



9.5 EDUCATION PROGRAM MANAGEMENT

Multi-institution Engineering Research Centers face special challenges in organizing, planning, and administering their education programs. Despite the added complexity, however, a multi-institution Center offers many unique benefits, including opportunities for students to take a wider variety of courses or work on research in more than one university. These students can be exposed to a broader spectrum of research.

9.5.1 Challenges

A fundamental challenge that ERC Education Directors need to address at the outset of the Center is determining the best organizational structure for implementing the multi-campus education program. Early on, the Center management team holds strategic planning sessions to determine the mission and goals for their education program. They then develop a plan, staffing, schedule, and budget to accomplish these goals. Issues to be addressed include:

- What resources (faculty, staff, and infrastructure) are available on different campuses?
- How can multi-campus education committees best be formed?
- Who should be on the committees?
- Will administrative staff be available on each campus?
- Will management of the education program be centralized or distributed?
- Will inter-institutional agreements be necessary?

As a multi-campus Center begins offering education and outreach programs, such as a Research Experience for Undergraduates (REU), Research Experience for Teachers (RET), outreach programs for precollege teachers and students, Student Leadership Councils (SLC), student exchanges and seminars, the best ways to administer these programs will need to be determined. Questions such as these must be addressed:

- Which campuses will participate?
- Who will coordinate each of these efforts?
- What resources are available?
- How will recruiting for the outreach programs be coordinated?
- Which principal investigators will host students and teachers?
- Where will seminars be held?
- How will communication between participants on the different campuses be facilitated?
- How can video, teleconferences, and the web be best used to promote communication?

As the multi-campus Center develops new courses, course materials, certificates, and degree programs, ways for students on all Center campuses to take advantage of these offerings will need to be arranged. Inter-institutional agreements on credits and fees may require authorization. Mechanisms to offer distance and web courses as well as jointly taught courses may need to be developed.

Similarly, offering multi-institutional continuing education short courses to industry presents challenges. Short courses may be offered either for degree credit or continuing education units (CEU). Mechanisms for receiving credit at different schools and sharing revenues need to be worked out. With Industrial Advisory Board (IAB) input, course topics and instructors will need to be established, as well as mechanisms for delivery (short course, web, or distance course). Finally, the sponsoring university(s) needs to be ascertained. Alternatively, a Center can offer a non-credit short course without any sponsoring university. Subcontracts may be needed to pay speakers, and mechanisms for sharing advertising and administrative costs will need to be determined.

For the secondary-school level and community outreach, strategies for instituting partnerships with schools and organizations in the different communities need to be developed. For example, Center staff can partner with other outreach programs at their university; professional organizations offering precollege outreach, or member-company outreach efforts in various communities. Decisions will need to be made about which campuses can best initiate outreach programs, administer funds,



coordinate activities, and provide oversight. For recruiting purposes, partnerships with various minority-serving institutions in different locations can help the Center achieve diversity goals. Here again, decisions about which Center universities, and who at each university, will initiate these partnerships will need to be made.

The following sections will discuss in more detail the challenges and opportunities for multi-institution Centers in:

- organizational structure and strategic planning (5.2)
- developing new curriculum, degrees, and certificates (5.3)
- managing special programs for students (5.4)
- outreach to industry (5.5)
- facilitating collaborations and partnerships with schools and community organizations (5.6).

Each section will also summarize some of the lessons learned in developing multi-institution ERC education programs and illustrate the best practices using case studies.

9.5.2 Organizational Structures and Strategic Planning: Education Director's Role

9.5.2.1 *Central vs. Distributed Management*

It is important to build a network of communication and an atmosphere of cooperation among participating faculty and universities to address the Center's research and education missions. A common understanding of respective academic procedures must be built so that obstacles to carrying out specific Center-based educational activities can be minimized. This is particularly true for curriculum development activities, which may require departmental approval for a program created by non-host institution faculty. These issues can arise even within a university, if a Center wishes to implement cross-disciplinary courses or modules involving other than engineering disciplines. Regardless of these barriers, inter-institutional, cross-disciplinary knowledge and technology transfer remain a significant element of the National Science Foundation's mission for the ERC program. It is important for Education Directors to involve their Center Directors in exploring avenues to successfully address these issues.

Finding an ideal approach to surmount administrative obstacles can be very time-consuming and may result in an undesirable lag in transferring timely and valuable knowledge derived from research endeavors to students and other potential end-users. If such delays appear likely, it may be that this knowledge can be more effectively communicated by integrating it into existing credit-bearing courses, with CEUs or independent study programs as alternative solutions. It is important to maintain a robust interface between research, education, and the end-user community.

The Education Director may well serve the Center's interests by working with each institution to learn about the structure of course administration, so as to better understand which issues might keep ERC education exchanges between universities from becoming a reality. As educational products are developed, these constraints and ways to address them may be kept at the forefront of consideration.

Remote learning opportunities also have burgeoned in the past decade, making access increasingly easy, affordable, and convenient, and bypassing some of the usual institutional constraints. At the same time, these efforts require oversight and maintenance and must address necessary education standards (whether academic or professional), if credits of any kind are to be awarded. Furthermore, credits earned through online learning programs are not always given equal weight within the discipline or profession.

Overall, it is necessary for the Center Director and Education Director to establish leading guidance and give encouragement to program advocates at each participating university. Without this advocacy and support, extra-institutional commitment to Center-wide programs is not likely to occur and outcomes are less likely to be realized. A Center-based Education Director (with support of the Center Director) can be an important catalyst by establishing proposed activities, budget limits, desired outcomes, and standards, which can be endorsed and promoted to the other institutional participants. The Center Director can provide further incentive by emphasizing to faculty the relative weight of education within the overall Center program. Willingness to advance the education objectives of the Center will then be viewed as having a bearing on funding decisions regarding individual investigators.

On an administrative level, it can be very difficult to extend financial support to other institutions in a timely way, including



student stipends, travel funds, etc. This can be an impediment to accomplishing desired tasks, and is an area where Centers can learn and benefit from each others' experiences to improve the funds-exchange mechanisms. For multi-institution Centers, relinquishing funds to other institutions may mean losing control over use of those funds, selection of activities, recruitment of students, etc. In spite of bureaucratic headaches associated with Center management of distributed education funds, it does allow the Center to remain true to its objectives and standards. Center representation at major education functions should involve all participating institutions, yet should always reflect the central vision and leadership.

9.5.2.2 Negotiating Inter-institutional Agreements

Formalized agreements allow Centers to predetermine desired educational goals and outcomes. It may be very difficult for institutions to agree to exchange curricular products as a requirement of their subcontracting agreement. Institutional agreements may instead take the form of something less legally binding, while still demonstrating a mutual agreement between institutions to work toward a common education agenda. A memorandum of understanding may help to achieve this, with clearly stated goals, desired outcomes, and timetable for execution

9.5.2.3 Forming and Using Multi-campus Committees

Some Centers have established multi-institutional committees to direct and achieve their education goals. Often, teaching, research, departmental obligations, and other functions interfere with the faculty participants' dedication to the multi-campus committee activities. It is often necessary for involved faculty to seek released time or other benefits from their institution to devote sufficient time to education committee activities. This will bring an added benefit to the Center, however, as a demonstration of cost sharing.

It is also extremely important for the faculty members to be able to devote their efforts on behalf of the Center, over and above their own individual professional efforts. There must be an exhibited level of commitment to the education vision and mission for this participation to be of optimum value to the Center's education program. In addition, for multi-campus committees, there must be regular interaction (monthly, at minimum) to assure continuity of communication. This is essential to sustain momentum of the activities planned, particularly in view of the continual turnover of participating students and changing demands on faculty. The latter is particularly true for tenure-track faculty.

Rotation of committee members helps infuse enthusiasm. Retaining some long-term members helps to assure that momentum is maintained. The ability of committee members to rely on administrative support and assistance from Center headquarters is also helpful.

If these difficulties can be overcome, a multi-institutional education committee can truly enrich the education experience for those involved. Institutional support and faculty commitment are necessary ingredients in the success of this framework.

9.5.2.4 Setting Program Goals and Objectives

Center program goals are based on the leadership team's determination of its vision and mission, its anticipated outcomes, and the resources (both human and financial) at its disposal. Both goals and objectives need to be shared with all faculty and NSF Program Officers, iterating the process until general consensus is reached on future activities.

9.5.2.5 Allocating Resources

The Center must have clearly defined education activities, objectives, and outcomes when allocating resources. For a multi-institutional activity, the Center must give extensive consideration to fiscal regulations and procedures at its institutions. Unexpected indirect cost recovery, misallocation of costs incurred, and other fees associated with administrative management or education program conduct (e.g., charges for facilities for video/tele/communication activities) can place an unexpected drain on Center funds. A yearly plan that outlines desired activities, costed out at participating institutions, can help to anticipate financial difficulties. While there will always be unanticipated costs, it is incumbent on education leadership to develop an understanding of probable costs and operational issues that may impact the conduct of the program.

Funding of students for special activities such as conferences and study tours is best decided based on a predetermined level of academic standards and expectations. The Center should try to encourage participating institutions to have input into setting benchmarks for spending on various activities, with ultimate decisions to be made by the Center Director and the Education Director.



9.5.2.6 Identify Center Activities

Center-sponsored courses and outreach activities all need to be clearly marked with the Center logo and attributed to the Center, as well as to each of the participating universities. Any press releases issued should also clearly identify the activities as Center sponsored.

CASE STUDY: Multi-institutional Education Committees. *The education program at the Pacific Earthquake Engineering Research (PEER) Center is designed to introduce, stimulate, cultivate, and educate undergraduate and graduate students with the knowledge that will enable them to contribute to the earthquake engineering profession from a variety of disciplines and perspectives. PEER's Education Committee, comprised of representatives from all 18 core and affiliated universities, is charged with the planning and implementation of the Education Program.*

9.5.3 Developing New Course Curricula and Degrees

Development of new curricula, degree, and certificate programs may be a key output for an ERC, and one of the means by which a Center creates a legacy. Examining core research area curricula, during the proposal and early award, will establish baseline information for the Center's operations and identify strategic planning issues that may be important to intercampus collaboration. This section provides ideas and recommendations for developing new courses; for creating new programs out of these new courses; and for implementing, tracking, and disseminating information relative to this component of the Center's work. Subsections include specific examples pertaining to distance learning, web courses, team teaching, and inter-institution agreements relating to these.

New course development in a Center is a single variable within the larger context of curriculum development, course revision, new course module development, and new program development. Innovations and modifications within individual curricula also provide Centers with a means of addressing their goals within the ERC, such as: promoting visibility of key disciplines within undergraduate and secondary school communities; providing critical resources for industry; and building interdisciplinary bridges within a department and college structures of a university. In addition, multi-campus Centers are organized in order to bring together institutions with diverse strengths, often pairing programs with long histories of contributions to core disciplines and technologies with emerging programs. Consequently, the very organizational structure of the ERC may dictate that the approach to curricular issues be considered at both a campus level and a Center level. Therefore, early consideration of the following key questions should prove useful in the strategic planning phase of education program development.

1. Creating a common frame of reference for existing courses:

- Which courses at each institution form the support structure for the core and associated research areas? Create a reference document with appropriate supporting material that aggregates this information for all partner campuses.
- Among these courses, which ones are suitable for intercampus cross-listing for student exchange and distance learning purposes?
- Among these courses, which are currently in distance format? This information should be publicly accessible to students and industry. Course descriptions, registration, deadlines, and contact information should be posted on the Center's web site and updated regularly.

2. Planning curriculum development:

- Based on the Center's research goals and areas of expertise, which courses should receive the highest priority for conversion to distance format? Based on the evolution of the Center's research program over time, research advances in the field, and emerging areas of expertise, this question should be revisited throughout the ERC award period and the strategic plan modified as appropriate.
- What new courses should result from the Center's core research mission and areas of expertise?
- Which existing courses should be modified to include the ERC's latest research results?
- Will the creation of new textbooks (or chapters for existing textbooks) be a priority for the education program development effort? To what extent will this reflect the multi-institutional nature of the research effort?
- Will curricular development extend to the precollege level? If so, have appropriate relationships been established with



precollege teachers and other STEM (science, technology, engineering, and mathematics) educators and experts? Will test beds or pilot programs be developed as part of this effort?

3. *Developing new courses within the framework of ERC goals:*

- How does new course development reflect the interdisciplinary nature of the ERC's research?
- How are courses distributed across undergraduate and graduate levels, both within individual institutions and within the Center as a whole? How will new course development support both the need to involve more undergraduates in the Center's core research area and the needs of graduate students who will be working in emerging, interdisciplinary, or nontraditional research areas?
- Will new course modules be developed in support of the ERC's student recruitment and information dissemination priorities? If so, who is the target audience, which concepts are key for presentation, and at what academic levels should they be presented? Which campuses are best suited to undertake the development work? How will this information be disseminated?
- What resources will be needed to support new course development and implementation? What resources will be allocated through the Center's core award for these efforts? How will funding decisions be made? What external sources can be sought for support of these initiatives? To what extent do new courses depend on new facilities/infrastructure within the Center?
- How will the needs of the Center's industrial collaboration program be served through course development? How will needs in this area be determined and addressed?
- How can the collaborative nature of the ERC's research program, as well as the expertise of key faculty and thrust leaders, be cultivated through its education program? Will courses team taught by faculty across partner campuses be a goal?

4. *Addressing the needs of each core partner institution:*

- Do any of the Center's core partner institutions lack key courses that are needed for them to become fully engaged in the research effort? If so, how will this be addressed?
- When reviewing the Center's core curricula from an intercampus perspective, are any course articulation issues apparent? If so, how will these issues be addressed for successful implementation of distance learning and exchange programs?

5. *Repurposing materials to serve constituents:*

- How will the products of curriculum development efforts (courses, modules, etc.) be leveraged? Can sections of new courses be retooled and restructured to form new short courses for industry? Will new course modules be implemented across campuses? Should existing modules be retooled for implementation in different courses?

6. *Developing new programs:*

- How should new and planned courses aggregate to form new programs for options, certificates, and degree programs as well as short courses and workshops?
- How will new certificate, option, and degree programs be distributed across academic levels and Center constituents (precollege, undergraduate, graduate, postdoctoral, and industry)?
- What buy-in is needed from departments, colleges, and universities as well as committees (research area, distance learning, graduate, undergraduate, curriculum) located within these administrative structures? For undergraduate engineering courses, how will these courses address ABET requirements?

7. *Implementing new courses and programs:*

- How will new courses and programs be implemented and disseminated? Who will be responsible for each of these tasks?
- How will new course materials be shared throughout the Center's partner institutions? How will this information be shared outside the ERCs? What format will the shared materials take?



- How will the policies and procedures necessary for the sharing of curriculum-based resources across campuses be developed, approved, and implemented?
- What will be the long-term impact of this education program development and how can it be quantified? How will progress be measured relative to the strategic plan? How will success be measured?
- If a program is to be implemented across campuses, must it take the same form at each institution?
- How will the education program leadership ensure that education program results are disseminated through conferences and journal publications?

The Education Director, in consultation with an intercampus Education Committee, should consider the above questions early in the award period. Since curriculum development is linked with the Center's research focus and reflects its interdisciplinary and multi-institutional nature, it is important that the Education Director and the Education Committee reflect this reality throughout its membership and functions.

It is important to note that the success of curriculum development initiatives depends upon a certain level of buy-in from various constituencies within departments, colleges, and universities. In the case of interdisciplinary course and program development, bridges must be built beyond the level of the individual faculty member and articulation among various degree programs (relative to courses and their prerequisites, as well as degree requirements) may also be warranted. For this reason, the Education Director (or other education program representative) must be prepared to devote a significant level of effort to communication, discussion, and strategic planning with these groups. It is essential to ensure that the education program at each campus includes both the faculty and support personnel necessary to advance the Center's efforts, and to maintain and promote new courses and programs once they have been developed. Often, administrators at partner campuses can assist with this function.

Departments often include support personnel such as undergraduate and graduate academic advising staff, outreach coordinators, and/or enrollment services coordinators. Such offices routinely receive feedback from students that can be helpful in strategic planning relative to curriculum. These offices can also help raise student awareness about these new programs.

It is important to recognize that throughout the life of the ERC, curriculum development initiatives and the Education Strategic Plan as a whole are living documents that are influenced by a variety of factors. For example, through the NSF Site Visit, industry and student SWOT processes, additional opportunities and priorities may be identified. Similarly, initiatives such as certificate, concentration, and degree programs established early in the Center's life cycle must be reviewed and updated at regular intervals to include new and modified courses that are developed under Center leadership. An Education Director of a multi-institution ERC can assist in this process by monitoring administrative changes and progress at all campuses at regular intervals and soliciting assistance from campus administrators to follow up on key issues.

It is important to keep the faculty involved in the education program in general and in curriculum development initiatives in particular. It is useful to solicit input directly from research thrust leaders and other key researchers within the Center at regular intervals to discuss progress vs. plans, strategic planning for out-years of the award, and response to SWOT issues. In this way, barriers can be identified and addressed early in the process, and in an environment that takes advantage of relevant multi-campus expertise issues.

CASE STUDY: *At the Center for Power Electronics Systems, a Research Retreat is held on an annual basis for the purposes of long-term strategic planning. Each year, one afternoon and/or evening of the Research Retreat is reserved for an Education and Outreach Program Retreat to which all of the Center's research investigators are invited. This meeting has proved a useful forum for reviewing the work of the Education Committee and soliciting input relative to key implementation issues.*

9.5.3.1 Issues in Offering Distance Learning and Web Courses

Distance learning can serve as an important tool for dissemination of Center expertise and resources to partner institutions, to entities external to the core partners, and to industry. Successful implementation of distance learning programs within the context of an ERC depends upon the degree to which courses have been integrated across campuses and the extent to which students view this knowledge as essential to the research that they are conducting within the Center. It is important to understand the distance-learning component of the Center's education program within the context of its research mission, and as a resource for emerging programs within its consortium. Further, it is important to identify and prioritize courses to be converted to distance format as a part of new course-development strategic planning.

Since distance learning programs often are institutionalized through departmental and/or college committees, outreach program



offices, or special initiatives offices, it is necessary to determine how decisions related to distance learning courses are made within each partner university, how new course development is prioritized within departments and colleges, how resources are allocated, and who will provide leadership within the committee structure of each university in order to champion the Center's programs and objectives.

In some cases, the Education Director or Coordinator may be responsible for organizing intercampus student input relative to the distance learning course development plan, distance delivery modes, and learning objectives. The Education Director or Coordinator may also play a role in coordinating logistics for distance learning courses that involve team teaching across institutions.

Intercampus agreements supporting the distance-learning component of the education program should address issues of registration, advising, required approvals, information dissemination, grade assignments, costs, and credits. Depending upon the nature of individual distance learning programs, some partner campuses may rely more heavily on distance access of courses than others. If this is an underlying issue for an education program, the associated cost considerations should be addressed as part of the Center's cooperative agreement.

CASE STUDIES:

Using Distance Learning as a Tool for New Course Development. During a strategic planning meeting at the Center for Power Electronics Systems (CPES), it was discovered that one of the partner campuses lacked a key element within its curriculum. The absence of this course was a barrier to full engagement of that partner institution in the Center's research program. A course that addressed this need was identified within the curriculum of the lead institution. Center resources were then devoted to converting this course to distance format, which was then offered exclusively to students at the partner institution. Office hours were also conducted through distance delivery by graduate student mentors at the lead institution. The following year, the faculty responsible for this course at the lead institution shared all course materials, including lecture notes, projects, and homework assignments, with a faculty member at the partner institution. Videos furnished by the lead institution were then used as the basis for offering the lecture component of the course, while recitation sessions were conducted by faculty at the partner institution. During the third year the course was offered, it was customized to better resonate with the curriculum of the partner campus. The course was then conducted entirely on site at the partner institution, after having been approved as a permanent part of the curriculum. This course development, while not originally a part of the Center's curriculum development plan, had an immediate positive impact on the number of students pursuing power electronics at the undergraduate and graduate levels, and led to increased involvement of the partner campus in the Center's research and academic exchange programs.

Multi-institution Course Credit Agreements. CPES has established two cooperative agreements that support intercampus collaboration in the Educational Outreach program area. During Year One of the ERC award, CPES established a core course listing in the areas of power electronics, packaging, and systems design and integration. At present, more than 80 power electronics and related courses are available through CPES partner campuses, with credits for these classes accepted by each student's home institution. Twenty-seven of these courses are offered for distance registration. In order to facilitate intercampus course registration, CPES established a Cooperative Agreement for the Distance Access of Courses. This document, signed by officials of each ERC partner institution, establishes a set of common policies and procedures for cross-registration including billing for tuition and fees, payment of incremental costs, recordkeeping, registration, and the terms of distance delivery. The Cooperative Agreement for Exchange of Graduate Students allows Center students access to the portions of the core curriculum that are not offered by distance delivery, while also providing them access to the research facilities at each of the partner institutions. The goal of this agreement is to exploit the diverse technical strengths of each of the Center universities by developing uniform policies and procedures regarding student exchange among the core partner institutions. As part of this agreement, CPES partner universities established policies pertaining to tuition, billing, registration, course curriculum, and reporting of annual statistics to NSF.

9.5.3.2 Team Teaching Courses in a Multi-Institutional Environment

While distance learning courses shared among campuses can be a useful mechanism for creating synergy within the Center, many are often taught by a single instructor. Multi-institution ERCs provide significant opportunities to expand this model of sharing expertise across institutional boundaries. In some Centers, significant benefits have been derived from introducing team teaching into the ERC's strategic plan for new course development. Models may include new courses, which cross the boundaries of a single departmental and/or discipline; or new courses, taught in distance format, which involve instructors at one or more partner institutions. In the latter case, the Education Director or Coordinator may play a significant role in coordinating the planning, development, and implementation of these courses, and in soliciting feedback in a multi-



institutional format.

CASE STUDY: Team Teaching as a Method of Disseminating the ERC Research Vision. The course Power Electronics System Integration (PESI) is team taught by professors at all CPES campuses, and serves students at each of the five partner campuses. This one-credit seminar course is required for all Center students. The course serves to communicate and reinforce the Center's research vision to upper-level undergraduate and new graduate students. This course involves lectures and intercampus discussion sessions related to the Center vision and each research thrust area. Lectures include introductions to new research foci and breakthroughs, and linkages among CPES research thrust areas. All course materials are freely available on the Center's web site and are revised annually to reflect new research developments as well as the evolution of the Center's research program.

9.5.4 Cross-institutional Student Opportunities and Organizations

Students in a multi-institution ERC have a somewhat different experience than students in a single-university ERC. For example, the Student Leadership Council at a multi-institution ERC often is composed of students from all of the universities, and students have the opportunity to participate in exchanges with partner institutions. Students are exposed to partner university faculty through distance learning and team teaching, so students graduating from one partner university often go to another partner because they are known and the institutions have similar academic and research foci. The programs and events of the ERC—education, research, symposia, and Site Visit—bring the students from the partner universities in contact with other students, professors, industry professionals, and NSF professionals. The SLC needs a budget to carry out its duties.

9.5.4.1 Multi-institutional Student Internships and Student Exchange Programs

Internships can be very valuable. A central coordinator and budget manager with administrative contacts at participating institutions can help make the educational experience shine. Grant administration of funds to support student internships and exchanges at multiple institutions may vary widely. While a stipend might work at one institution, it might be unacceptable at another. The Education Coordinator needs to explore a wide range of mechanisms that can be employed to support student exchange programs and ensure their success.

9.5.4.2 Multi-institutional Student Leadership Council (SLC)

Students at multi-institution ERCs meet and interact with their peers from partner institutions periodically throughout the year. These meetings may coincide with other ERC activities, such as an annual research colloquium, site visits, the NSF Annual Meeting, etc. Prominent annual technical meetings associated with the field also offer opportunities for the students to meet and work together. Videoconferencing is also very popular, as are web-based communication tools such as Net Meeting. An accurate and up-to-date e-mail listserve helps to mediate communication issues that can arise because of geographical separation. Newsletters and SLC websites also provide a forum for participants.

Recruiting students into the SLC can be problematic. It is imperative that, in addition to the Education Director, an enthusiastic faculty member at each institution champion student participation in the SLC.

9.5.4.3 Recruiting Across Partner Institutions

Regular interaction among members of the Center research teams is instrumental in promoting involvement and recognition of participating students. This may open doors for students to seek professional opportunities at other Center-affiliated institutions. Center management should encourage this exchange, particularly for the matriculating student.

CASE STUDIES:

SLC Exchange Program. As a five-university research Center, CPES has been challenged to develop innovative programs supporting a culture of exchange among faculty and students. CPES students have identified novel approaches to traditional programs in order to achieve this goal. In 2002, CPES established Research Experiences for Undergraduates (REU) programs at Virginia Tech (VT) and the University of Puerto Rico-Mayagüez (UPRM). This program complements an existing student-developed initiative to provide short-term exchange opportunities to undergraduate and graduate students interested in performing collaborative work in power electronics. Through the short-term exchange program, CPES is able to invite graduate students for a parallel eight-week summer research experience. During the past two years, CPES has hosted REU and graduate exchange students from the same



home campuses, providing undergraduate students who are new to CPES and power electronics with experienced mentors from their home campus as well as the VT campus. The pairing of these two programs has also allowed the Center to maintain closer contact with program participants over time, and has provided opportunities to create a support system for participating students to continue their research after they return to their home campus. Summer exchange students are encouraged to continue their collaboration with host institutions by completing follow-on work through short-term exchange experiences throughout the academic year. Students who have completed undergraduate research exchanges are welcomed back as graduate student mentors in subsequent years. In some cases, students who have been recruited by the host institution for advanced degree work serve as mentors for undergraduates from their former institution. CPES sponsors more than 30 short-term exchanges annually, more than half of which involve underrepresented Hispanic or African-American students.

Weekly Research Teleseminars. The ERC for Environmentally Benign Semiconductor Manufacturing uses weekly teleseminars to update students, PIs, and industrial partners on the current progress of research projects. These teleseminars are an effective tool used to give industry members access to research developments as they occur. The seminars follow a simple but effective format: Visual presentation materials are posted weekly on the Center's website for download in advance. This gives all participants the opportunity to view the presentation materials in advance. At the time of the presentation, Center members, industrial advisors, PIs, and students dial in to the teleconference from their desks or conference rooms. In a typical one-hour teleconference presentation, a short discussion on one of the active research projects is presented. Instant feedback is obtained from the industry partners and other Center researchers, and all are kept abreast of the status of current research activities. This series is very well received and is an excellent tool for rapid information dissemination to industrial mentors and advisory boards. It is also an excellent means of communication within the Center. Students are involved in the teleconferences. They are given the opportunity to invite and coordinate speakers, present research results, and lead discussions on specific activities, as well as hear the results of the Center's research. This same teleconference format has been used for discussion of other ERC activities and Center-wide planning and discussions. Typically, 40 to 45 teleseminars are held annually.

Multi-Campus REUs. Because their REU students were located at multiple institutions, the Earthquake ERCs—the Mid-America Earthquake (MAE) Center, the PacificEarthquakeEngineeringCenter (PEER), and theMultidisciplinaryCenter for Earthquake Engineering Research (MCEER)—initially encountered some challenges in implementing REU programs. They have since overcome those difficulties and even learned to cooperate among themselves very successfully in this area. The ready availability of videoconferencing has been very helpful in this regard, along with a multi-Center REU symposium at the end of the summer. Some of the REU activities have led to closer collaboration between graduate students and faculty members. Since their inception, the three ERCs have had many such tri-center projects. While each Center has an REU on its diversified campuses, there is a combined REU symposium for all participants. The three Centers take turns in putting this on. The Centers develop and then share graduate teaching modules on specialized subjects.

- **Networking Multi-institution Centers.** Researchers at MCEER, at the University of Buffalo, are leading the initiative to create an electronic network linking its diverse experimental facilities. The object is to overcome geographic limitations and leverage the existing capabilities to share experimental and advanced computational resources and data. The establishment of the network requires developing new procedures and methods, adapting and integrating existing technologies, and developing new methods of communication, storage, and interpretation.
- **Graduate Student Exchange Program.** Virginia Tech's CPES students majoring in electrical engineering may attend classes at all five CPES universities, with credits for classes accepted by each student's home institution. The goal of this program is to provide students with a broader background and allow them to take courses not offered at their home institution. It is designed to maximize interactions among graduate students, provide opportunities for students to experience different learning environments, and expose masters-level students from one of the campuses to the possibilities of pursuing a PhD at another campus. It has been necessary to devise collaborative agreements to set forth the policies and procedures governing cross-university programs and student exchanges.

Joint ERC Student Activity: In 2002, PEER initiated a tri-center Earthquake Field Study program. Four graduate research assistants from each Center plus four non-Center graduate students (selected by professional earthquake engineering organizations) compete to spend ten days visiting a recent earthquake site in order to engage in a hands-on field assessment exercise. Each Center may send one advisor to accompany the student team. Funds to cover round-trip travel, participation in the week-long field trip, food, and lodging are provided and industry fellowships are encouraged.



In October 2003, thirteen graduate students, two professors, and a staff member traveled to Italy for a week-long study and tour of earthquake laboratories and field sites. The students were sponsored by the three earthquake centers: MCEER, PEER, and the MAECenter. The mission was organized by MCEER. The trip began with visits to laboratories in the area surrounding Milan. Site visits included the Joint Research Centre's European Laboratory for Structural Assessment (ELSA) at Ispra, University of Pavia, University of Rome, La Sapienza, University of L'Aquila, the devastated village of San Giuliano di Puglia, and Naples.

After their return to the U.S., the students were asked to make at least two presentations during 2003-04 based on what they learned during the trip. One presentation was directed at students or adults without an academic background in engineering or earthquakes—for example, upper-grade high school students or lower-division undergraduate students. The second presentation was a technical seminar for graduate students and professors at the earthquake Centers.

9.5.5 Outreach to Industry

Offering multi-institutional Continuing Education Unit short courses for industry can be challenging. The focus of initial planning is on prospective topics and industrial interest (with IAB input, possibly through a market survey), potential instructors, and mechanisms for delivery (short course, web, or distance course). The originating university(s) needs to be decided. Mechanisms for receiving credit at different schools (academic credit or CEUs) need to be arranged. Or a Center can simply offer a non-credit short course. Mechanisms for sharing advertising and administrative costs as well as formulas for sharing revenues may need to be determined. Procedures to pay the speakers both from industry and universities may need to be established.

9.5.5.1 Planning the Course

Certain questions can arise in the planning process: should the industrial courses be a push (i.e., the ERC wants to offer a course) or a pull (i.e., industry requests a course) activity? Are the administrative and financial resources available for planning and teaching a course? Will the Education Director and/or Coordinator plan the courses using Center administrative resources, or will the activity be decentralized to the course champions at different universities?

Determining course objectives and target markets is very important prior to offering any courses for industry. This may involve adopting a private-sector mentality rather than a traditional academic viewpoint. Market research through industrial members and advisors is key to offering successful industrial courses. A questionnaire distributed via the IAB with potential topics of interest for courses is a fairly easy mechanism used to gauge industrial interest. Industry should also be surveyed for preferences about location, cost, credit, and format.

If a live short course is offered, a venue that is convenient for the target market needs to be selected. It can be either on- or off-campus (e.g., in a hotel or conference center). That decision in turn may affect which university or universities sponsor the course, based on availability of resources and meeting facilities.

9.5.5.2 Choosing and Recruiting Course Instructors

Finding champions—professors and instructors—who want to offer courses geared toward industry interest (as expressed in a market survey) is key to success. Soliciting course ideas and topics from professors and industry instructors is good practice. At times, it may be necessary to recruit professors and/or IAB members to offer a topic requested by industry. But in general it will work better if the instructors are enthusiastic about the idea. It is good to have a mix of professors and industry instructors. The expertise and reputation of the instructors (marketability), their availability, and payment mechanisms need to be addressed. The instructors will need to be paid by the entities collecting the registration fees. It is important for the institutions collecting those fees to determine what financial mechanisms are available to pay the instructors. Subcontracts (as independent contractors) are usually best for industry speakers or professors from other universities, while supplemental compensation may work best for professors at the sponsoring university.

9.5.5.3 Choosing the Delivery Mechanism

The partners involved in offering the course (university and industry) will need to develop marketing materials and mailing lists. Partnering with industrial trade organizations to distribute marketing materials and course publicity is very effective. In



addition, targeted mailing lists can be purchased from commercial suppliers. A traditional rule of thumb is to expect a 1% return from a mailing list. If the course is offered via distance learning, the university distance learning departments are also key marketing partners.

For course delivery, it is ideal for a Center to have partners. Course books, meals, and breaks will need to be provided for short courses. Finding commercial partners to sponsor breaks or meals can be useful as long as advertising is restrained. For distance courses, mechanisms such as live or satellite video or streaming video can be a daunting challenge. Many ERCs offer distance-learning courses through their institutions' central distance learning or "industrial outreach" program offices, to help minimize such problems.

CASE STUDIES:

Non-credit Short Course. *The ERC for Environmentally Benign Semiconductor Manufacturing offered a successful non-credit short course on Chemical Mechanical Planarization (CMP). The course was offered by the Center with SEMATECH (a trade organization) and other industrial co-sponsors. An IAB member who was on sabbatical working at the Center was the driving force behind organizing five Center PIs from four universities to teach the course. The Center paid instructors' travel costs and honoraria. An initial planning meeting was held at the Center's annual retreat meeting, and planning continued via teleconferences. The Center education coordinator organized the course logistics. The Center compiled a mailing list with the help of its industrial members, and also worked with trade organizations in the San Francisco Bay area to publicize the course. In addition, the Center purchased a commercial mailing list and sent flyers to about 8,000 people in the semiconductor industry. The PI instructors also marketed the course through their contacts. Marketing efforts were successful in that 70 people attended the initial 1.5-day course, which was held in a hotel in Palo Alto in 1999. The majority of attendees were engineers or managers, with a significant number from sales. About 50% of the attendees were from the Bay area. The rest came from all over the US and as far away as Korea. This course was offered again in 2000 in Belgium, Japan, Taiwan, and California. For the second California course, the ERC partnered with a private training company, PTI Inc., to offer the course. The foreign courses had organizational partners and sponsors in those countries. Those sponsors handled the local logistics. These and three subsequent offerings of this course have been attended by a total of 280 people from more than 10 countries and representing 72 companies. More recently, the CMP course has been offered via streaming video and audio on the web, on-demand to enrolled industrial students via a commercial partner, Semizone.com (an affiliate of Stanford University's Center for Professional Development).*

Continuing Education Seminar Series. *The Mid-America Earthquake (MAE) Center offers educational programs to the earthquake hazard mitigation community, to emphasize products of the MAE Center's research and to build an audience of professionals in Mid-America interested in earthquake engineering and in the MAE Center's activities in particular. The Center's Continuing Education Advisory Committee identified a need for earthquake seminars with a regional concentration. Accordingly, the Center developed three series of seminars focused on earthquake hazard mitigation in Mid-America.*

Speakers were selected to match industry needs with the Center's areas of expertise, as well as representation from stakeholders and practitioners. Seminar locations were selected based on their close proximity to a large number of practicing engineers and engineering organizations that served as cosponsors. The seminars were advertised in cosponsor publications and mass mailings. CEUs were awarded to participants through the University of Illinois Office of Continuing Engineering Education. High-quality notebooks were produced that contained paper and CD copies of speaker presentations, research papers, and notes.

9.5.6 Collaboration and Partnerships (Outreach) with Schools and the Community

The first thing to remember about collaborations and partnerships is "don't reinvent the wheel." Find out what is currently available at each of your member institutions. Do they already have a K-12 component in place? What do they offer? Look at the community. Do you have science and technology museums that have outreach programs? What are the needs of the school systems in your area? What could you offer that might enhance their curriculum in the science and technology/engineering tracks? Diversity is a major issue for all Centers. What departments on your campus are addressing diversity? What minority-serving institutions nearby would mutually benefit from a partnership with your Center? Should your Center apply for a Louis Stokes Alliance for Minority Participation (LSAMP) supplement from NSF? These are all good questions to answer before developing your outreach programs.



9.5.6.1 How Education and Outreach Partners Add Value

Just as an interdisciplinary research team produces outstanding results, having partners and collaborators for your education and outreach components helps develop well-rounded and beneficial programs. Collaborations and partnerships should complement your Center's expertise. Identifying offices, programs, and organizations that complement your education and outreach goals is a place to start. Set up fact-finding meetings with these offices to determine if there are some mutual goals and if collaboration would be beneficial. After that first meeting, you may not feel there is a good match. There is no obligation to take it further. If, however, there are mutual goals, you can determine what all parties could bring to the table. Whereas your Center might bring the engineering component, your collaborators might bring the school systems, the particular age group you want to impact, an industry that uses your technology, etc. For example, The Center for Education Integrating Science, Math, and Computers (CEISMC) on the Georgia Tech campus has as its main focus outreach to the K-12 education community. They were the first office the Georgia Tech/Emory Center for the Engineering of Living Tissues (GTEC) contacted when beginning to plan for K-12 outreach. Not only does CEISMC know the needs of the various school systems in Atlanta, but they had an established teacher program that GTEC could tap into to enhance its Research Experiences for Teachers (RET) program. GTEC offered the research experience the teachers wanted and CEISMC offered the structure to turn the research into lesson plans. It has been a very productive and beneficial partnership.

Having a diverse group of students, faculty, and staff is a major focus for NSF and your Center. It is very important to make connections with offices on each of your campuses that provide assistance to underrepresented populations. Determine what programs are available. Is there a way you could tap into this resource? It is also very beneficial to establish a partnership with minority-serving institutions (MSI). It may be possible to develop a partnership with an MSI at each of your Center's member institutions, or a strong partnership with one or two MSIs could benefit all campuses. It is very important when beginning to establish these partnerships that this be a win-win situation for all concerned. The minority institutions need to see that you are interested in offering their students and faculty valuable experiences. In addition, NSF requires each ERC to develop a partnership with a Louis Stokes Alliance for Minority Participation and an Alliance for the Graduate Education of the Professoriate. The purpose is to engage the broad base of minority students and these alliances. These students usually participate in the ERC's REU program or other research efforts that involve graduate students.

It is important in partnerships like those described below to determine what the Center wants from the collaboration and what the other parties want and need. Coming to an early consensus will help get the project started on a positive note and proceeding productively.

CASE STUDY: *The VaNTH ERC for Bioengineering Education Technologies has contracts with the University of Memphis and the University of Texas-Pan American—both minority-serving institutions—and Fisk University, an HBCU (Historically Black Colleges and Universities) in Nashville, TN. In all contracts, it was very important to balance the need for financial, intellectual, and infrastructure support. The needs and the programs may be different at each partnering institution. For example, for all three of these institutions, funding is provided for new seed research projects. At Fisk University, there is also the added value of intellectual support for participating Fisk faculty and funding for infrastructure (equipment). There are also student exchanges from all the universities for VaNTH's REU program.*

CASE STUDY: *GTEC, the Georgia Tech/Emory Center for the Engineering of Living Tissues, has established a partnership with the Atlanta University Center (AUC), a consortium of five HBCUs in the Metro Atlanta area. GTEC sought the partnership for several reasons. It wants to enhance its biology-based research initiatives and is providing funding for two seed projects for the Morehouse School of Medicine for research that is closely aligned with GTECs. The Center will also provide an avenue for undergraduates from Morehouse and Spelman College to do research in the GTEC labs at either Georgia Tech or Emory University. The last component of the partnership will provide partial summer funding for Morehouse and Spelman science faculty to work in GTEC and Morehouse School of Medicine laboratories to experience new techniques, equipment, and applications. This partnership is unique in that GTEC is also partnering with the Georgia Tech College of Engineering (GT CoE) and their Dual Degree program. This program allows undergraduates to do their first three years at Spelman and Morehouse Colleges, and then transfer to Georgia Tech into an engineering curriculum. A program coordinator was hired to work with GTEC, GT CoE, and the AUC to encourage students to participate in the Dual Degree program. Supplemental funding from NSF is making this partnership possible, in addition to the CoE sharing one-half of the cost of the Program Coordinator.*

9.5.6.2 Motivating Member Universities to Pursue Collaborations/Partnerships



Working within the Center's multi-campus organizational structure, the essential components of the education and outreach programs need to be decided. Next, determine what is feasible at each campus. Brainstorming on possible partnerships and collaborations will encourage member campuses to initiate contacts. Again, looking to see what is available in the community of each member institution is the best first step. Encourage each campus to think creatively. Other suggestions for motivating member institutions to pursue collaborations might include:

- Ask the Student Leadership Council what they would like to develop and present for outreach. Ownership in the programs greatly increases participation of your graduate and undergraduate students.
- Create a culture of appreciation for education as well as research. Just as your Center funds research projects, you should fund specific ventures that focus on education issues, i.e., curriculum development, precollege educational modules, and involvement of undergraduates in research projects.
- Develop a matrix for the internal review of research projects for the purpose of funding. Projects can be strongly encouraged or required to have an educational component in order to receive funding. Those that do not have an educational component would be less likely to be funded. Collaboration with community organizations can give added weight to a project proposal.

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