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A Model for Engineering Faculty Development*

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Since its inception in 1992, the NSF-sponsored Southeastern University and College Coalition for Engineering Education (SUCCEED) has successfully induced large numbers of engineering faculty members to participate in instructional development programs and to adopt proven but (in engineering) non-traditional instructional methods. This paper briefly reviews the events in engineering education that led to the formation of SUCCEED, outlines the coalition's faculty development program structure, summarizes the program assessment data, and discusses possible implications for reform of engineering education.

THE EVOLUTION OF AMERICAN ENGINEERING EDUCATION

FROM THE TIME it began in the nineteenth century until World War II, engineering education in the United States consisted almost exclusively of shop, drafting, and laboratory courses that emphasized training for industrial practice. After World War II, the emphasis began to shift away from practice and toward scientific and mathematical fundamentals. The launching of Sputnik in 1957 accelerated this shift, and by the early 1960s most of the old hands-on courses had been replaced by lectures.

Throughout both the industrial and scientific phases of engineering education, research-based principles of teaching and learning were largely unknown to most engineering professors. Almost simultaneously with the shift from practice to theory in the curriculum, two developments occurred that began to change this situation. First, a chorus of complaints began to arise from employers of engineering graduates that their new hires lacked skills in such areas as critical and creative thinking, communication, and teamwork. At about the same time, the engineering student body began to change from mainly white males with high aptitudes for science and math to a much more diverse population. It became increasingly clear that the theory-oriented lecture-based instruction dominating engineering education by then was failing to address both the development of skills desired by industry and the learning needs of much of the student population. By the late 1970s and through the 1980s, calls for educational reform were sounded with growing frequency, and teaching effectiveness workshops and seminars were offered at professional society conferences and on campuses around the country.

Engineering faculties at that time (as in previous times) included some effective and innovative teachers, many of whom found a community of kindred spirits in the American Society for Engineering Education, and these individuals welcomed and supported the emerging reform effort. They were only a small fraction of the total U.S. engineering faculty, however. Achieving meaningful engineering education reform on a national scale would clearly require engaging a much broader spectrum of the engineering professoriate than had ever been willing to explore alternative approaches to teaching.

THE ENGINEERING EDUCATION COALITIONS AND SUCCEED

In 1991, the National Science Foundation began funding coalitions of engineering schools to develop, implement, institutionalize, and disseminate reforms in engineering education. In the second year of the program, the NSF funded SUCCEED, a coalition of eight institutions in the Southeastern United States (Clemson, Florida A&M/Florida State University, Georgia Tech, North Carolina State, North Carolina A&T, University of Florida, University of North Carolina at Charlotte, and Virginia Tech) with a combined engineering faculty of over 1,500. In its first five-year funding period, SUCCEED focused primarily on developing innovative teaching materials and programs, including integrated first-year engineering curricula, instructional modules and delivery tools for technology-based courses, programs to promote writing and design

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across the curriculum, and programs to promote recruitment and retention of minorities and women. Another area of emphasis in SUCCEED was learning outcomes assessment, which rose dramatically in the consciousness of the engineering education community following the adoption by the Accreditation Board for Engineering and Technology of 'Engineering Criteria 2000,' a new outcomes-based program accreditation system [1].

In 1997, SUCCEED was awarded funding for an additional five years, with its mission shifting from program development to scale-up, institutionalization, and dissemination of the innovations developed in the first funding period. When the second funding period began, an estimated 10% of the SUCCEED faculty had participated in coalition activities. Moving the innovations developed in the first five years into the mainstream curriculum would clearly require the involvement of many more faculty members, so in 1997 SUCCEED initiated a coalition-wide faculty development (FD) program. The FD program goals were to design and implement a model for sustainable faculty development in engineering on all of the coalition campuses and to involve at least 60% of the coalition faculty in FD offerings by the end of the second five-year period. At the end of the tenth and final year of funding, the faculty development model has been formulated, implementation is well under way at all of the coalition campuses, and faculty participation in FD programs has exceeded its target level.

THE SUCCEED FACULTY DEVELOPMENT MODEL

The need for and importance of professional development in education is almost axiomatic. Guskey [2] observes that every proposal for educational reform emphasizes the need for high-quality professional development that will enable instructors to keep abreast of a rapidly growing knowledge base in education. He also notes that most professional development programs in education have had little effect on changing faculty teaching practices, with faculty members typically regarding them as a waste of their time. However, some programs have been extremely successful. He adds that 'every successful instructional improvement program, curriculum revision project, school restructuring design, or systemic reform initiative has at its center the provision of high-quality professional development,' citing Sparks and Hirsh [3] as a source of data on successful programs.

The primary challenges facing the SUCCEED faculty development program at its inception were, firstly, the traditional reluctance of faculty members to participate in professional development (Guskey's general observation is particularly relevant to engineering), and second, the likelihood that any engineering FD program created and maintained with SUCCEED funding would disappear when the funding ended. The objective of the faculty development team was to design a program that would involve a substantial fraction of the engineering faculty and could be sustained without significant external funding. The result is shown schematically in Fig. 1 [4].

The SUCCEED faculty development program has six components. Three of them involve instructional development and support: (1) programs open to all faculty, (2) programs specifically for new faculty members, and (3) programs for graduate students. The other three involve campus infrastructure and climate: (4) a faculty or staff member within engineering whose principal responsibility is coordinating faculty development efforts, (5) links to campus-wide faculty development programs, and (6) provisions in the faculty incentive and reward system that support improvements in teaching and educational scholarship.

Workshops and learning communities

The principal vehicles for instructional development in the SUCCEED model are workshops designed for engineering and science faculty. Offerings include a 1.5-day teaching effectiveness workshop covering various aspects of pedagogy and shorter workshops and seminars on teaching with technology, learning outcomes assessment, supporting women and minorities in engineering, teaching multidisciplinary design, and other topics.

One of the goals of the SUCCEED FD program has been to equip each participating campus with its own sustainable faculty development program. To this end, most workshops given in the first two years were followed by half-day training sessions at which engineering teaching leaders and faculty development personnel from each campus received instructional materials and guidance on offering the workshops on their home campuses. The teaching leaders were taught elements of effective workshop presentation such as keeping content relevant to the backgrounds and interests of the participants, maintaining a reasonably high level of activity and interactivity, and modeling

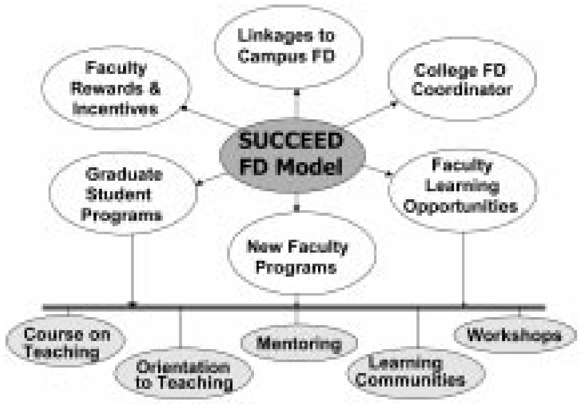

Fig. 1. SUCCEED faculty development model.

recommended teaching methods. The faculty developers—most of whom had backgrounds in education and/or psychology—were given suggestions of ways to establish credibility with engineering faculty, including using engineering and science examples whenever possible, citing solid research to support workshop recommendations, emphasizing practical suggestions, and avoiding educational jargon. The desirability of collaboration between engineering teaching leaders and FD personnel was obvious once these points had been made, and representatives of the two groups were encouraged to co-present with each other to the greatest possible extent.

In addition to workshops and seminars, *learning communities* play an important role in the SUCCEED FD model. These programs—which often take the form of luncheon forums organized around pre-announced topics—may be departmental or (better) college-based or campus-wide. Communities may also take the form of teaching support groups that include mutual observation and critiquing of classes, assignments, and tests.

Programs for new faculty

College teaching may be the only skilled vocation that neither requires prior training of its practitioners nor provides it to them on the job. Successfully completing a Ph.D. dissertation project defined by someone else is presumed to be adequate preparation for designing and teaching courses, planning and initiating funded research programs, attracting and managing graduate students, and balancing the relentless competing time demands imposed by research, teaching, service, and personal life. This presumption is mistaken. It typically takes new faculty members 4–5 years to become as productive in research and effective in teaching as they are capable of being, while a good faculty development program can reduce the learning curve to the 1–2 years characteristic of what Robert Boice terms 'quick starters' [5].

In the first year of the SUCCEED FD program, a coalition-wide new faculty teaching workshop was held, followed by a training session for engineering teaching leaders and campus FD personnel on how to conduct such events on local campuses. Events for new faculty are currently in place on all but one of the campuses. One of the most successful new offerings is a week-long new faculty orientation workshop covering effective teaching, establishing and maintaining a successful research program, time management, and learning about and integrating into the campus faculty culture [6].

Administrative support and individual mentoring by experienced colleagues can also do much to help new faculty get their careers off to a good start. Half-day workshops on mentoring and supporting new faculty members have been presented to deans, department heads, and senior faculty on the SUCCEED campuses [7]. This workshop first reviews material from Boice [5] and Sorcinelli [8] on the stresses and problems typically faced by new faculty. It then reviews models of formal and informal mentoring programs, outlines steps department heads can take to support their new faculty, and suggests incentives and rewards that can be provided to senior faculty who serve in mentoring capacities.

The promotional material for this workshop stresses that it is not just about making new faculty members good teachers (a function with limited appeal to many engineering administrators) but that it is also about helping them to become productive in research. The workshop has been most effective on campuses where the dean personally invited department heads to attend, attended himself, and communicated a clear expectation of follow-up to the heads.

Programs for graduate students

The learning curve for new professors can also be shortened by providing them with some training while they are still in graduate school. The SUCCEED faculty development model calls for offering workshops and seminars to graduate students and post-doctoral fellows on topics such as addressing different student learning styles, effective lecturing techniques, active and cooperative learning, dealing with common student problems, and the success strategies outlined by Boice [5]. On some SUCCEED campuses the graduate students participate in workshops together with new faculty, and on others they attend their own workshops.

College-level faculty development coordinator

In most colleges of engineering, either no one assumes responsibility for faculty development or faculty development is one of many charges given to an associate or assistant dean. An important component of the SUCCEED model is the designation of an individual within engineering whose primary responsibility is to coordinate faculty development activities. The FD coordinator is expected to identify engineering teaching leaders and to involve them in activities such as leading workshops and facilitating learning communities.

Linkages to campus-wide faculty development programs

Campus-wide teaching centers are frequently sources of pedagogical expertise that complements the disciplinary expertise of engineering faculty members. Engineering FD programs in SUCCEED coordinate their activities with campus programs to the greatest possible extent. Teaching center personnel participate as co-presenters or co-facilitators in engineering FD programs and coordinate participation of non-engineering faculty members (particularly those in the sciences and mathematics) in workshops and other instructional development programs. The engineering FD coordinator keeps engineering faculty informed about opportunities available to them through the teaching center and other campus-wide programs.

Institutional incentives for improving teaching

Designing and implementing any of these programs on a continuing basis requires a substantial commitment of faculty time and energy. For systemic institutional change to take place (as opposed to isolated changes made by a few dedicated individuals), administrators must demonstrate with more than rhetoric that they value efforts by faculty members to improve teaching. The demonstrations might involve providing tangible support for teaching improvement efforts, educational research, or faculty development activities, and including those efforts in a meaningful way in the faculty evaluation system. (Specific examples are given in the next section.) Part of the SUCCEED faculty development program mission is to make campus administrators aware of the possibilities for such support measures and to encourage their adoption.

MODEL IMPLEMENTATION

The eight SUCCEED institutions vary considerably in size, mission, and resource levels and the model implementations show corresponding variations, but every campus has something in place for each of the six model components. All of the schools offer teaching workshops and seminars to all faculty, all but one offer separate programs for new faculty, and all but one have established faculty learning communities that meet regularly. All but two schools either offer programs to graduate students or invite graduate students to participate in faculty workshops, and the remaining two rely on university-level workshops for graduate students. All eight schools have faculty development as a formally recognized college-level function. FD coordination is currently done by a faculty or staff member at four schools, by the associate dean for academics at three schools, and by a teaching effectiveness committee at one school. All eight schools have formal links between engineering faculty development programs and campus centers for teaching and learning.

Incentives and rewards for teaching quality and improvement also vary from one campus to another. They include an endowed chair for teaching innovation, release time and summer support for course development and re-design, travel support to attend education-related conferences and workshops, small grants for education-related projects, materials, equipment, student assistance, payment of ASEE dues, awards for effective mentoring and teaching, and formal inclusion of teaching innovation and scholarship in tenure and promotion decisions.

ASSESSMENT OF PROGRAM EFFECTIVENESS

When SUCCEED began in 1992, only two of the eight member schools had instructional development programs specifically targeted to engineering faculty. Two other institutions had campus-wide teaching centers, but engineering faculty participation in center activities was generally negligible. Although no participation data were collected at that time, anecdotal evidence suggests that well below 10% of the combined coalition engineering faculty had participated in any faculty development activities and far fewer were using (or even knew about) such non-traditional instructional methods as active and cooperative learning.

In 1997, when the focus of the coalition shifted from innovation to dissemination and institutionalization, the challenge arose of assessing the effectiveness of the programs that had been offered in the previous five years and that would be offered in the next five. In a survey of faculty development program evaluation practices, Chism and Szabó [9] observe that the assessments reported by the survey respondents had one or more of three goals: (1) ascertaining participant satisfaction with FD programs, (2) judging the impact of FD programs on the teaching of the participants, and (3) discovering whether the programs had an impact on students' learning. Assessment of participant satisfaction using written rating forms or (much less often) interviews was by far the most common practice. Assessing the impact of FD programs on teaching practices was much less common, and direct assessment of impact on learning was virtually never done. Explaining the last observation, survey respondents noted the high cost and difficulty (or, in the opinion of many of them, impossibility) of obtaining meaningful data conclusively linking improvements in learning to changes in teaching practices.

Participation satisfaction surveys are routinely collected for all SUCCEED programs, but with very few exceptions they all indicate a high level of satisfaction and provide little useful information about the impact of the programs on teaching and learning, and direct assessment of program impact on students' learning was ruled out for the reason given above. The second of the stated goals—determination of the impact of FD programs on faculty teaching practices—was therefore adopted as the basis of the SUCCEED program assessment effort.

The FD program directors worked with the SUCCEED program assessment team to construct an e-mail survey to be administered to the active engineering faculty at all eight coalition institutions. The respondents were asked about their involvement in faculty development programs and the frequency with which they used various teaching techniques emphasized in coalition workshops. The survey was first administered late in

1997 and a modified version was administered late in 1999.

The 1999 survey was sent by e-mail to 1,621 faculty e-mail addresses, and a follow-up survey was sent a month later to non-respondents. After blank surveys and duplicates were eliminated from the returns, 586 valid and usable surveys remained, a return rate of 36%. Of those, 75 were excluded from most analyses (except for demographic summaries), because the respondent had not taught undergraduates in the prior three years and the survey administrators wanted the results to reflect current teaching practices. The demographic profile of the respondents closely matched that of the full faculty with respect to sex, rank, position, engineering discipline, and participation in SUCCEED-sponsored activities. (The last of these claims is supported by independent participation data.)

A report of the survey results is given by Brawner *et al.* [10] and summarized below.

- *Participation in faculty development activities:* 82% of the respondents reported attending one or more teaching workshops on their campuses, 64% attended a meeting or brown-bag lunch dealing with teaching, 62% consulted books, 59% consulted a newsletter or a web site, 40% observed a videotape, 35% participated in a mentoring program, and 13% worked with a teaching consultant.
- *Use of active learning:* 60% assigned small group exercises for brief intervals in their classes, with 22% doing so once a week or more, and 37% used active learning for most of a class period, with 8% doing so once a week or more.
- *Use of team-based learning:* 73% gave assignments on which students had the option of working in teams, with 35% doing so weekly or more often; 54% gave assignments on which teams were required, with 16% doing so weekly or more often; and 82% reported assigning a major team project in some or all of the courses they taught.
- *Writing instructional objectives:* 65% reported usually or always writing formal instructional objectives for their courses.
- *Giving writing assignments:* 88% gave writing assignments in their engineering classes, with 21% doing so weekly or more often.

The reported frequencies of use of these techniques were higher than those reported in 1997, although the differences were generally not statistically significant; however, 1997 was SUCCEED's fifth year, and most of the faculty likely to adopt non-traditional methods would have already done so. There is no doubt that the techniques were used far more widely in both 1997 and 1999 than they were when SUCCEED began in 1992.

The most telling evidence of the impact of the faculty development programs is provided by responses to questions asking about instructional methods the respondents had adopted as a consequence of attending teaching workshops, seminars, or conferences. Of roughly 500 respondents to these questions, 59% reported that they either began or increased their use of active learning, 43% wrote instructional objectives, 43% used team-based learning, 28% provided study guides before tests, and 18% participated in a mentoring program. When asked how the changes they made affected their students' learning, 69% of the respondents reported improvements, 6% said that they could see no improvement, and 25% indicated that they had not made any changes.

For a more detailed summary and discussion of the survey results, see Brawner *et al.* [10].

DISCUSSION AND CONCLUSIONS

We believe that several factors have contributed to the success of the SUCCEED faculty development program. We offer them as suggestions to faculty developers seeking to involve engineering faculty and faculty in the sciences (who have much in common with the engineers) in their programs. For the sake of brevity, we will use the term 'engineers' to denote faculty members in all technical disciplines.

Emphasize disciplinary relevance in FD programs. Perceived relevance is perhaps the single most important feature of faculty development programs that induces engineers to sign up for them and to take them seriously. In workshops and seminars, include discipline-specific examples of recommended teaching strategies. If the presentation has indeed been tailored to the needs of the targeted audience, be explicit about it in promotional materials. Engineers are most likely to come to a workshop with an open mind if they believe that the presenters are aware of their specific needs and problems and plan to address them.

Keep it practical. The second most critical characteristic of successful engineering FD programs is their perceived practicality. Most engineers who attend teaching workshops are not seeking philosophical discussions about the nature of learning; they just want to know what they can do next Monday to make their classes work better. Some material from educational and cognitive psychology (especially research data) is essential, but it should be brought in to support the practical ideas that constitute the bulk of the workshop rather than being an end in itself.

Include both disciplinary and pedagogical expertise on workshop facilitation teams. A workshop co-facilitator with an engineering background can easily construct practical examples and exercises with technical content. For example, one of the authors (RB) has a background in education and the other (RF) is from chemical engineering. Many engineering faculty members who come to our workshops do so because they know that one of the facilitators is one of them, and that one goes out of his way to reinforce that notion early in the workshop, injecting terms like 'partial differential equations' and 'entropy' whenever he can shoehorn them into the discussion. Once the participants hear those magic words, they tend to be more willing to listen to what both presenters have to say.

Cite the research. Most engineers are 'thinkers' on the Myers-Briggs Type Indicator, tending to make decisions based on facts, logic, and hard evidence. The methods recommended in most teaching workshops have solid theoretical foundations and are supported by extensive empirical research, much of it in science, mathematics, engineering, and technology [11, 12]. Workshop handouts should include summaries of relevant research results and references for those who wish to check the research for themselves.

Avoid appearing prescriptive, dogmatic, or evangelical. While making it clear that the recommended methods have solid evidence to back them up, the presenters should not imply that they are providing a recipe for the only acceptable way to teach. Most professors resent being told that most of what they have been doing in their classes is wrong and that they must either do it differently or accept that they are bad teachers. Rather, they should be encouraged to take a gradual approach, trying one or two new techniques at a time rather than trying to do everything at once, taking small steps, and avoiding methods with which they feel seriously uncomfortable.

Practice what you preach! Participants are acutely conscious of whether or not presenters do what they are recommending. If a recommendation is to write instructional objectives for courses, a set of objectives should be presented for the workshop. If the importance of presenting information visually rather than relying entirely on words is emphasized, the workshop presentation graphics should look professional. If active learning is advocated, the workshop should include a large number of group exercises of different types.

Faculty development programs are like college courses, in that one can do the same thing in two successive offerings and it will work well one time and fall flat the next. Faculty are also like students: no matter what is done in a workshop, someone may not like it. We therefore offer no guarantees of success if the above suggestions are adopted. We only say that, based on our experience, adopting them should significantly increase the chances of presenting a faculty development program that is both attractive and persuasive to a broad spectrum of the campus engineering faculty.

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