AC 2011-188: STRENGTHENING THE COMMUNITY COLLEGE ENGINEERING PIPELINE USING TABLET PCS AND ONLINE INSTRUCTION

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Strengthening the Community College Engineering Pipeline Using Tablet PCs and Online Instruction

Abstract

The California Community College system has been very successful in providing affordable and accessible education to diverse student populations by allowing them to complete all of their lower-division course work and then transfer to a four-year institution to complete a bachelor's degree. Recent developments, however, have threatened the viability of engineering programs in California community colleges, endangering this very important pipeline in the engineering educational system. The increasing divergence of the lower-division requirements among different four-year institutions and among the different fields of engineering, coupled with the recent State budget crisis has forced many community colleges to cancel low-enrollment classes and high-cost programs including those in engineering.

In response to this situation, Cañada College, a federally designated Hispanic-serving institution in the San Francisco Bay Area, has developed an innovative program entitled Online and Networked Education for Students in Transfer Engineering Programs (ONE-STEP). Funded by the National Science Foundation Engineering Education and Centers through the Innovation in Engineering Education and Curriculum, and Infrastructure (IEECI) program, ONE-STEP aims to improve community college engineering education through the use of Tablet-PC and wireless network technologies. The program includes a Summer Engineering Teaching Institute that will assist community college engineering faculty in developing a Tablet-PC-enhanced interactive model of engineering instruction, and implementing online courses using CCC Confer—a videoconferencing platform that is available free of charge to all faculty and staff of the California Community College system. ONE-STEP will also develop partnerships with community colleges currently without an engineering program to design and implement a Joint Engineering Program that is delivered through CCC Confer. The program has the potential to significantly increase the viability of engineering programs by increasing teaching efficiency and effectiveness with minimal additional costs.

1. Introduction

The critical role that community colleges play in building a larger and more diverse workforce that is educated in Science, Technology, Engineering, and Mathematics (STEM) fields has long been recognized.[1] Specifically, community colleges are an important source of prospective engineering students for several reasons: (1) millions of students attend them; (2) many women and students from underrepresented minorities attend community colleges; and (3) many community college students in engineering do not transfer to four-year engineering programs after earning their two-year degree.[2]

The California Community College system has grown to be the largest system of higher education in the world, serving close to 3 million students every year,[3] and providing affordable and accessible education to diverse student populations. Students are able to complete all of their lower-division coursework at a community college and then transfer to a four-year institution to complete a bachelor's degree. In 2007, for instance, nearly half of California State University (CSU) and University of California (UC) graduates began their college years at a community college[4]—and, upon transferring to a four-year institution, obtained GPAs equal to, or better than, "native" CSU or UC students.[4] The success of California community college transfer students is consistent with a recent national study based on a database tracking of students from 21 flagship universities showing that students who transferred from community colleges graduate at the same rate as those who enrolled as first-time freshmen, despite being more likely to be from low-income families and more likely to have not had great pre-college academic credentials.[5]

For years, this 2+2 concept worked well for community college engineering students. In 2002, the California Council on Science and Technology reported that 48 percent of graduates with engineering degrees from the California university systems (UC and CSU) began at community colleges and then transferred.[6] This was made possible by a common set of lower-division courses—commonly referred to as "the core"—required by four-year engineering programs and replicated at community colleges. Students were able to start their engineering coursework at a local community college with the option of transferring to one of the many four-year schools across the state.

Recently, the diversification of transfer requirements among university engineering programs, driven partly by the continual improvement process required by ABET 2000 criteria, has led to the erosion of the core, and has increased the number of courses that community colleges must offer in order to maintain transfer options to different engineering majors and different universities.[2] The diversification includes variability of requirements for students in the same major transferring to different institutions, as well as for students in different majors transferring to the same university, and has resulted in declining enrollments in community college engineering programs.[7] The erosion of the core lower-division curriculum, coupled with recent budget crises in California, is threatening the viability of community college engineering programs all over the state. In response to this pressing need to strengthen community college engineering programs, Cañada College, submitted a successful grant proposal to the National Science Foundation. This paper is a description of this NSF-funded project that attempts to improve community college engineering education using technology, and establish collaborations and partnerships among institutions in order to increase the viability of community college engineering programs in the State.

2. Struggling California Community College Engineering Programs

Engineering is an important transfer program in California community colleges, with over 100 community colleges that have students who transfer to four-year schools as engineering majors. However, the numbers of these transfer students have been decreasing. Figure 1 shows the distribution of California community college students who transferred to University of California (UC) and California State University (CSU) in 2008 as engineering majors. Of the 101 colleges with engineering transfers, the average number of transfers from a college was 21.3 students (median of 17.0 students). In fact, 78 of the 101 colleges transferred less than 30 students, and 44 colleges had fewer than 15 transfers each. In light of the current budget crisis in California, a significant number of these small engineering programs will have difficulty sustaining their programs due to cancellation of courses with low enrollments.

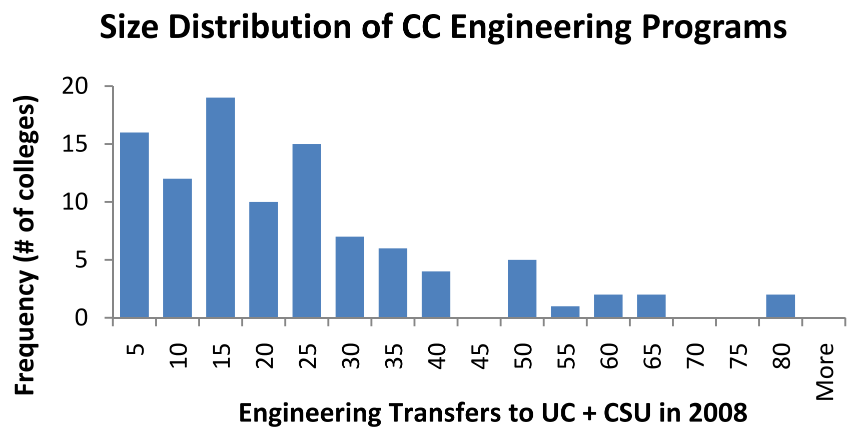

Figure 1. Distribution among individual California Community Colleges of engineering transfers to UC and CSU in Fall Term 2008. Of the 101 colleges with engineering transfers, 78 colleges transferred less than 30 students each, accounting for exactly 50% of the 2,148 total transfers. Median number of transfers = 17.0 students; Mean number of transfers = 21.3 students. Data are from California Postsecondary Education Commission.[8]

To further illustrate the decline of California community college engineering programs, the number of transfer students in CSU and UC engineering programs is compared with those in all other majors. As shown in Figure 2, approximately 33% of all UC and CSU engineering graduates in 2008 transferred from a community college (individually, 23% of UC and 41% of CSU graduates).

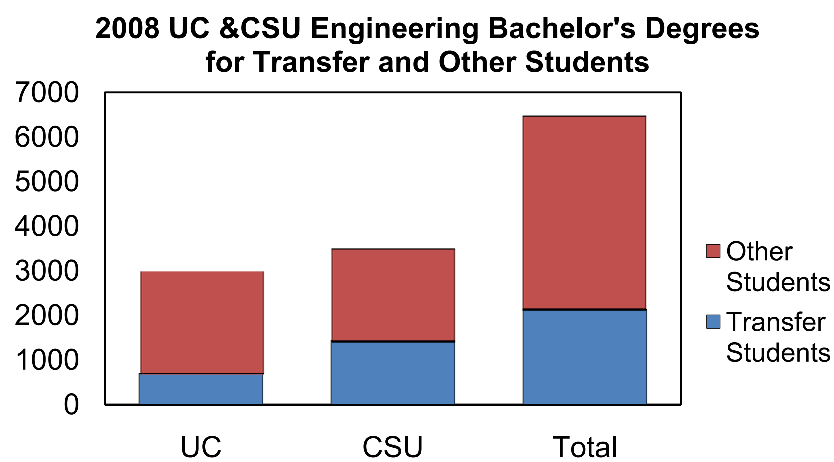

Figure 2. UC and CSU engineering graduates for 2008 showing engineering transfer students from community colleges compared to students who did not transfer from a community college. Data are from California Postsecondary Education Commission.[8]

Although this percentage is impressive, if other disciplines are considered, the percentage of transfer students at the UC and CSU schools is even higher. Figure 3 shows that among all non-engineering bachelor's degree recipients in 2008, 47% of all UC and CSU graduates were transfer students (individually, 30% of UC and 56% of CSU graduates). In other words, there is a relatively smaller representation of community college transfers among engineering graduates when compared to other majors.

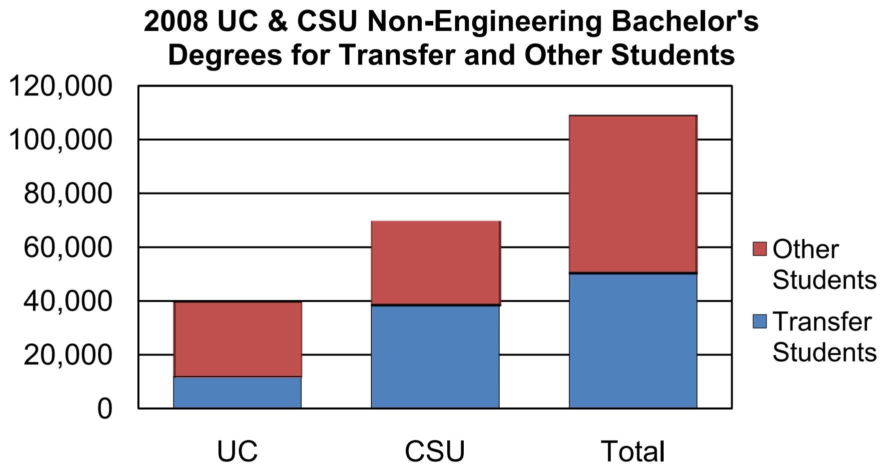

Figure 3. UC and CSU graduates in all disciplines for 2008 showing transfer students from community colleges compared to students who did not transfer from a community college. Data are from California Postsecondary Education Commission.[8]

It is worth noting that the lower percentage of engineering transfer students among four-year degree graduates is not because engineering transfer students are less successful at UC and CSU. On the contrary, a 2002 UC study found that engineering transfers were actually more successful, in terms of both GPA and completion rates, than all other types of transfer students.[9] Although there may exist a number of other possible explanations for why transfer students are relatively less common among UC and CSU engineering majors, certainly among the contributing factors is the increasing difficulty for community college engineering programs to offer engineering courses that are articulated with the increasingly diverging four-year engineering lower-division curricula.

California Council on Science and Technology Board Chair Karl Pister stated – on improving California's science and technology workforce pipeline – that "the community college system is a particularly crucial juncture where the state needs to focus attention if it wants to improve the production of science and math college graduates, particularly among underrepresented groups.[4]" The CCST Task Force Report, California's Response to Rising Above the Gathering Storm, recommended that the state focus on transitions from community colleges to four-year institutions and to graduate schools. Clearly, to meet the future needs for science and technology workforce, California community college engineering programs have to improve their ability to produce successful transfer students by improving student learning and streamlining the transfer process. Four year institutions also need to take into account possible effects on community colleges of any changes they implement on their curriculum. Furthermore, to improve the entire engineering education system, research efforts on innovative and effective instructional pedagogies in engineering should pay close attention not only to university engineering programs but to community college programs as well.

3. Online and Networked Education for Students in Transfer Engineering Programs

To address the problems resulting from the gradually decreasing ability of California community college engineering programs to produce enough successful transfer engineering students, Cañada College has developed the Online and Networked Education for Students in Transfer Engineering Programs (ONE-STEP). The project has two main focus areas for achieving program goals. The first one is the use of Tablet PCs to improve the effectiveness of engineering education, and to develop online instruction to increase productivity and improve viability of community college engineering programs. The second focus area is developing partnerships with community colleges without an engineering program to design a joint engineering curriculum that is delivered through CCC Confer, as well as establishing collaboration among existing community college engineering programs to better serve community college students interested in pursuing degrees in engineering.

Tablet-PC Enhanced Instruction

Various uses of technology have been found to be effective in enhancing the classroom experience to achieve more interactive and collaborative learning environments. These techniques include handheld wireless transmitters in Personal Response Systems (PRS),[10] various forms of computer-mediated collaborative problem solving,[11] and the use of wireless Tablet PC technology.[12,13]

Tablet PCs are essentially laptop computers that have the added functionality of simulating paper and pencil by allowing the user to use a stylus and write directly on the computer screen to create electronic documents that can be easily edited using commonly available computer applications. This functionality makes Tablet PCs more suitable than laptop computers in solving and analyzing problems that require sketches, diagrams, and mathematical formulas. Combined with wireless networking technology, Tablet PCs have the potential to provide an ideal venue for applying previously proven collaborative teaching and learning techniques commonly used in smaller engineering laboratory and discussion sessions to a larger, more traditional lecture setting. Currently, the range of use of Tablet PCs in the classroom includes enhancing lecture presentations,[13,14] digital ink and note taking,[15] E-Books (books in electronic format) that allow hyperlinks and annotations,[16] Tablet-PC-based in-class assessments,[13,14] and Tablet-PC-based classroom collaboration systems such as Classroom Presenter,[17] Ubiquitous Presenter,[18] NetSupport School,[19,20,21,22] and DyKnow.[23]

As part of the ONE-STEP program a Summer Engineering Teaching Institute (SETI) will be held to help California community college engineering instructors use various models of Tablet-PC-enhanced interactive model of instruction. The SETI curriculum will include the following instructional models of Tablet-PC use:

a. One-Tablet PC model similar to the one implemented by Rogers and Cox,[13] wherein the Tablet PC is used mainly by the instructor in lieu of the traditional chalk and blackboard to generate class notes during instruction. Advantages of this model over the traditional approach include: generation of electronic documents of lecture notes that are available for later distribution, ability to use enhanced graphics and annotation capabilities, and more efficient coverage of course material with time-consuming steps preloaded in the class presentation. The single Tablet PC can also be passed around the classroom to allow students to show their work without having to "come up to the board."

b. Several-Tablet-PCs model wherein several Tablet PCs are available for student use in groups of three or four. This model is effective in collaborative problem-solving sessions because it forces students to work together using a Tablet PC to analyze problems and generate solutions. Each group can then be asked to present their solution, giving the class an opportunity to see multiple approaches to the problem, as well as identify common misconceptions and errors.

c. Individual Student Tablet PC use for Real-Time Assessment. This model requires each student to have access to Tablet PC use during lectures to allow real-time formative assessment of individual student learning. This is an enhanced version of the Personal Response System (PRS),[10] which only allows multiple-choice or short-answer questions. With a Tablet PC, individual student responses may also be submitted as sketches, and numerical solutions with multiple steps.

d. Fully Interactive Learning Network. For this instructional method, in addition to real-time assessment as in the previous model described above, various levels of two-way interactions between the instructor and individual students or groups of students, as well as among students within a given group will be explored. These interactions will enhance the instructor's ability to solicit active participation from all students during lectures, to conduct immediate assessment of student learning, and to provide needed real-time feedback and assistance either individually or in groups to maximize student learning.

Synchronous Online Teaching Using CCC Confer

Online teaching is one of the fastest growing trends in educational technology in the U.S. A 2008 study[24] released by the US Department of Education indicates that online enrollments are growing at substantially faster rates than overall higher education enrollments (12.9% vs. 1.2%), with over 3.9 million students (or over 20% of all U.S. higher education students) taking at least one online course in the fall of 2007. In the September 2009 report on distance education issued by the California Community College Chancellor's Office,[26] it was reported that among California community colleges, the enrollment growth for distance education is even faster, with a growth rate of 18.8% compared to 4.1% for traditional education in 2008. However, of the 58,551 total courses offered at California community colleges in academic years 2006-07 and 2007-08, only 963 courses (or about 1.6%) utilized synchronous interactive two-way audio and video delivery.

The 2008 Education Department study on online education in the U.S. also reveals that among the eight major discipline areas examined, engineering has a much lower online representation compared to others. There have been many studies on the reasons why higher education faculty choose to adopt or refrain from adopting online teaching pedagogies.[26,27,28,29,30,31] Reasons for not participating in online instruction include concerns about academic integrity, and perceptions by some faculty and administrators that online courses are not equivalent in content, rigor, and level of achievement of learning objectives when compared to the traditional, face-to-face courses.[31,32,33,34,35,36,37]

There have been numerous studies done across various disciplines to determine the effectiveness of online teaching and learning.[31,38,39,40,41,42,43,44,45,46,47] The most comprehensive study to-date is a 2010 meta-analysis released by the US Department of Education,[48] which included a systematic search for experimental or quasi-experimental studies of the effectiveness of online learning published in the literature from 1996 to 2008. This meta-analysis concluded that "on average, students in online learning conditions performed better than those receiving face-to-face instruction." It should be noted that for studies included in this meta-analysis, the most common subject matter is medicine or health care. Other content areas include computer science, teacher education, social science, mathematics, languages, science and business. As with most previous studies on effectiveness of online instruction, engineering is not well represented.

Studies of the effectiveness of online teaching in engineering have been limited. A recent study[49] found no difference between final exam scores in the hybrid sections and the face-to-face sections of an Engineering Graphics course. Although supporting the effectiveness of online instruction in engineering, the hybrid instruction studied includes considerable (once a week) face-to-face instruction. The online portion of the course included voiced-over content presentations, software demonstrations, and sketching examples. A similar study[50] shows how the provision of online lectures, audiovisual material, discovery-based learning activities and communication tools can improve the effectiveness of subject content delivery in engineering.

A recent study of the effectiveness of dual delivery mode (content is delivered simultaneously to on-campus students and online students) in an Introductory Circuits Analysis course shows no statistically significant difference in the levels of performance of the online and on-campus students despite favorable demographics for the on-campus group.[51] In this study, synchronous delivery of lectures to online students is achieved using Elluminate Live!, a multipoint videoconferencing software application that is available for use free of charge to all faculty and staff of the California Community College system through CCC Confer.[52] Online students also rated their experience in this online class to be better than other online courses they have previously taken. These results are particularly important for a small engineering program where budget cuts and low enrollments threaten the viability of course offerings and the program itself.

The ONE-STEP project will use the above model of synchronous delivery to help small community college engineering programs in California to increase their teaching productivity, as well as provide the opportunity for community colleges without engineering programs to offer core lower-division engineering courses to their students. Community college engineering faculty selected to participate in the Summer Engineering Teaching Institute will be trained to use Tablet PCs and CCC Confer to develop this instructional mode.

Developing Partnerships Among Community College Engineering Programs

A third major goal of the ONE-STEP program is to develop partnerships with community colleges without an engineering program to design and implement a joint engineering curriculum that is delivered through CCC Confer. It will also establish collaboration among existing engineering programs in order to better serve students.

The CA Engineering Liaison Council website[6] lists less than 80 community colleges with engineering programs out of the 112 colleges in the California Community College system. Many of these programs only offer one or two courses every semester. It is the goal of ONE-STEP to improve these community colleges' ability to offer a full range of lower-division engineering courses needed for transfer. This will make their students more competitive in the transfer process, and reduce the time that these students need to spend in four-year institutions to complete their degrees. This has the potential to increase the number of future engineers in the engineering educational pipeline while reducing the cost of their education.

In identifying partner institutions, colleges with existing Math, Engineering, and Science Achievement (MESA) Programs but do not offer engineering courses, or have limited engineering course offerings are given special consideration. To this effect, the effort to establish collaborations among community colleges is initiated through the CA MESA Statewide Office. This allows the program to take advantage of existing partnerships and relationships that are currently in place among community college MESA Programs.

4. Status of ONE-STEP Program

At the time of writing of this paper, the ONE-STEP program is only three months into its first year. The curriculum for the Summer Engineering Teaching Institute has been developed. The application processes for the 2011 Summer Engineering Teaching Institute and the Joint Engineering Program have been completed. The first group of ten SETI participants has been selected, and five partner institutions have been identified for the Joint Engineering Program.

The urgency of the current state of community college engineering transfer programs is manifested in the overwhelming response to the ONE-STEP program among engineering faculty. Within one week of having the online application available, 27 highly qualified applications were received, many expressing a sense of desperation.

The following is a short sampling of the situations that community college engineering faculty are facing.

- A tenured engineering faculty member from a Bay Area community college who has been a full-time faculty at the said institution since 1991 has been under reduced load (ranging from one-third to one-half of a full-time equivalent position) for the last two years since many of the courses she has been assigned have been cancelled due to low enrollment. Last semester, she was forced to take a Sabbatical leave. This semester she is teaching at half load, and next semester she will either be forced to take another Sabbatical leave, or teach only a third of her normal load.

- A tenure track faculty from a Northern California community college who is on her fourth and final year before receiving tenure was given notice that the college would be downsizing its Engineering Department with only three core classes being offered (Circuits, Statics, and Materials) and dropping the rest of the engineering courses (Introduction to Engineering, Engineering Graphics, Surveying, and Intro to CADD/Drafting). As a result, her position was changed to a part-time position, and she would not be receiving her tenure.
- In many community college engineering departments all over the state, engineering courses are being cancelled, forcing engineering faculty to teach courses in mathematics. Although happy to keep their jobs, most of them are limited to teaching basic, remedial courses in pre-algebra, or elementary algebra. In many instances, engineering instructors are required to take math courses, or obtain degrees in mathematics to satisfy the minimum qualifications required to teach math.

5. Conclusion: The Future of California Community College Engineering Programs

A recent development in California higher education is the passing of SB 1440 bill, which establishes the Student Transfer Achievement Reform Act. SB 1440 would "require a student that receives an associate degree for transfer to be deemed eligible for transfer into a California State University.[54]" The associate degree for transfer would include a set of general education requirements and a defined set of courses in their major area, to be determined by the community colleges. This bill is intended to streamline the transfer process for community college students. However, for high-unit majors like engineering, designing a common lower-division curriculum for all CSUs can lead to further erosion of the core engineering curriculum.

In the past, as a response to the state legislature's increasing pressure to streamline the transfer process for millions of California community college students, both the CSU and the UC systems have attempted to make the lower-division requirements more consistent. Although CSU's Lower Division Transfer Pattern (LDTP) project,[55] and UC's Intersegmental Major Preparation Articulated Curriculum (IMPAC) project[56] have had success in creating common lower-division curricula for many majors, streamlining the curriculum for engineering majors has been a challenge.

For the LDTP statewide engineering pattern, there is a high degree of uniformity in the General Education classes, as well as the required courses in mathematics and physics, but a high variability in the required engineering courses for Civil, Electrical and Mechanical engineers. In fact, out of the 45 units of core courses in the LDTP engineering curriculum, not a single engineering course is common to all three majors. The rest of the major-specific lower-division curriculum that is needed to complete the 60-70 units needed to transfer is campus specific, which again results in variability in the curriculum, making it difficult for community colleges to develop curriculum that is widely articulated and to maintain programs that have healthy enrollments.

The results of the IMPAC project are even less promising. The project recommends an Engineering Transfer Curriculum (ETC) base that only includes one engineering course – Introduction to Engineering or Skills for Engineering Success, which is not even a required course for transfer to most UCs.[10] In fact, the IMPAC 2005-2006 Annual Report does not even recommend using the ETC pattern, and instead recommends that the ASSIST[57] web site be used as the best source of guidance for community college students who have decided on a specific engineering major and university campus.

It should be noted that the demand for engineering among students remains high; most engineering majors in almost all CSU and UC campuses are impacted. In community colleges however, class sizes that would have been big enough a few years ago are now being cancelled because of budgetary pressures that force colleges to cancel courses and programs that are expensive to offer. In some colleges, administrators base their decisions on program cancellations or downsizing based solely on productivity or efficiency (number of students served, and cost per student). Courses in engineering, which are typically higher, transfer-level courses with fewer students and require expensive lab equipment and supplies, are sacrificed in favor of basic or remedial courses in English as a Second Language (ESL), English, or low-level Mathematics that a majority of community college students need. As a result, many community college engineering students are unable to complete their lower-division course work, and are at a considerable disadvantage when they transfer to a four-year institution.

Most importantly, a significant number of the students from educationally disadvantaged communities will never hear about engineering, much less consider it as a career option, without engineering courses, engineering programs and engineering faculty in community colleges. The California higher education system has essentially dismantled a large portion of the engineering education pipeline, barring access to those students least likely to find a detour around the barriers that have been inadvertently created.

With the uncertainty in the future of California community college engineering curriculum, and even more budget crises looming, programs like Cañada College's ONE-STEP are needed to help strengthen community college engineering programs. The Summer Engineering Teaching Institute has the potential to serve as an effective model of facilitating broad adoption of innovative instructional pedagogies that are based on research while the Joint Engineering Program may serve as a model for future institutional collaborations not only in engineering but in other disciplines as well.

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BIBLIOGRAPHY

1. Adelman, C. (1999). Women and Men of the Engineering Path: A Model for Analysis of Undergraduate Careers. Washington, D.C., U.S. Government Printing Office.
2. Mattis, M. and Sislin J. (2005). *Enhancing the Community College Pathway to Engineering Careers*. Committee on Enhancing the Community College Pathway to Engineering College Pathway to Engineering Careers, Committee on Engineering Education, Board on Higher Education and Workforce, National Academy of Engineering, National Research Co. National Academies Press. Retrieved December 20, 2009 from http://www.nap.edu/catalog.php?record_id=11438.
3. CCLC (2010). Community College League of California. *Fast Facts 2010*. Retrieved November 28, 2010 from http://www.ccleague.org/files/public/FF2010_revNov10.pdf
4. CCST (2007). Community Colleges Important Key to Future of Higher Ed in California. *CCST Newsletter*. Retrieved December 20, 2009 from http://www.ccst.us/newsletter/2007/2007feb8.php.
5. Bowen, W., Chingos, M. and McPherson, M. (2009). *Crossing the Finish Line: Completing College at America's Public Universities*. Princeton: Princeton University Press.
6. CCST (2002). Critical Path Analysis of California's Science and Technology Education System. Riverside, CA: CCST. http://www.ccst.us/publications/2007/2007TCPA.php.
7. Enriquez, A., Disney, K., and Dunmire, E. (2010). The Dismantling of the Engineering Education Pipeline, *Proceedings: 2010 American Society of Engineering Education Zone IV Meeting*, Reno, NV, March 25-27, 2010, 88-100.
8. California Postsecondary Education Commission (n.d.). Retrieved November 29, 2009 from Detailed Data – Custom Reports website: http://www.cpec.ca.gov/OnLineData/OnLineData.asp.
9. University of California Office of the President (2002). *Community College Transfer Students at the University of California: 2002 Annual Report*. Retrieved December 1, 2009 from http://www.ucop.edu/sas/publish/transfer_ar2002.pdf. Note that the authors of this grant proposal were unable to locate a more recent version of this "annual" report.
10. Beekes, W. (2006). The 'Millionaire' Method for Encouraging Participation. *The Journal of the Institute for Learning and Teaching* 7: 25-36.
11. Rummel, N., and H. Spada. (2005). Learning to Collaborate: An Instructional Approach to Promoting Collaborative Problem Solving in Computer-Mediated Settings. *The Journal of the Learning Sciences* 14: 201-241.
12. Koile, K., and Singer, D.A**.** (2006). Development of a Tablet-PC-based System to Increase Instructor-Student Classroom Interactions and Student Learning. *Proc WIPTE 2006 (Workshop on the Impact of Pen-Based Technology on Education)*, Purdue University, April, 2006.
13. Rogers, J. W., & Cox, J.R. (2008). Integrating a Single Tablet PC in Chemistry, Engineering, and Physics Courses. *Journal of College Science Teaching 37*, 34-39.
14. Ellis-Behnke, R., Gilliland, J., Schneider, G.E., & Singer, D. (2003). *Educational Benefits of a Paperless Classroom Utilizing Tablet PCs*. Cambridge, Massachusetts: Massachusetts Institute of Technology.
15. Colwell, K. E. (2004). Digital Ink and Notetaking, *TechTrends* 48: 35-39.
16. Goodwin-Jones, B. (2003). E-Books and the Tablet PC. *Language Learning & Technology* 7: 4-8.
17. Anderson, R.J., Anderson, R.E., Davis, P., Linnell, N., Prince, C., Razmov, V., and Videon, F. (2007). Classroom Presenter: Enhancing Student Learning and Collaboration with Digital Ink. *IEEE Computer Magazine*, 36-41.
18. Price, E., Malani, R., & Simon, B. (2005). Characterization of Instructor and Student Use of Ubiquitous Presenter, a Presentation System Enabling Spontaneity and Digital Archiving. *2006 Physics Education Research Conference, AIP Conference Proceedings, 893,* 125-128.

19. Enriquez, A. (2007). Developing an Interactive Learning Network Using Tablet PCs in Sophomore-Level Engineering Courses. *Proceedings; 2007 American Society of Engineering Education Conference and Exposition, Honolulu, HI*, June 24-27, 2007.

20. Enriquez, A. (2009). Using Tablet PCs to Enhance Student Performance in an Introductory Circuits Course. *Proceedings: 2009 American Society of Engineering Education /Pacific Southwest Section Conference, San Diego, CA*, March 19-20, 2009, 32-43.

21. Enriquez, A. (2008). Impact of Tablet PC-Enhanced Interactivity on Student Performance in Sophomore-Level Engineering Dynamics Course. *Computers in Education Journal*, Vol XVIII, No.3,2008, 69-84.

22. Enriquez, A. (2010). Enhancing Student Performance Using Tablet Computers. *College Teaching*. 58:. 77 - 84.

23. Berque, D. (2006). An evaluation of a broad deployment of DyKnow software to support note taking and interaction using pen-based computers, *Journal of Computing Sciences in Colleges*, 21: 204-216.

24. Allen, I. E., and Seaman, J. (2008). Staying the Course: Online Education in the United States, 1008. Needham MA: Sloan Consortium.

25. CCCCO (2009). Periodic Report on Distance Education Prepared by the Academic Affairs Division and the Office of Communications. Retrieved December 21,2009, from http://www.cccco.edu/Portals/4/Reports/Distance%20Learning%20Report827093%20%282%29.pdf

26. Beaudoin, M.R. (1990). The instructor's changing role in distance education. *The American Journal of Distance Education, 4(2)*, 21-29.

27. Bower, B.L (2001). Distance education: facing the challenge. *Online Journal of Distance Learning Administration*, Volume (2) 2, retrieved August 22, 2009 from: http://www.westga.edu/~distance/ojdla/summer42/bower42.html.

28. Clark, T. (1993). Attitudes of higher education faculty toward distance education: A national survey. *The American Journal of Distance Education, 7(2)*, 19-33.

29. McKenzie, B. K., Mims, N., Bennett, E., & Waugh, M. (1999, Fall). Needs, concerns, and practices of online instructors. *Online Journal of Distance Learning Administration*, 2(3). Retrieved October 3, 2009 from: http://www.westga.edu/~distance/ojdla/fall33/mckenzie33.html

30. Rockwell, K., Schauer, J., Fritz, S.M., & Marx, D.B. (1999). Incentives and obstacles influencing higher education faculty and administrators to teach via distance. *The online Journal of Distance Learning Administration, 2(3)*: Winter. Retrieved August 30, 2009 from http://www.westga.edu/~distance/ojdla/winter24/rockwell24.html.

31. Schifter, C.C. (2002). Perception differences about participating in distance education. *Online Journal of Distance Learning Administration, 5 (1).* Retrieved October 2, 2009 from http://www.westga.edu/~distance/ojdla/spring51/schifter51.html.

32. Adams, J. (2008). *Understanding the Factors Limiting the Acceptability of Online Courses and Degrees. International Journal on E-Learning*. 7 (4), pp. 573-587. Chesapeake, VA: AACE.

33. Oomen-Early, J. & Murphy, L. (2009). *Self-Actualization and E-Learning: A Qualitative Investigation of University Faculty's Perceived Barriers to Effective Online Instruction. International Journal on E-Learning*. 8 (2), pp. 223-240. Chesapeake, VA: AACE.

34. Page, K. E. (2000). The integration of on-line instruction into a Kansas community college: A naturalistic study. (Doctoral dissertation, University of Kansas, 2000). Dissertation Abstracts International, 61, 08A.

35. Russell, T.L. (1999). The no significant difference phenomenon. Raleigh: North Carolina State University.

36. Wallace, T.L. (2002). Reducing face-to-face instructor contact time with Web-based and Web-enhanced instruction. An examination of achievement and attitudes of undergraduate students in a pre-service teacher education course. (Doctoral dissertation, University of South Florida, 2002). Dissertation Abstracts International, 63, 05A.

37. Wilson, C (2001). Faculty attitudes about distance learning. *Educause Quarterly, 2,* 70-71.

38. Connolly,T. , MacArthur, E., Stansfield, M. & McLellan, E. (2007). A Quasi-Experimental Study of Three Online Learning Courses in Computing. *Computers & Education*, v49 n2 p345-359 Sep 2007.

39. Jang, K.S., Hwang, S.Y., Park, S.J., Kim, Y.M., & Kim, M.J. (2005). Effects of Web-based teaching method on undergraduate nursing students' learning of electrocardiography. *The Journal of Nursing Education*. 44(1):35-39.

40. Mentzer, G.A., Cryan, J, and Teclemaimanot, B. (2007). A comparison of face-to-face and Web-based classrooms. *Journal of Technology and Teacher Education*, 15(2):233-46.

41. Schulman, A. H., & Sims. R. L. (1999). Learning in an online format versus an in-class format: An experimental study. *THE Journal*, 26(11), 54-56.

42. Sener, J., & Stover, M.S. (2000). Integrating ALN into an independent study distance education program: NVCC case studies. *Journal of Asynchronous Learning Networks*, 4(2).

43. Sitzmann, T., Karaiger, K., Stewart, D., and Wisher, R. (2006). The comparative effectiveness of Web-based and classroom instruction: A meta-analysis. *Personnel Psychology* 59:623-64.

44. Smeaton, A. & Keogh, G. (1999). An analysis of the use of virtual delivery of undergraduate lectures. *Computers and Education*. 32, 83-94.

45. Vroeginday. B.J. (2005).Traditional vs. online education: A comparative analysis of learner outcomes. (Doctoral dissertation, Fielding Graduate University, 2005). Dissertation Abstracts International, 66, 10A.

46. Warren, L.L., & Holloman, H.L. (2005). On-line Instruction: Are the outcomes the same? *Journal of Instructional Psychology*. 32(2), 148-152.

47. Zhang, D. (2005). Interactive multimedia-based e-learning: A study of effectiveness. American Journal of Distance Education 19(3):149-62.

48. U.S. Department of Education, Office of Planning (2010). *Evaluation and Policy Development. Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*, Washington, D.C. Retrieved November 5, 2010 from http://www.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf.

49. Branoff, & T., Weibe, E. (2009). Face-to-Face, Hybrid, or Online?: Issues Faculty Face Redesigning an Introductory Engineering Graphics Course, *Engineering Design Graphics Journal* 73(1):25-31.

50. Blicblau, A.S. (2006). Online Delivery Management for Teaching and Learning. *European Journal of Engineering Education,* 31(2):237-246.

51. Enriquez, A. (2010). Assessing the Effectiveness of Synchronous Content Delivery in an Online Introductory Circuits Analysis Course. *Proceedings: 2009 American Society of Engineering Education Zone IV Meeting*, Reno, NV, March 25-27, 2010..

52. CCC Confer (n.d.). CCC Confer Products. Retrieved December 21, 2009 from http://www.cccconfer.org/products/products.aspx

53. Kowalski, F., Kowalski, S., & Hoover. E. (2007). Using InkSurvey: A Free Web-Based Tool for Open-Ended Questioning to Promote Active Learning and Real-Time Formative Assessment of Tablet-PC-Equipped Engineering Students. *Proceedings; 2007 American Society of Engineering Education Conference and Exposition*, Honolulu, HI, June 24-27, 2007.

54. Lay Consulting (2010). Around the Capitol. Retrieved December 26, 2010 from http://www.aroundthecapitol.com/Bills/SB_1440

55. California State University Division of Academic Affairs (n.d.). Retrieved November 29, 2009 from The Lower Division Transfer Pattern (LDTP) Project website: http://www.calstate.edu/AcadAff/swp.shtml.

56. Mathias, D. (2006). *IMPAC Annual Report: 2005-2006*. Retrieved November 28, 2009 from http://www.cal-impac.org/ScienceI/Engineering06_Annual.doc.

57. Welcome to Assist. (n.d.). Retrieved January 2, 2011 from ASSIST website: http://www.assist.org/web-assist/welcome.html.