction, amounting to a $28,064 cost savings 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 each semester do not need to repeat the course. These students comprise three discussion sections and four laboratory sections. The personnel needed to cover these sections equates to 1.5 GTA, no longer necessary, a cost savings of $7,022. Not surprisingly, most of the redesign projects are trying to reduce course repetitions simultaneously while saving resources from one of the other two approaches.

What are the most effective cost-reduction techniques used by the redesign projects? Since 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:

- *Online Course-Management Systems*: Course management systems—software packages that are 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 redesigns. Some projects use commercial products like 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 different kinds of tailored messages that provide needed information to students. They can also 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 in nonacademic tasks like calculating and recording grades, photocopying course materials, posting changes in schedules and course syllabi, sending out special announcements to students—as well as documenting course materials like syllabi, assignments, and examinations so that they can be used in multiple terms.

- *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 of the projects use the quizzing features of commercial products like WebCT. Others use specially developed grading systems like Mallard at the University of Illinois. Still others take advantage of the online test banks that are 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 easily generated, 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. VT's use of online course delivery techniques in its linear algebra course has enabled radical reductions in teaching staff. Individual faculty members are no longer required to present the same content through duplicative efforts. Nor do they need to replicate exercises and quizzes for each section. Interactive tutorials can replace part—and, in some cases, all--of the “teaching” portions of the course. Similarly, at RCC, 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 concept information.

Access to web-based resources has reduced labor costs at TCC by decreasing the amount of time faculty spent in diagnostics, preparation of lectures, grammar instruction, monitoring progress, grading and making class announcements. Faculty logs kept during the spring 2003 semester indicate a 33 percent decrease in time spent on course activities associated with the preceding tasks. At Iowa State, salary savings in the redesigned course are directly attributable to online delivery and online testing. Since instructors do not have to meet students in the classroom and do not need to design several exams per term, each instructor can handle between 500 and 600 students in comparison to 150 in the traditional format.

- *Shared Resources*: When an entire course (or more than one section) is redesigned, faculty must begin by analyzing the amount of time that each person involved in the course spends doing each activity. This highly specific task analysis often uncovers instances of duplicated effort and can lead to shared, more efficient, approaches to course development. The often substantial amounts of 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 that 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 for the course can save a considerable amount of instructional time since responsibility for improving and updating the materials is shared among instructors, thus reducing each faculty member's workload.

Another benefit of creating shared course resources is the opportunity for continuous improvement of those resources. During each phase of implementation, redesign teams are able to modify, update and revise learning activities based on what works well and what does not. Student feedback on the clarity and number of assignments, as well as their expressed need for greater explanations and models, provides multiple indicators for areas needing change. The online environment permits flexibility in design and expansion where needed, and timely changes can be made. In addition, many teams have found that once the course resources have been developed, only a minimum amount of additional labor has been necessary to improve the course content and keep it current. The shared course materials not only save the original instructors involved in the redesign preparation and maintenance time, but also enable their use by new faculty members who would have had to prepare the course during the first semester of teaching it.

- *Staffing Substitutions*. By constructing a support system that comprises various kinds of instructional personnel, institutions can apply the right level of human intervention to particular kinds of student problems. Employing ULAs in lieu of GTAs, for example, not only improves the quality of assistance available to students, as noted earlier, but also serves as a key cost-saving device. By replacing expensive faculty members and graduate students with relatively inexpensive labor, an institution can increase the person-hours devoted to the course and at the same time cut costs.

  At Alabama, the initial redesign plan was to staff the MTLC primarily with instructors and to use graduate students and upper-level, undergraduate students for tutorial support. In the first semester of implementation, it became apparent that the undergraduate students were as effective as the graduate students in providing tutorial support, making it possible to replace the graduate students with lower cost undergraduates. In addition, data on student use of instructional staff was collected during the first semester of operation and refined on a semester-by-semester basis. Based on that usage data, it was possible to reduce the number of instructors and undergraduate tutors assigned to the MTLC by matching staffing levels to trends in student use.

  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.

  FGCU redesigned course is taught 100% by full-time faculty supported by a new position called the preceptor. Preceptors are responsible for interacting with students via email, monitoring student progress, leading Web Board discussions and grading critical analysis essays. Each preceptor works with 10 peer learning teams or a total of 60 students. Replacing adjuncts independently teaching small sections ($2,200 per 30-student section) with preceptors assigned a small set of specific responsibilities ($1,800 per 60-student cohort) in the context of a consistent, faculty-designed course structure allows FCGU to accommodate ongoing enrollment growth at a reduced cost-per-student.

- *Reduced Space Requirements*: Using the Web to deliver particular parts of a course as a substitute for face-to-face classroom instruction enables institutions to use classroom space more efficiently. Because one of the goals of its redesign was to reduce the amount of rented space needed, UCF delivers portions of its American government course via the Web. Two or three course sections can be scheduled in the same classroom where only one could be scheduled before.

  Delivering portions of the PSU Spanish course via the Web as a substitute for face-to-face classroom instruction brings significant space savings to this urban university with rapidly increasing enrollments. Online chat allows communicative use and practice of Spanish to extend beyond the limits of the classroom while maintaining student-student contact and instructor supervision. FGCU's redesign helps the university deal with a space crisis caused by enrollment which is growing at a faster pace than its buildings. Because the course is entirely online, the redesigned course no longer needs to use any classroom space.

- *Consolidation of Sections and Courses*. By redesigning the whole course rather than a single class, it is possible to realize cost savings by consolidating the number of sections offered or the number of courses offered. In the emporium model used at Alabama and Idaho, multiple sections of a course are combined into one large course structure, replacing duplicative lectures, homework, and tests with collaboratively developed online materials. Alabama combined 44 intermediate algebra sections (~35 students) into one 1,500-student section; Idaho moved two pre-calculus courses, previously organized in 60 sections (~40 students), into its Polya learning center, treating each course as a coherent entity. Each university, by teaching multiple math courses in its facility, can share instructional person-power among courses, significantly reducing the cost of teaching these additional courses.

  At Fairfield, the biology redesign involved the consolidation of four separate sections into a single section, reducing the faculty by almost half. This change depended on using technology successfully to create dynamic learning environments for the students to make up for the larger class. Because of the success of the chemistry redesign at Iowa, the department has been able to combine the general chemistry sequence with a separate chemical sciences sequence, previously required by the College of Engineering, and decrease the number of faculty members needed to teach those courses. Now the special sequence is no longer needed, and 1.5 faculty per term are available for other institutional 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 a savings of about $3.6 million annually. Final results show that the 30 courses saved about $3.1 million annually. Some saved more than they planned to; others less.

Producing a savings in excess of $3 million for 30 courses is impressive, but it is important to note that the amount of savings produced by the redesigns is *under-stated*. The $3 million figure is calculated by multiplying the differences in the cost-per-student between the traditional and redesigned formats by the number of students enrolled in the course.

The cost-per-student calculation does not include:

- *Savings accrued through increased retention*: Eighteen of the 30 projects have increased retention. Savings accrued through increased retention are not counted except in the UCF case, used as an example of how to calculate cost savings based on increased retention.

- *Savings in campus space*: Twenty-four of the 30 projects have substantial space savings because of reduced seat-time. Space savings are not counted except in the UCF case, used as an illustration of how to calculate space savings.

- *Serendipitous savings*: Savings that were not part of the plan but occurred as a result of the redesign are not counted. For example, at Fairfield University, laboratory costs in general biology decreased by nearly 73 percent (from $2470 to $680) by replacing dissection labs with computer-based activities. By putting course materials online, UTK has reduced the cost of materials students needed to purchase. In the traditional format, students paid a total of $182 for the textbook, a CD-ROM, two workbooks and audio CDs accompanying the workbooks. 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 above, produced an additional cost savings of $25,959 (1.5 faculty 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 expense savings. A more accurate picture would be to calculate the savings over the life of the course. Since introductory courses have a relatively long shelf life--somewhere between five and ten years--on average, calculating the savings over the same five- or ten-year period would mean that the total savings for the 30 courses is, in fact, *five to ten times higher* than reported.

Why is there such a large range in cost savings across the projects? Differences are directly attributable 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 they change the way faculty members actually spend their time (for example, lecturing versus interacting with students.)

Others substantially reduce the amount of time devoted to the course by non-faculty personnel like GTAs, but keep the amount of regular faculty time constant. Decisions like these reduce total cost savings. By radically reallocating faculty time to other courses and activities, in contrast, VT shows cost savings of 77 percent in its redesigned linear algebra course--the most substantial cost savings among the 30 projects. But most of the other projects could have saved more with no diminution in quality, if they had made different design decisions.

By using technology-based approaches and learner-centered principles to redesign their courses, these 30 institutions are showing us a way out of higher education's historical trade-off between cost and quality. Some of them rely on asynchronous, self-paced learning modes, while 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 and has created an initial proof-of-concept: that technology can be used to improve student learning while reducing instructional costs. Each participating institution has found that implementing the redesign methodology successfully involves a partnership among faculty members, professional staff and administrators.

Does the implementation of NCAT's redesign methodology offer a well-considered, practical alternative to the current postsecondary dilemma facing the nation? The answer is yes, provided that it can scale.

Does every redesign project need a grant of $200,000 as NCAT provided in the Pew-funded PCR? The answer is no. NCAT is currently partnering 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 it is possible to redesign large-enrollment courses without providing direct grants. Twenty-two new redesign projects are currently underway, relying 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 at Manoa, for example, recently analyzed its campus enrollment patterns and found more than 120 courses with enrollments exceeding 100 students taught by more than one faculty member for a total enrollment of 34,534. Any of these courses can benefit from NCAT's redesign methodology to improve learning and reduce costs.

Even courses taught by single faculty members can benefit from many of the redesign approaches in order to reduce costs. Using some of the automation techniques and differentiated personnel strategies discussed above, for example, would enable faculty members to increase their course loads without increasing their workloads. Employing a course assistant to deal with the nonacademic aspects of courses--with or without the addition of instructional software use where available--would allow each faculty member to teach an additional course beyond current course loads. Applying those same strategies would also permit an increase in class size in high-demand, bottleneck courses, again with no increase in faculty workload.

What would be the impact on the cost of higher education if all institutions of higher education in the U.S. adopted NCAT's methodology to redesign their top 25 courses? The cost of instruction would be reduced by approximately 16 percent *annually*. At the same time, student learning and student retention would be improved. Here's how that figure is derived:

- Fifty percent of community college enrollments and 35 percent of four-year enrollments are in the top 25 courses.
- Half of all higher education enrollments 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., about 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.
- 37 percent of 42.5 percent = 16 percent.

It is difficult to pin down exactly the dollar value of that savings since estimates about the total amount of higher education expenditures and the E&G portion of those expenditures seem to vary, depending on the source. Here's one way of estimating what the impact of all higher education spending would be:

- The National Center for Education Statistics (NCES) says that total higher education expenditures are 2.3 percent of U.S. 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. = $230 billion
- If the portion devoted to instruction averages 35 percent, the cost of instruction = $80.5 billion
- 16 percent of $80.5 billion = $12.9 billion per year
- $12.9 billion = 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."

Recommendations

What should those concerned about the future affordability of higher education—particularly those in leadership positions—do with the knowledge that it *is* possible to reduce costs and improve student learning by redesigning our traditional methods of instruction?

- First, we need to change the national conversation about what is possible. Once we break the higher-quality-more-money nexus, 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 in order to provide a framework and incentives for institutions to begin the process.

- Third, we then 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 that emphasizes measuring learning outcomes and instructional costs and rewards those who make constructive changes and penalizes those who do not.

Perhaps the most significant contributor to the success of the PCR has been the way in which NCAT has taught institutions the redesign methodology, especially the rigorous approach to understanding cost savings, since neither faculty nor administrators are accustomed to understanding the full instructional costs of a course including the personnel costs that are often viewed as "sunk." Once those are understood, the framework for achieving savings through the use of technology becomes clear. Both faculty and administrators involved with the PCR have repeatedly indicated that learning the methodology is central to the effectiveness of the process. Once learned, however, the methodology is easily transferable to other courses and disciplines. By initially partnering with NCAT to replicate this process locally, states, systems, districts and individual institutions will be able to develop internal capacity to support this process on an ongoing basis.

The biggest challenge higher education faces in the coming decade is addressing the challenge of providing a cost-effective, high quality education for all Americans who can benefit. As Russ Edgerton 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 re-think the ways we teach and the ways 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 twenty-first century higher education system that will serve our nation well.