Institutionalizing Curricular Change: The SUCCEED Experience

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Abstract: SUCCEED is one of the National Science Foundation's (NSF) Engineering Education Coalitions charged with a 10-year mission to improve undergraduate engineering education in the US. Currently completing its eighth year, SUCCEED spent its early years developing and testing curriculum and cultural innovations on its member campuses. Those innovations that were proven to be successful then provided the framework for a curriculum model, which is based on desired characteristics of the engineering program and desired attributes of engineering graduates, to be implemented on all campuses during the last five years of NSF funding. In addition, to support the implementation of the curriculum model, each campus is also installing an engineering-based faculty development program, a network-based collaborative learning environment, and a continuous improvement culture. This paper provides examples of how the coalition has successfully implemented its curriculum vision on its member campuses based on the results of a two year qualitative assessment study. The factors that have contributed to this success include strong leadership, sense of purpose, coalition support, and a climate for change both within and outside of the campus communities. This paper should provide insight to those institutions seeking to implement substantive change in their engineering education curricula and to those who may be called upon to evaluate such change.

Keywords: curriculum change, coalition, changing status of engineering education, evaluation

1. Introduction

SUCCEED (Southeastern Universities and Colleges Coalition for Engineering Education) [1] is one of the engineering education coalitions funded by the National Science Foundation (NSF) "to stimulate bold, innovative, and comprehensive models for systemic reform of undergraduate engineering education and to increase the retention of students, especially women and those minorities underrepresented in engineering" in the US [2]. The eight members of SUCCEED are all publicly funded universities located in the southeastern United States. Four of them are among the 10 largest colleges of engineering in the United States and two of them are institutions that historically have educated African-American students. Originally funded in 1992, SUCCEED is completing its eighth year of operation.

One inference that can be drawn from the original NSF call for proposals to reform undergraduate engineering education through the coalitions program is that there was something wrong that needed to be fixed. Undergraduate education had progressively become less important at many institutions, particularly those that focus on research, and many students were getting shortchanged in the process. Students were dropping out of engineering to pursue other majors at a time when national interests dictated that more engineers were needed. Businesses were also complaining that engineering graduates did not possess all of the skills necessary to be successful on the job. By providing funding that treated educational research like disciplinary research, the NSF coalitions program elevated the stature of educational scholarship in engineering. This gave those people at the participating institutions who were interested in educational reform the incentive to focus their scholarship toward improving the undergraduate experience.

SUCCEED's approach to meeting the goals laid out by the NSF was to create a curriculum model that carried the student through successive stages of learning from pre-college through graduation. During its early years of National Science Foundation funding from 1992-1997, SUCCEED lay the groundwork for this curriculum model which was based on desired characteristics of the engineering program and desired attributes of engineering graduates. Program characteristics included an early introduction to engineering concepts and thought process and their integration with other subject areas, an exposure to professional practice, and a culture of continuous

improvement. Desired graduate attributes included technical competence, an ability to work in teams, and an understanding of systems design and integration. Faculty members developed, tested and evaluated innovations that they believed fit with this curriculum vision. Since 1997 the best of those ideas have been incorporated into a model for student experiences supported by faculty development, engineering program assessment and renewal, and the development of a network-based collaborative learning environment. The student experience model includes summer transition programs for minority and transfer students, mentoring, a revised freshman engineering experience, and more opportunities to work in teams and on multidisciplinary, industry-based problems.

In order to ensure that the curriculum model was implemented on all of the member campuses and that its various elements were adequately supported on a coalition-wide basis, SUCCEED adopted an organizational structure that consisted of eight campus-based teams and six coalition-wide teams. Each campus team is charged with implementing the model there. These Campus Implementation Teams or CITs consist of a leader (often the associate dean for academic affairs for the College of Engineering), members of each of the Coalition Focus Teams (CFTs), and others who may be appropriate for that campus. The CFTs facilitate the implementation of the curriculum model in four primary areas – Faculty Development, Outcomes Assessment, Student Development, and Technology-Based Curriculum Delivery. Through their leadership, they bring together members from each campus team to share experiences and to produce innovations that can be adopted on all the member campuses. The Assessment and Evaluation team supports both the CITs and CFTs and monitors and evaluates the progress the coalition is making toward achieving its goals. The Dissemination Team promotes SUCCEED innovations outside of the member schools.

To date, each campus has made substantial progress in implementing the curriculum model. Each one has chosen to focus on those areas that fit best with its own College of Engineering mission in order to ensure that sufficient support will remain for the program beyond the end of NSF funding. Many parts of the curriculum model have been fully institutionalized to the point where they no longer require sustained NSF funding. Other areas have demonstrated sufficient progress that it is reasonable to expect that they, too, will be self supporting by the end of the grant period. This paper will highlight a few of the areas where lasting, systemic change has been made on the member campuses and those elements that contributed to this success.

2. Changes in engineering education on campus

This section will highlight three areas where SUCCEED has made lasting changes on its member campuses. These are: a change in approach to freshman engineering, the introduction and support of multidisciplinary design experiences, and instituting faculty development programs that support the scholarship of teaching with disciplinary research. There are certainly other areas where SUCCEED has also made significant progress including approaches to distance education, outcomes assessment, preparation for accreditation by the Accreditation Board for Engineering and Technology (ABET), effective teaching with technology, mentoring for women and minority students, summer transition programs for minority students, and transition programs for transfer students. Anyone who is interested in information about these programs should contact the authors.

2.1 Freshman Engineering

One of the biggest changes that has come to many campuses during the SUCCEED award has been the complete restructuring of the freshman engineering program. At most institutions before SUCCEED, freshman engineering classes involved an introduction to computing resources and some type of large introductory class where each discipline was introduced in a lecture format over the course of the semester. This class usually carried little or no credit and was graded on a pass/fail basis. Many students did not pay attention, preferring to sleep or read the campus newspaper during class sessions. Several SUCCEED investigators hypothesized that improving the experience of students in these classes would improve overall retention in engineering and they developed a number of approaches to changing these classes. Most of these involved hands-on experiences for the students. These kinds of experiences have been adopted by most of the SUCCEED institutions in their freshman program. A few notable examples can be found at University of Florida, Virginia Polytechnic Institute and State University (Virginia Tech), Florida Agricultural & Mechanical University-Florida State University (FAMU-FSU), and North Carolina State University (NC State).

At University of Florida, students now attend a three hour session once a week and receive a letter grade for the course. These sessions include two computer skills sessions and an introduction to each engineering discipline over the course of the semester. During the sessions, students are introduced to the discipline in a short lecture and then are put into teams to work on a simple lab experience that demonstrates some basic skills and content of that discipline [3].

At Virginia Tech, students are introduced to engineering through "take-apart" lab experiences. Students work in small teams to take apart, study, and reassemble common items such as one-time-use cameras, lawn mowers, and power drills. During pilot testing, students were invited to take the class if they did NOT show engineering aptitude in a basic assessment in order to expose those students who may not have had experience tinkering with things before coming to college to common engineered products. Student who did not take the full semester course were offered a one-time experience as part of their introduction to engineering class where they took apart, diagramed and reassembled a one-time-use camera.

The FAMU-FSU College of Engineering is a joint program offered together by these two institutions located in Tallahassee, Florida. They have begun a freshman class titled "Introduction to Engineering Concepts and Computations" which is noteworthy, not only because it allows students hands-on experiences like the other programs, but also because it is the first engineering course offered to lower division students from the two universities. Before this program, students took all prerequisite coursework at their home institution (FAMU or FSU) before begin engineering studies on the FAMU-FSU campus.

NC State now offers its revised "Introduction to Engineering" course to all freshmen engineering students. This course includes a hands-on component and stresses team-based problem solving, critical thinking, integration with other science and engineering courses, integration with the introduction to computing environments, and inductive discovery of what engineers do and how multidisciplinary problem solving occurs. It also includes an embedded writing and communication component [4].

2.2 Multidisciplinary Design Experiences

Through the new requirements for accreditation of engineering programs in the United States ("ABET 2000"), engineering colleges are required to ensure that their students are capable of working on multidisciplinary teams [5]. Although it is left to the colleges to determine how that criterion is satisfied, one way that it has been approached by SUCCEED institutions is through capstone design courses that include students from a number of disciplines working on industry-based problems. University of Florida, Clemson University, NC State, and Virginia Tech have developed different approaches to this design experience which have been very successful in their environments.

University of Florida has developed Integrated Product and Process Design (IPPD). This program involves multidisciplinary teams of senior engineering students (along with a few business students) who work on industry sponsored design projects for an entire academic year. Approximately 120 students participate on 22 teams, each of which has a faculty coach and an industry liaison. Each participating company is required to make a $15,000 contribution to their project. In addition to their design work, students are expected to make regular oral and written presentations to their faculty coaches and sponsors.

Clemson University has a similar approach but in its case, multiple student teams are assigned to each project. Approximately 80 students from Mechanical, Industrial, Chemical, and Ceramic Engineering participate in the semester-long program. Each team has faculty coaches and an industry liaison. Participating companies are expected to make a financial contribution and get to select a solution to their problem from among the alternatives presented by the students.

NC State offers the Engineering Entrepreneurs Program in which students form companies and work on industry sponsored or student initiated design projects. In addition to the engineering design work, students also attend weekly seminars on topics of importance to entrepreneurial companies such as writing a business plan, arranging for venture capital, marketing, and team building. They also hear from successful (and not yet successful) entrepreneurs about building a business from an idea. Student teams include not only seniors, who are ultimately responsible for the success of the product, but also lower level students who participate to the extent of their capability.

Virginia Tech has created Virtual Corporations that are student-run corporate entities developed to give students high-quality work experience on campus. Anyone at the university may participate, although most of the 120 students are from the Colleges of Business and Engineering. The corporations focus on two primary businesses, Personal Electric Rapid Transit (PERT) and DISC, a software development company. Each business has developed prototype products and has real clients for their final work. The companies have faculty advisors who act as the corporate board and to whom students must go for funding. Students also attend weekly seminars on such topics as workplace diversity, starting a high tech business, and making hiring decisions (which the students must do for their teams).

2.3 Faculty Development

In order to achieve systemic institutional change, SUCCEED recognized that program participation among faculty members needed to be expanded beyond the original few enthusiasts to others on the faculty. Therefore when

SUCCEED began its second phase of funding in 1997, it included among its goals to "establish a comprehensive engineering faculty development program on each SUCCEED campus" [6]. Operationally, this includes:

- providing ongoing learning opportunities for all engineering faculty through engineering-specific teaching workshops and seminars and learning communities where faculty members meet to discuss teaching issues;
- programs for new faculty including orientation workshops and mentoring programs; and
- rewards and incentives for faculty for improving teaching [7].

The SUCCEED faculty development team has taken a two-pronged approach to meeting its goal. First, the coalition team leaders, drawing on their own expertise and experience, traveled to the participating campuses and provided workshops on teaching effectiveness to the faculty. They hosted a coalition-wide conference on faculty development to which all faculty in the coalition were invited. Sessions at this conference included workshops on active learning techniques, integrating technology in education, effective on-line teaching, and helping new faculty members become quick starters (a session for administrators and mentors). They have also developed a seminar on "Evaluating and Rewarding the Scholarship of Teaching" targeted to department chairs and others involved in the promotion and tenure process.

No matter how well designed and delivered these workshops were, the team realized that true institutionalization of teaching scholarship would only happen if each campus had ownership of engineering faculty development activities. The second approach that the team used to achieve its goal was to have faculty development leaders on each campus take the responsibility of offering continuous learning opportunities to engineering faculty members. Campus leaders at Clemson and Georgia Tech transformed the effective teaching workshops into a series of short seminars that would expose faculty to the teaching techniques without overwhelming them. The campus leader at University of Florida developed an orientation program for new faculty and a guidance and mentoring program for young faculty. Many of the campus leaders also instituted "learning communities" within their colleges where engineering faculty get together regularly to discuss a topic of interest pertaining to teaching and student development.

3. Keys to success

Institutional changes such as these do not simply happen without catalysts and do not stick without solid commitment from a core group of people. In the case of SUCCEED, the catalysts included a climate for reform initiated by business groups who demanded more from engineering graduates, state legislatures who demanded more accountability from university faculty in teaching undergraduates, and ABET which changed the manner by which engineering programs were accredited to be more outcome focus and less process focused. These catalysts, coupled with National Science Foundation funding, created an environment that was conducive to change. Once the momentum for change had begun, quality leadership at the coalition and campus levels has ensured that the changes become institutionalized.

In the first five years of NSF funding, faculty members who were interested in educational innovations received grants from SUCCEED to pilot test their ideas. Each campus was required to match the NSF grant on a dollar for dollar basis. This system helped to form a community of scholars within the coalition who shared an interest in improving the undergraduate experience and institutions that had a stake in the reform efforts. These faculty members, who may have been alone in their departments, found like-minded peers in other departments in their colleges and in their own discipline at other member institutions. This helped to create the critical mass of interested individuals to allow the momentum for change to build. This shared sense of purpose helped to forge lasting relationships among faculty members and solidify the partnership among the participating institutions. The funding from the NSF also legitimized educational research as a worthwhile expenditure of faculty time and effort.

After a few years of pilot testing innovations, SUCCEED took many of the best ideas and incorporated them into the student experience model described above and began the process of institutionalizing the reforms on each campus. This has been successful on most of the campuses due to the strong leadership of the campus teams. In addition, strong leadership of the coalition focus teams, like faculty development, that support the student experience model has contributed to a cross-fertilization of ideas and innovations across the campuses. Strong leadership and vision at the coalition level has also contributed to holding everything together and beginning the process of creating a legacy that will endure beyond the end of NSF funding.

4. Conclusion

Achieving institutional change is a process, not an event. In the case of SUCCEED, the process involved pilot testing a number of ideas, choosing those that would have the greatest educational impact and creating a structure that integrated those changes successfully into the unique environments of each member school. Without an

external environment for change, without the impetus of NSF funding, and without the wholehearted commitment of many of the participants, few of the innovations described above would have happened. The process also has required a number of years. Many of the innovations are now fully supported at their host institutions while it is reasonable to expect others to stand on their own within the next few years.

SUCCEED has also attempted to create a supportive infrastructure on each campus by involving faculty in programs designed to improve their teaching and helping the colleges develop faculty incentive and reward systems that recognize the scholarship of good teaching. By involving all of the faculty in the process of improving undergraduate education and rewarding their work, the hope is that the changes that have been implemented will continue with their active support.

With the work on its own campuses nearly completed, SUCCEED is turning its attention to sharing what it has learned with the engineering education community at large. Those who are interested in making these kinds of changes in their undergraduate student experience and would like help from SUCCEED may contact the authors to learn more.

5. References

[1] The members of the SUCCEED coalition are: Clemson University, Florida A&M University-Florida State University College of Engineering, Georgia Institute of Technology, North Carolina A&T State University, North Carolina State University, University of North Carolina at Charlotte, University of Florida, and Virginia Polytechnic Institute and State University.

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[5] Accreditation Board for Engineering and Technology, *Engineering Criteria 2000 Third Edition*, December 1997, http://www.abet.org/EAC/eac2000.html

[6] Cooperative Agreement No. EEC972741, October 9, 1997, p. 2.

[7] SUCCEED, *Year 8-10 Strategic Plans*, April 1999, Faculty Development section.