Costs of ICT use in Higher Education:
What Little We Know

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This article focuses on the costs of use of Information and Communication Technologies (ICT) for teaching and learning in higher education, bearing in mind that these technologies also supports a wide range of other core activities in higher education institutions. The research on costs to date is limited in scope as well as in volume, with much of it based on data available from universities and colleges in industrialized countries - with particular emphasis on the North American experience. Only a handful of published studies examine the costs and/or cost-effectiveness of advanced computing and telecommunications in higher education.

To add to the literature on the costs of using educational technology in developing countries, the World Bank is funding a study that examines costs related to the use of ICT at selected institutions in developing countries. Through a comprehensive literature review, interviews, and site visits, the research team is gathering and synthesizing much-needed data about the costs related to the latest alternative models of educational service provision in developing countries. While the first results of this work are not expected until March 2000, this article relies on the limited body of relevant research available.

The existing models of teaching with technology in higher education span a continuum from technology that minimally assists classroom instruction (e.g., faculty encouraging students to keep abreast of current-events in preparation for a group presentation) to multi-media instruction that occurs entirely at a distance. In the United States, it appears many types are expanding rapidly. K.C. Green (1999) found that "the percentage of [U.S.] college courses using Web resources in the syllabus rose from 10.9 percent in 1995 and 33.1 percent in 1998 to 38.9 percent in 1999." An estimated one million students are taking courses online, and 25% of higher education institutions in the United States are said to be offering courses delivered via the Internet. Some evidence suggests that a surprising number of on-campus students enroll in online, "virtual" courses.[1] Rather than treating the phenomenon as a continuum, the literature examining the costs of technology use in higher education tends to divide the subject into two distinct categories: (1) on-campus use of computers and (2) "virtual education."

CAMPUS-BASED COMPUTER USE

Recently, higher education institutions (in the US) have consistently made substantial investments in information technologies (IT). "An average of five percent of operating budgets is spent on IT expenditures" (Ehrmann and Milam, 1999, p. 1). Technology as used on campuses today typically represents additional costs, rather than cost reductions, to institutions. "Although technology holds promise for making educational operations more efficient and less costly, there is no evidence to date to indicate that the use of technology in higher education has resulted in widespread cost savings to colleges and universities" (Harvey et al., 1998, p. 16 as reported in Ehrmann and Milam, 1999, p. 1).

Estimating the total costs of computer use on campus is rarely a matter of straightforward accounting. The "Total Cost of Ownership" (TCO) is a method used in business to calculate all of the expenses associated with adding a personal computer into the workplace.[2] Through the efforts of the Consortium for School Networking, the TCO for US primary and secondary schools is currently better documented than for institutions of higher education (http://www.cosn.org/tco/). One study cited in the report found that the total cost of computers in "eight pioneering high-tech schools" ranged from $142 per student to $490 per student (mean per student cost was reported at $333).

Over time, many hidden costs of computer use in education have emerged. In order to accommodate the installation of technology, buildings must often be renovated, including upgrading heating and cooling systems, increasing electrical capacity, and improving security systems. In addition, many

institutions must provide supplemental training to faculty, and the same faculty must invest additional time adapting to the new technologies - time that might be otherwise spent on research or teaching. Few estimates of the cost in staff time exist because institutions of higher education rarely record specific staff time allocations. Moreover, technology users generally require regular technical support. The costs of computer assistance and maintenance have been difficult to establish.

Support Service Costs. The COSTS Project (http://www.its.colgate.edu/kleach/costs/costs.htm) is an effort to identify and benchmark costs of information technology services in higher education internationally. The COSTS study team has reported that in the United States, median network services cost approximately $255 per used network port (Leach and Smallen 1998). Support services are subject to economies of scale; the cost for services tended to drop as the number of ports increased. The COSTS study found, however, that administrative information systems were not subject to these economies. "For most of the institutions, the total cost of providing these services [performed by administrative information systems] fall in a narrow band, from $200,000 - $500,000" (Leach and Smallen 1998).

Production Costs. The production of multimedia content is integral to both on-campus computer use and virtual education. Costs for producing content per hour of instruction appear to be somewhat similar, whether distributed on-line or by CD-ROM. While academia has done relatively little to establish benchmarks for web-based courses in higher education, Hall (1998) reports the following rates associated with web-based training:

Instruction technologist	$75 - 100/hr
Instructional Designer	$75 - 100/hr
Writer/editor	$40 - 65/hr
Graphic Artist	$35 - 65/hr
Programmer/authoring specialist	$30 - 65/hr
Java/CGI programmer	$85 - 120/hr
Media Expert	$65 - 120/hr

These figures are clearly illustrative, as the complexity of a particular course module- technical and otherwise- will have direct impact on the total costs of production. Clearly, these unit costs differ significantly by country.

COST AND COST-EFFECTIVENESS OF COMPUTER-AIDED INSTRUCTION (CAI)

A few case studies are underway that explore the economics of computer-aided instruction (CAI)[3] in higher education. Once again, because of the relatively small number of studies, findings will likely be viewed as suggestive rather than definitive. The comparison of four such studies in the United States - Indiana University/Purdue University Indianapolis (IUPUI), City University of New York (CUNY), California State University (CSU), and Brevard Community College - further demonstrates the current limitations of the research.

IUPUI and CUNY both introduced computers into their writing courses in the early 1990's. IUPUI offers two distinct kinds of sections for its English curriculum core writing courses: one section is classroom-based, without technology; while the other uses half of its class time in a computer lab. The computer-lab sections are limited to enrollments of 22 students due to the size of the computer lab. One study (IUPUI Economic Model Office in Ehrmann and Milam, 1999) found that computer use was NOT cost-effective on a per-student or per-"completer" basis. Establishing and operating the computer lab increased costs, but the difference in the performance and completion rate of students in the computer section to the students in the traditional section was not found to be statistically significant. The authors caution that their "study does not consider whether the high differential costs were inevitable, or simply one of the results of not exploiting the strengths of technology in instruction by reengineering the instructional process" (IUPUI Economic Model Office in Ehrmann and Milam, 1999, p. 67).

CUNY developed a computer program called DAEDALUS, which allows students to comment on each other's written work. The CUNY study compared the cost-effectiveness of using this program to not using it. Differences in pass rates on an exam between the control and intervention cohorts were not statistically significant, although use of DAEDALUS increased the cost of a course section by $540. Since class sizes were similar, the study concluded that use of DAEDALUS was not cost-effective when compared to the cost of administering traditional courses.

CAI in remedial math courses paints a slightly different picture. In two studies of CAI for algebra, the introduction of certain computer programs was shown to be potentially cost-effective compared to traditional instruction, given sufficient enrollments. In the CSU study, differences in the scores of students with and without CAI were not determined to be statistically significant - nor were pass rates for the same groups. However, CAI did allow for larger course enrollments without a discernable loss in learning outcomes as measured by the study. At enrollments greater than 2,500 students, the CAI course was projected to be more cost-effective than traditional courses (although at that time the university was enrolling only about 1,500 students in the CAI program).

Another study at Brevard Community College, however, reported that CAI tended to increase student success and productivity in developmental algebra (King and Crouse 1997). The course in the study relied on self-based instruction using CD-ROMs in computer labs. “As they become

more adept, instructors are able to work with larger numbers of students in each class" (King and Crouse 1997 p. 22). Administrators at Brevard Community College currently enroll about 38 students per section, up from 25 students in previous classes. The study does not explicitly address the costs of development or the costs of maintaining the computer lab. Researchers from this algebra study report that students learn faster and faculty productivity increases over time. Therefore, if sufficient numbers of students cycle through the course, economies of scale can be realized. These may be sufficient to drop per-student and per-completer costs below that of basic classroom instruction.

Admittedly, the findings of these four case studies are contradictory: two studies suggest that CAI is not cost-effective compared to traditional classroom instruction, while another two suggest that it is. Although the findings from these two sets of studies are at odds with each other, the differences in their conclusions might possibly be explained by variations in subject matter, implementation, instruction, or other such factors. Many more studies on the cost effectiveness of computer aided instruction will be required before any definitive conclusions can be made. At this time it is impossible to say if the selection of appropriate pedagogy, increased training of faculty, and reduced use of faculty time allotted would help to increase the cost-effectiveness of CAI. A re-engineering of the educational process may be necessary as well.

A unique study of the cost-effectiveness of CAI at George Mason University (GMU) seems poised to offer some insights into the relevant strengths and weaknesses of CAI compared to basic classroom instruction (Milam in Ehrmann and Milam, 1999). This particular study is based on "a teaching/learning schema that arrays different levels of personal contact between instructor and student (touch) and levels of incorporating technology in classes (tech). The resulting grid includes sixteen squares with degrees of no, some, moderate, and high touch versus degrees of low, some, moderate, and high tech" (Milam in Ehrmann and Milam, 1999, p. 71). It will compare the cost-effectiveness of courses with these alternative mixes of touch and tech, and results are expected within the next year.

VIRTUAL EDUCATION

On the other side of the teaching spectrum is "virtual education,"[4] which takes place without a teacher and student having to be in the same physical space at the same time. Connotations of virtual education differ somewhat from distance education in that content and communication is often administered over the Internet.

There are a growing number of studies that attempt to assess the costs of providing an on-line course. Estimates vary considerably. Unfortunately, many are incomplete or use competing methodologies, making them difficult to compare. For instance, a study of a virtual course at the University of British Columbia in Canada found that the annual break-even enrollment based on projected costs and revenues over 4 years was 44 students (Bartolic-Zlomislic and Bates, 1999). The study projected that this virtual course would earn a profit of about $12,000 over four years. Another study of a virtual course did not include overhead cost estimates or initial development expenses. The second study estimated that the course would make close to $2,000 per year and required an enrollment of about six students to break even (Bartolic-Zlomislic and Bates, 1999).

Other studies are emerging that specifically compare the costs of an Internet-based virtual course, to traditional classroom-based courses. The Rochester Institute of Technology (RIT) completed one study comparing the operational costs of instruction "anytime/anywhere,"[5] in traditional classrooms, and "site-based"[6] (Geith and Cometa in Ehrmann and Milam, 1999). The study emphasis on operational costs precludes any examination of planning and production costs as well as the implications of investments in technical infrastructure. Given these exclusions, "results indicated that 8 of the 9 course sections in our sample cost the same or less per credit hour than their on-campus counterparts" (Geith and Cometa in Ehrmann and Milam, 1999, p. 50). Faculty reported using equal or more time in anywhere/anytime courses,[7] and they reported using their time differently.

Virtual Institutions. Although the promises of virtual education are as yet unclear, some virtual courses are already undergoing quality assurance procedures and the first "virtual university" has been accredited. Jones International University recently became the first entirely virtual university to be accredited in the United States (Crow 1999). In spite of this formal approval, there are no published studies regarding its costs. Nevertheless, Turoff (1995) earlier estimated the costs to develop a hypothetical virtual university. He found that "the establishment of such a University would cost less than the addition of a single classroom building on a physical college campus (approximately US$15 million)." Turoff estimated that the costs associated with a virtual university to be approximately $4,500 per student per year, assuming an enrollment of 2000 students. Turoff does not offer any estimates for the design and production of course content, so his estimates are likely to be low. Planners often underestimate the costs of distance education projects. For instance, an experienced distance education practioner and researcher planned for only a fraction of the actual costs involved with an on-line course (Bartolic-Zlomislic and Bates 1999). Total project costs were 176% of that anticipated. Unexpected costs in planning, marketing and instructional time were the primary causes for the apparent miscalculation.

CONCLUSION

While these studies begin to offer some limited benchmarks and estimates of the costs of CAI and Internet use for higher

education courses, we still lack a firm understanding of the cost-drivers of these projects. However ICT might be used, the scale, production quality, and personnel use are likely to influence costs dramatically. Part of the difficulty in developing a more precise understanding of costs is the rapidly evolving state-of-the-art of computer use.

Computers and the Internet have the potential to improve access to and quality of higher education institutions throughout the world. The most obvious obstacles include prohibitive Internet connection costs and inadequate technical infrastructures. Several factors suggest that the use of ICT in education, at least in the short-term, will be relatively more costly in developing countries, even if Internet access were readily available and affordable. Where the computer hardware industry is less developed, import taxes and international shipping will increase the costs of computers, hardware and software. Skilled instructors and technicians might also be more expensive in developing countries because of their very limited supply and competition from the private sector for their expertise. Faculty, who have had more limited exposure to the technology will likely require additional training. There are also distinct cultural, linguistic and other pedagogic needs of students in many developing countries that will make costs even more prohibitive in many contexts.

Although findings are preliminary, the World Bank's study suggests that countries interested in adopting ICT may have difficulty finding appropriate and relevant content in suitable languages. In developing countries in particular, any experimentation will be limited by budgets. Limited finances also make missteps in technology use all the more risky. Therefore, it is important for academics and policymakers to pay close attention to the cost-effectiveness of CAI and virtual education in developing country contexts. It is important for both administrators and policy makers to gain a more complete understanding of the factors influencing the cost-effectiveness of CAI and Internet-based instruction so that strategies can be developed to make such educational innovations universally viable.

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[1] See, for instance, the experience of the University of Colorado, Denver where 500 of 609 students enrolled in an on-line course were also enrolled in a course on campus (Guernsey).

[2] More information about TCO is available from Microsoft at http://www.microsoft.com/technet/tco/default.htm.

[3] "Computer-aided instruction" is a common term referring to classroom-based teaching that is supported by students using computers.

[4] The term "virtual education" as used here is considered synonymous with other terms often used to describe similar phenomenon, including "on-line learning," "computer-mediated instruction," etc.

[5] Defined as "asynchronous instruction using a range of technologies including email, Internet and telephone conferencing, web resources, videotape, audio-tape and CD-ROM" (Geith and Cometa in Ehrmann and Milam, 1999, p. 53).

[6] In site-based instruction, students are organized at formal educational institutions other than RIT but enrolled in a distance RIT course.

[7] The finding of an INCREASE in faculty time used in virtual courses is consistent with the findings of other studies. Researchers at the University of Illinois at Urbana-Champaign found that "of the students using conferencing in the Spring, 64% reported increased interaction with the instructor (up 13% from the fall), [and] 50% reported increased quality of instructor interaction" (Scale Evaluation Results: Spring 1996 Semester: Executive Summary, p. 2, available at http://franklin.scale.uiuc.edu/scale/evaluations/spring96/exec_sum.html).