The financial management of American higher education is under intense scrutiny. Significant pressure to reduce costs stems from students, parents, legislators and others, even though in the vast majority of cases the price charged students for their education is less than the cost to the university for providing it. The issue is not new, but concerns have intensified as tuition has risen more rapidly than CPI, to the point where at private institutions it equals roughly half the median family income. Total costs at most public institutions are also a substantial fraction of median family income.

**Cost Pressures in Higher Education**

The resultant pressure on higher education institutions to be more cost effective in the delivery of services to students is substantial. Low and declining productivity in faculty work is often cited...
as a key factor in the rapidly rising costs of quality education, because rising faculty costs result in higher tuition. Meanwhile, revenue sources are increasingly strained as universities strive to enhance quality, improve access through financial aid, and serve the many related functions society believes to be part of their obligations. These include not only research but also public service, a role that continues to broaden: universities are often expected to help, for example, in economic development and K-12 education, as well as many other endeavors. Each of these activities requires support, yet revenue sources are still fundamentally limited to tuition, income on endowment, current gifts, grants to support research, and state appropriations. Both revenue growth and cost improvement are essential for colleges and universities to continue to serve their many roles.

As in many other service organizations, personnel costs are dominant among higher education costs. All such enterprises have suffered from what economists have termed the “cost disease.” Fundamentally, the problem is that wage increases continue to outstrip increases in productivity, as the methods of operation of many service industries remain unchanged. In contrast, the manufacturing sector has reduced its costs by substituting improved capital equipment for labor, which increases productivity. To date, in most service businesses and in higher education in particular, the use of improved capital equipment has not resulted in significant cost savings. Advances in computer technology have made possible many new research opportunities, but have increased costs as well. Generally, instruction has not experienced significant productivity improvement through the use of technology.

Over the last 50 years, faculty research expectations have grown as well. Moreover, because research universities are responsible for the training of most new faculty, the importance and values of research have penetrated all four-year degree institutions. Although research unquestionably adds value to the learning process, all its costs are not borne by funding agencies. Further, at many colleges and universities, faculty teaching loads have been reduced to allow more time for research and other scholarly activities. Thus, universities have added costs as a result of changes in faculty work patterns.

The Unfulfilled Potential of Technology

Historically, faculty have been reluctant to substitute technology for direct human interaction, because so much of what is valued in higher education is the opportunity for advanced learners to share their knowledge and expertise with students who are less advanced. Recent developments in technology, however, provide new opportunities to reexamine instructional paradigms with the explicit goal of retaining what is best in education while also reducing costs. Many of the strongest advocates of the application of technology to teaching assert without providing evidence that costs will be reduced; others assert that costs are not a concern—that quality is all that matters. A review of the literature on the applications of technology to instruction shows little compelling evidence that
costs have been reduced. Many applications have been reported that suggest improved quality and increased costs. That is, more has been done with more. More can always be done with more. The important questions are: Can more be done with less? Can the same be done with less?

Every academic administrator receives requests for additional support to undertake exciting and potentially quality improving projects with technology. However, there is a limit to society’s willingness to pay for “more with more” through many such experiments. The Mellon Foundation grant program concerning the cost effective use of technology in teaching is based on the premise that higher education can no longer (if it ever could) afford to operate as if doing “good things” is all that counts. Instead, the program insists on a mindset that cost-effectiveness matters. Approaches to the use of technology in teaching that consider cost-effectiveness as well as educational outcomes are essential for higher education to continue to improve its service to society in a period of revenue constraints.

Paradigm-challenging experiments are not always welcomed by educators. Because American higher education is excellent—the envy of the world, in fact—challenging its premises is often viewed as destructive rather than constructive. However, today’s revenue constraints are real, and new approaches are required to avoid the possibility of a slow decline in quality across the board. The thoughtful application of technology could alleviate some of the cost pressures facing institutions today, while retaining the best aspects of quality higher education.

Some observers are calling for universal adoption of a technology-based education system in which most instruction is accomplished through distance learning or by independent student work via use of either local or wide area networks. Western Governors’ University, for example, has proposed a virtual university as a lower-cost alternative to building new campuses, and a number of private for-profit organizations make extensive use of distance learning. Such all-encompassing applications of technology are not, however, the subject of this project. Rather than encourage wholesale adoption of technology-based education, the program’s aim is to accomplish change in effective but less dramatic ways.

The project’s goal is to discover ways to use technology in traditional university settings that can reduce costs while maintaining or increasing educational quality. More specifically, it aims to answer questions such as the following:

- Can human resources be deployed more effectively by using technology to serve more students? This is an issue of great relevance where there is a need to expand higher education opportunities.
- Can more material be covered in basic courses so that the number of courses required to reach advanced material is reduced? This would enable faculty to teach courses that are more exciting to them and to their students.
- Can several campuses share scarce specialized talents in some subject matters? This would reduce the need for adjunct faculty to replace faculty on leave.
• Can the number of graduate assistants necessary to teach basic materials be reduced through mediated uses of technology?

• Can some faculty time be redeployed by making better use of the time faculty spend in the classroom? What activities (for example, language drills and math exercises) are better done outside than inside the classroom?

Attempting to answer these and related questions could reveal applications of technology that enable institutions to reduce the rate of growth of costs while enhancing quality.

Technology has great potential in higher education if approached with an understanding of the high value so many dedicated faculty put on human interaction with students as they learn, as well as recognition that there is a limit to how much students, parents and the rest of society are willing to pay for even a first-rate education. Achieving these simultaneous goals requires relaxing some of the rules under which teaching and learning are now conducted. Unless many of the current components of education—such as semesters, contact hours, office hours, methods of preparation, text materials, use of libraries, and others—can be altered, the goal of cost-effectiveness cannot be achieved. Given its expense, technology cannot be merely an add-on to current processes. New approaches and new paradigms are required.

The first applications of technology in industry reproduced existing processes without rethinking their overall objectives. The results were higher costs and no improvements. Later, successful applications of technology to industrial processes were made possible by releasing the constraints imposed by the prior approach. Successful application of technology to instruction does not require changing every constraint for every course, educational program, or student-faculty interaction, but flexibility is essential. Those who wish to experiment with new approaches that consider both costs and educational effectiveness need to be free to think broadly and to experiment widely. To be successful, such experiments must be faculty driven, not top-down cost saving exercises.

Mellon Projects

New instructional paradigms are being implemented through Mellon projects at the University of Cape Town in South Africa, George Mason University, and the University of Pennsylvania. Each maintains the high value that faculty place on human interaction in the learning process by using learning technologies in traditional campus settings.

University of Cape Town

The University of Cape Town (UCT) has begun a project that will improve the teaching of basic skills while simultaneously widening knowledge of African history. Over the course of three years, the University’s archeology department will develop a set of computer-based materials, entitled “Deep Foundations,” that will be introduced into four large core courses. The project’s goal is to minimize problems created by differences in students’ precollege academic preparation and make better use of faculty members’ and instructors’ time.
The use of self-paced teaching materials is particularly appropriate in South Africa. A legacy of apartheid and a tradition of authoritarian schooling mean that many students who now enter South African universities have underdeveloped learning skills in areas such as taking notes, using library materials, assembling evidence, constructing arguments, reading textual sources, solving problems, and writing. Attempts to teach such generic skills outside a substantive context have been unsatisfactory. At the same time, in South Africa, where disadvantage is usually associated with race, remedial academic development programs are interpreted as patronizing when they enroll only black students. Computer-based materials have the great advantage of allowing students to control their own learning programs, and to repeat course work if necessary until they achieve the required level of competence.

The University of Cape Town, like most other institutions of higher education in South Africa, is committed to developing a curriculum that respects African themes. Currently, South African history encompasses mainly the experiences of European settlers. Archeology provides deep history to the majority of South Africa’s citizens, for whom written records extend back only a few generations, and at the same time takes advantage of South Africa’s unusually rich set of archeological sites.

Three broad areas of cost avoidance are anticipated. First, by automating much of the assistance currently provided by academic support staff, Deep Foundations will relieve some of the mounting pressure at UCT to hire additional staff at a time when budgets are severely constrained. Second, programs such as Deep Foundations will enable students to complete their degrees in a more timely fashion. At present, only a minority of students graduate in four years, because many students who have been poorly prepared for higher education must gain foundation skills through an iterative process of repeating courses. Such a process is a highly inefficient use of UCT’s teaching resources and deeply demoralizing for students. Third, it is hoped that Deep Foundations will make it possible for all 21 of South Africa’s universities to respond to the increasing pressure to recognize the varied heritages of South Africa’s people. At present, there are departments of archeology in just three institutions, and archeology is not taught at all in 15 of the 21 universities. It is unlikely that departments of archeology will be established in other universities or that the existing programs will be expanded; however, if this new approach to teaching foundation skills succeeds at UCT, it may be possible to export it to other schools.

Expected outcomes of the UCT effort include development of a set of electronic teaching materials with substantive content on African archeology. At least 1,000 first-year students at UCT will have used the materials to acquire generic learning skills. A formal method to assess the Deep Foundations project also will be developed. Assessment will be both diachronic—following the progress of student cohorts—and synchronic—comparing the performance of sample groups given access to new resources with that of other groups taught by traditional means. Such methods will make it possible to
measure the educational impact and full costs of this promising new approach.

**George Mason University**

Over the course of four years, George Mason University (GMU) will undertake five experiments aimed at evaluating the strategic use of information technology to reduce the unit costs of teaching. These experiments will leverage work already done at GMU, both on developing course materials and on creating new models of teaching that use electronic materials. Two broad types of experiments are proposed: (1) retrospective reviews of existing courses in which technology has been applied and in which subsequent efforts will be made to control costs; and (2) longitudinal studies of new applications of technology designed to reduce costs.

Throughout the past few years, with the support of GMU’s instructional design office, many faculty have integrated technology into their classes. One of the most comprehensive and promising applications has been an innovative, Web-based, introductory astronomy course developed by Assistant Professor John Wallin. Preliminary evidence suggests that Wallin is able to deliver superior content to several hundred students per semester. Wallin will analyze the budgetary impact of his approach, and carefully assess the educational outcomes of the new course as well.

Another effort involves replication of a controlled experiment initially conducted by Professor Stephen Ruth. In 1994, Ruth made radical changes to an introductory undergraduate course in management information systems, a required course at most schools of business administration. Ruth employed a great variety of technology—electronic classrooms, CD-ROM, Internet, World Wide Web, groupware conferencing, TV broadcasts for distance-learning modules, and autodidact materials for teaching spreadsheet and database skills. The course was extremely successful and reduced unit costs considerably when it was subsequently taught by junior faculty. The positive results stemmed primarily from a learning model in which students acted as discoverers, rather than as receivers, of imparted wisdom in a classroom. The model led to students attending fewer classes, doing more work outside of class, using a graduate textbook instead of the undergraduate version, and, by Ruth’s estimate, accomplishing 50 percent more tasks than a class taught in the traditional manner. Another key aspect of the project was that no information technology investments beyond normal university information technology capabilities were required.

The designs of Wallin’s and Ruth’s courses were based on the theoretical work of computer scientist Peter Denning, a faculty member at GMU. Denning has suggested that the teaching method of many courses can be changed by assigning a new role to professors. In Denning’s model, the professor becomes a course manager, capable of working with more students than before, but only on crucial course activities. Routine tasks and drills are handled by assistants or with autodidact materials. Other GMU faculty, including professors of business statistics, English, and African history, have begun
to experiment with Denning's models. The most promising experiments will be supported by the project and then carefully assessed.

Expected outcomes of the project include development of five courses in which information technology is used to enhance student learning and reduce costs. Each course will be taught and assessed based on factors including student achievement, financial return on investment, and how variables such as course structure, technology use, and faculty rewards affect educational outcomes and costs. The goal is to determine which combinations of factors produce the most successful results.

University of Pennsylvania

The engineering and applied sciences school of the University of Pennsylvania (Penn) has designed a project using the World Wide Web to reduce costs and improve teaching of undergraduate engineering labs. Engineering and science curricula are extremely expensive to teach because they involve many specialized classroom and laboratory courses. The high costs of laboratory teaching arise principally from the costs of personnel and equipment: it takes a great deal of time to ensure that experimental stations are maintained in proper working order and to instruct students in the safe and correct use of equipment.

The central focus of the Penn project is to develop online, apparatus-specific instruction so that students can learn how to operate expensive equipment before coming to the laboratory, and rehearse aspects of the experiments they will carry out. It is anticipated that the introduction of such online materials will improve the quality of laboratory instruction, because students will spend less time in class learning how to use the equipment and more time doing experiments. This should result in major savings of instructor time, a significant increase in the number of students a given laboratory can serve, and less damage to equipment.

The proposed project is based on a modest experiment already underway in the university's bioengineering department. Materials for five additional laboratory classes will be developed and tested over the course of the project. All five courses are taught by tenured faculty of the school of engineering and applied sciences, and the dean is very supportive of the project. If the experiments succeed, it is anticipated that the models produced will be used broadly across the university.

Expected outcomes of the project include development and use of Web-based laboratory materials for five engineering classes at Penn. Further, the educational and cost implications of the project will be evaluated. Costs of laboratory time, personnel, and equipment repair and replacement will be tracked before and after the experiments and then compared. Similarly, pre- and post-experiment student achievement and satisfaction will be monitored by an expert in evaluating the teaching and learning of college science from the school of education. Finally, both the online templates and results of the evaluation will be available on the World Wide Web to other institutions.
Conclusion

The Mellon Project is considering expansion of its efforts to encourage the cost-effective use of technology in education to foreign languages, writing, and mathematics curricula. The project is designed to discover and refine means by which to leverage the capacity of faculty through the appropriate use of technology—not to replace the professoriate with technological solutions. By reducing the rate of growth in the cost of teaching, such approaches have the potential to conserve much needed institutional resources.