

AC 2008-2033: ACTION AT DISTANCE: A MS DEGREE OFFERED THROUGH DISTANCE LEARNING AS A VECTOR TO STUDENT ENRICHMENT AND INDUSTRIAL INTERACTION

Lanny Griffin,

Lanny Griffin received his Ph.D. from the University of California at Davis in Materials Science and Engineering. He also has a BS degree in Mechanical Engineering from California Polytechnic State University in San Luis Obispo. Currently, he is a Professor of Biomedical Engineering at California Polytechnic State University in San Luis Obispo. He is also on the Mechanical Engineering faculty of the US Military Academy at West Point as an Army Reserve Officer. Dr. Griffin's research interests are in bone mechanics and biomaterials and has been the Principal Investigator of several projects from the Army, DOD, and NIH.

Daniel Walsh, California Polytechnic State University

Daniel Walsh is currently Associate Dean at the College of Engineering at California Polytechnic State University, San Luis Obispo. He received his B.S. (Biomedical Engineering) , M.S. (Biomedical Engineering) and Ph.D. (Materials Engineering) degrees from Rensselaer Polytechnic Institute in Troy, New York. Prior to joining Cal Poly, Dr. Walsh was employed by General Dynamics Corporation, as a principal engineer and group leader in the Materials Division.

Robert Crockett, California Polytechnic State University

Robert Crockett received his Ph.D. from University of Arizona in Materials Science and Engineering. He holds an M.B.A. from Pepperdine University and a B.S. in Mechanical Engineering from University of California, Berkeley. He is currently an Assistant Professor of Biomedical Engineering at California Polytechnic State University, San Luis Obispo. Dr. Crockett is a specialist in technology development and commercialization of advanced materials and manufacturing processes. Prior to joining Cal Poly, he was founder and President of Xeragen, Inc., a San Luis Obispo-based biotechnology startup company. He has also served as an Assistant Professor at Milwaukee School of Engineering and was employed by McDonnell Douglas Space Systems Company, where he was a lead engineer and Principal Investigator on projects to develop technology evolution plans for the Space Station.

Robert Szlavik, California Polytechnic State University

Action at Distance: A MS Degree Offered Through Distance Learning as a Vector to Student Enrichment and Industrial Interaction

Abstract

This paper describes the development and implementation of a flourishing MS program offered through distance learning (DL). The program serves the mission of the university – polytechnic education. It provides an intense life-long-learning opportunity for some of the 300,000 degreed engineers working in California industry who can benefit from graduate education. The DL Masters Degree Program in Engineering with a Biomedical Specialization was designed and developed with verisimilitude to the on-campus program in mind. The distance students attend the same classes as students on campus. The DL program has the same learning objectives and student outcomes as those expected for the on-site students. Furthermore, the program for distance students has the same standards and curricular flexibilities as available to students on campus, the program accommodates the challenging schedules of full-time industry employees.

The paper describes the motivations for the development of the program at the university and in industry. It treats the challenges faced in implementing the program during its early stages, and fault tolerance schemes developed by participants. It discusses the evolution of the program from single to multi-site. It describes the growth of the program from a specialization offered under an Engineering MS degree to a stand-alone MS Degree offered by the Biomedical Engineering Department over the eight year history of the program. The paper catalogs the benefits of the program to on-campus students as well as to off-campus participants. The paper discusses the evolution of the program from a synchronous mode to a hybrid mix of synchronous and asynchronous delivery modes to accommodate student needs. It also discusses the development of a resource model which allows the program to be implemented within a typical academic administrative structure.

This paper thus describes an innovative DL program which serves the aspirations of students, pedagogical goals of the department, and aspirations of faculty in BMED. The MS program in BMED is the largest MS granting program at the University, and about 10% of the degrees granted by BMED annually are DL degrees.

Introduction

The Master of Science in Biomedical Engineering at Cal Poly is the only MS in Biomedical Engineering in the California State University System (CSU) and is a logical evolution of the existing MS in Engineering with a Specialization in Biomedical Engineering (MSE-BME). Within the CSU, there are some Master's Level specializations, such as the Biomedical Engineering Master's in Mechanical Engineering at San Diego State University. The current MSE-BME program is by far the most popular option for both formal Master's and blended (4+1) degrees within the college of engineering. There is currently a vibrant distance learning program at St. Jude Medical at two sites, Sylmar and Santa Clara. Additionally, there are other

companies, such as Abbot, and Boston Scientific seeking to enroll their engineers in a distance learning Master's Program similar to that offered at St. Jude Medical. Currently, there are approximately 90 students enrolled in the program including 28 from industry (19 to ready to graduate in 2007 with a new cohort of 30 students to enroll Fall 2007) and the rest are in residence at Cal Poly. Cal Poly's MSE-BME is attracting students for a Master's Degree who could easily go to any institution in the country.

With the explosion of biotech industries throughout California, it is apparent to students throughout the College of Engineering that their more traditional BS, such as EE, ME, or MATE, might be marketable in biomedical industry, but having a Master's in Biomedical Engineering in addition to their BS will give them a tremendous competitive edge over other professionals seeking employment. The demand for a Master's in Biomedical Engineering is overwhelming and acute. There is a critical mass of high-quality students, a dynamic, broad-based faculty, and institutional commitment which support the establishment of a formal Master's in Biomedical Engineering at Cal Poly.

The Biomedical Engineering and General Engineering Department at Cal Poly has grown out of the General Engineering Program which has consistently attracted the highest quality students in the College of Engineering. In 2005, the College of Engineering responded to the overwhelming industry and student demand for a Bachelors of Science in Biomedical Engineering. The Biomedical Engineering Program is the only degree granting biomedical engineering program in the CSU system and has already experienced a tremendous growth both in students and faculty. Cal Poly is poised to become the national leader in biomedical engineering professional Master's programs due to the large number of graduates in the workforce who continue to do great things, and the recognition of our industrial partners.

Program Goals

The MS programs goals are: 1) to provide graduates with an underpinning of a rigorous, broad-based advanced engineering education and an opportunity to create an individualized focus that will propel graduates into the many diverse career opportunities of Biomedical Engineering. 2) to provide graduates an empowering professional degree for students who are currently or intend to become practicing engineers, 3) to provide graduates job-entry education and opportunities for the more complex and evolving interdisciplinary area of biomedical engineering, 4) to provide graduates a base that enables graduates to maintain currency in their fields, 5) to provide graduates preparation for further study in engineering and/or medicine, leading to the Doctor of Engineering, MD, Ph.D, or MD/Ph.D. degrees.

To ensure that these goals are met, and to ensure relevancy for our societal and industrial constituencies we guarantee that each graduate 1) possesses advanced practical knowledge to support industries of California meet their needs to design, optimize, and reengineer devices, processes, and methods to achieve success in the global arena, 2) possesses sufficient knowledge to develop innovative solutions to clinically relevant biomedical problems, 3) is able to apply their biomedical engineering knowledge in an ethical and responsible manner to the benefit of humanity. We feel that the participation of DL students from industrial sites serves as a key component to assure that these guarantees are satisfied.

Furthermore, we believe that the DL students help our faculty contribute to furthering the aspirations of all biomedical engineering students while developing and sustaining an environment where they can achieve their professional goals. In fact, our experience has shown that developing and sustaining a DL master's program helps attract support from federal, state, and industrial partners.

Strategic Basis for Masters and Distance Learning Programs

Clearly, a department should not pursue educational delivery through DL unless it serves its strategic plan as well as that of its parent College and University. Furthermore, such a program should not exist unless it serves the interests of three key constituents; students, faculty and society. The Biomedical Engineering Program specifically targets the MS degree as the marquee degree for its students. Furthermore we target a broad population for this degree, to include our own undergraduates, undergraduates from other departments at the university, graduates from other institutions, international students and professionals working in industry. We feel that this mix enriches the educational environment for all our students, including the undergraduates.

Several special boundary conditions exist for the initiation of DL MS programs at our institution. First, the graduate culture exists only in specific departments and many faculty feel any effort directed toward graduate programs detract from the undergraduate emphasis at the university. The Biomedical Program faculty believes that we would be doing a disservice to our talented students if we did not provide them an opportunity to earn a Master's degree in recognition of the vertical mobility and horizontal flexibility it provides them. Some evidence exists that the MS degree is becoming the preferred degree for entry into the engineering profession. Indeed, the American Society of Civil Engineers has legislated that an MS degree will be a prerequisite for professional licensure beginning in 2009¹. Second, there is no way to recover the true costs of instruction through tuition and course fees at public institutions. In the case of our college, the support we receive from the state and through tuition covers about half the cost of instruction in the classroom, let alone any additional costs associated with DL programs.

Fundamental Tenets of the DL MS Program

A priori, the Biomedical Engineering faculty strive to ensure that the experience of DL students is as similar to the experience of resident students as possible. Each course offered to DL students is also offered to our on-campus population. This includes those courses delivered synchronously as well as those presented asynchronously. The same faculty are actively involved in creating, providing, and improving the instructional program for all our students. The faculty are committed to creating vibrant and interactive experiences in a well thought out program of study which leads to substantive degrees structured around a flexible and relevant curriculum.

We are fortunate that the university has adequate technical infrastructure and physical facilities including staffing and technical assistance, to support our DL programs. This support includes access to information technology professionals, formal training and support for participating instructors and students, assistance to ensure compliance with copyright laws and access to systems which assure the integrity of student work and faculty instruction.

In keeping with a tenet suitable for on-campus instruction, faculty work to assure a consistent and coherent technical framework for students. The university and individual faculty provide students with technical support for hardware and software used in the course and the delivery system used off-campus. Consistency is sought in course-to-course implementations, where change is required efforts are made to minimize the impact on students.

Delivery methods do not dictate course, curriculum or program content! The program faculty make all curricular decisions. At our institution, there has been little experience with graduate programs, and the Byzantine and, occasionally, Machiavellian curricular machinations associated with the gerrymandering of undergraduate curricula have yet to tarnish the graduate curricula. The substance of the program, including its presentation, management, and its assessment are the responsibility of faculty with appropriate academic qualifications and agendas.

Early on, the number of faculty participating in the Biomedical Engineering department limited the course offerings in the department, to include DL offerings. Therefore it was incumbent on the program to offer a coherent plan for the DL students to access all courses necessary to complete the program. Choice was also limited by the requirement that synchronous courses be offered at particular times (partner requests). Efforts were made to create long-term (2 to 3 year) schedules which provided the DL student with information about course future offerings. Furthermore, as DL programs became more popular at the university, access to a limited number of DL classrooms (university controlled) became competitive. The department, and our educational partners developed asynchronous classes which alleviated the time requirement, and allowed students who were on extended deployments to remain in the program. Furthermore, we used well-qualified adjunct faculty to teach courses pertinent to the degree. Many of these faculty were Ph.D.'s or MD's employed by our partner, which allowed some of the courses to originate from off-campus sites. Currently we have installed DL equipment in several laboratories and classrooms under the control of the department to increase student choice in any given term, to allow a wider choice of delivery times, and to remove the challenge of accessing a DL facility on campus.

Instructional technology has made it easier to ensure that the experience of all students is optimal, and that individual students have access to instructional support. All departmental courses, including DL courses are managed and delivered with Blackboard Academic Suite, and all matriculated students have digital access to library resources. Library resources include reference and research assistance, remote access to data bases, online journals and full-text resources, document delivery services, library user and information literacy instruction, reserve materials; and institutional agreements with local libraries. Curricular elements are typically provided through Microsoft applications (Word, Excel, Powerpoint...), or Adobe portable document formats (pdf). These elements are available on Blackboard, as are digitally archived lectures. Students have secure access to registration, scheduling, their records and other information through PeopleSoft.

The faculty feel that interaction (synchronous or asynchronous) between instructor and students and among students is critical. The faculty actively promote this with the assignments they require in and out of class. Faculty use e-mail, phone conferences, fax, web-based discussions, chat rooms, computer conferences, and telephone office hours to achieve interaction with

individual students and student groups. Faculty are particularly committed to providing feedback on assignments and tests in classes delivered in the DL formats.

Faculty in our program do not receive added compensation for delivering a course with a DL component. Faculty teach DL courses because the environment improves the educational experience for on-campus students and because the relationship with industrial students leads to other industry-university interactions. Some teaching loads are reduced if the class sizes, including DL, become large. Participation in DL is seen as a positive activity for tenure considerations.

The university provides department faculty with suitable technical, design, and production support. This includes access to instructional designers for the development of asynchronous components. Similarly, they provide the DL student with the training and resources to successfully complete the program. Students are admitted to the program using the same rigorous criteria used to admit students on-site. The Admissions Office reviews pertinent student records and tests scores and provides this data to the Department for decision.

From the beginning, the department was aware that a shared sense of community between local students and distance students was critical to the success of the program, and that persistent relationships among students and between faculty and students was an important, beneficial aspect of the program. The program used a number of devices to encourage the evolution of this community, including the development of study groups, providing student directories through Blackboard, treating DL students as on-campus students in departmental publications and student governance, origination classes a minimum of 10% of the time from the off-campus site, encouraging participation in departmental campus events and visiting the DL site for feedback and for celebration at the end of each quarter.

Early Challenges

The key to a successful program is the will of the institution and the educational partner to see the program through to success. There will be enough technical problems to kill a project. Many institutions are accredited through WASC or similar accreditation organizations² and it may be necessary to apply for substantive program changes when establishing distance learning programs.

Some of our industrial partners have expressed an interest in developing distance learning programs, but also express concerns, such as curricular flexibility, number of faculty teaching the classes, and ensuring adequate access to resources. As previously indicated, public institutions are generally unable to charge sufficient fees to cover costs, of operation of the distance learning program. Synchronous experiences involve numerous fees such as connection costs, which are not covered by the fees. Therefore, the industrial partner must be willing to put forward a large sum of money up-front, which requires selling the program. This should be the easiest of all challenges assuming that the partner already understands the value of the educational experience.

Curricular flexibility is addressed by morning and afternoon sections, which enables the students to select courses that suit their interest. Laboratory instruction can be a challenge and requires a

little imagination to create equivalent experiences. We have found that some lab exercises involving software packages, such as MATLAB or Labview are problematic because these packages are expensive and not every engineer has access to them. The use of student versions of these programs are possible, but coordination with the vendor may be necessary in order to avoid possible license violations.

Our faculty are all invested in the distance learning concept, and so this provides depth and breadth to the DL site. One of the challenges we still face is associated with the thesis project. We encourage program participants to use projects at their place of employment for their thesis research. The biggest hurdle is sufficient communication with students as to what the requirements of the thesis are. Careful communication with the DL students is important in order to motivate them toward completion of the thesis. Typical time to completion for the MS is approximately three-years and employees seem to have a tendency to over-estimate the requirements of the thesis.

The industrial research does pose some difficulty, particularly in regards to intellectual property. Often times, the work is sensitive and publication of the work at conferences or in peer-reviewed journals may be restricted to protect the rights of the company. This requires vetting the thesis through the legal department, as well as signing of appropriate non-disclosure agreements.

We have experienced some difficulty with low resolution connectivity and the ability of students at the distance site to read the board or PowerPoint slides. Some of our workarounds have been to use the high-resolution web-based service provided by the partnering institution, and using the document camera instead of the board. Videotaping of lectures is standard because we have had numerous instances where either one or both sites are unable to obtain video, audio, or both.

The ability to introduce new courses which reflect the current state of the art has been a challenge because the curricular committees at the college and university levels are not accustomed to rapid change. We address this issue by using a special topics class which we can use to deliver cutting-edge classes with minimal academic review. The course topic is vetted through the academic programs office and published on the transcript of the individual so that the content of the course is evident to those who wish to review to program.

Periodic evaluation of the program is necessary to ensure quality and that program goals are being maintained. We use the thesis/project as one direct measure metric for assessing the quality of the experience. Our MS evaluation rubric is shown in Tables 1 and 2.

Table 1: Evaluation criterion for MS Thesis/Project.

- A) Clearly defines the relevant problem.
- B) Document is well organized, clear, and competently written.
- C) Document provides a contribution to the state of the art.
- D) Document demonstrated originality.
- E) Shows evidence of technical depth and achievement.

- F) Has potential for (peer-reviewed) publication.
- G) Has potential to lead to future research.
- H) Draws appropriate, reasoned conclusions.
- I) Uses appropriate research methods and/or technologies.
- J) Formulated an original hypothesis.
- K) Analyzes findings in adequate depth.
- L) Overall quality of the work.

Table 2: Five point scoring system for the evaluation criterion listed in Table 1.

- 1 Fails to demonstrate evidence for this educational objective.
- 2 Minimally achieves this educational objective, with very limited evidence of expected learning outcomes.
- 3 Demonstrates most learning outcomes for this educational objective (goal) at an adequate level.
- 4 Strongly demonstrates learning outcomes for this educational objective, with some variation in level.
- 5 Fully demonstrates all expected learning outcomes for this educational objective at an exemplary level

Conclusions

Despite the difficulties associated with starting and managing a DL master's program, the benefits far outweigh the challenges. The distance component of our master's program is larger than most other programs at our university. Each cohort of students is larger than the previous and several other companies wish to duplicate the program at their site. The DL master's is not for the faint-of-heart and requires a fair amount of time for academic advising, heavier teaching load, and administrative tasks. Yet it provides significant interaction with the industrial partner, access to technical staff and resources, employment opportunities for residence students, and project-based learning.

References

1. Academic Prerequisites for Licensure and Professional Practice, Policy Statement 465, American Society of Civil Engineers (ASCE) Reston, Va., Adopted April 24, 2007.
2. 2005 Substantive Change Manual. Western Association of Schools and Colleges. <www.wascsenior.org>