

ERC BEST PRACTICES MANUAL

CHAPTER 4: EDUCATION PROGRAMS

4.2 ENGINEERING EDUCATION PROGRAM PLANNING AND DIRECTION

4.2.1 Introduction

The Engineering Education Program Planning and Direction section of this chapter provides guidance for teams preparing new proposals, to newly awarded ERCs in their start-up phase, as well as to new Education personnel who join an established center. The section is organized into three main topic areas: (i) strategic planning, (ii) funding, and (iii) programs and Implementation. Specific programming suggestions and examples are detailed in later sections.

Planning the ERC's education programs must be conducted concurrently with the research and industrial/practitioner collaboration/innovation ecosystem components to insure maximum integration. All stakeholders should be included in the process, as education is a critical component of an ERC. Personnel qualified in collegiate and precollegiate education as well as education assessment and evaluation must be included at the beginning stages of the process. The Center Director, and representatives from each partner institution, as well as industry and practitioner representatives, must also be included in the process.

The primary objective of the comprehensive education programs at ERCs is to address the second goal of the ERC Program; that is, to produce graduates with deep knowledge of industrial practice and who will be creative U.S. innovators in a globally competitive economy. To that end, these programs include not only university-level education strategies but also strategies that attract precollege and non-traditional students to engineering careers. The programs will include assessment and evaluation to monitor progress and impacts over time and to improve the program as needed. All ERC education programs are tasked with improving the diversity of the engineering student body.

Each ERC has a strategically designed University Education Program focused on instilling in its undergraduate and graduate students the capacity for effective industrial practice, creativity, and innovation. The primary goal is to produce graduates who are technically prepared, able to integrate knowledge across disciplines to advance technology, knowledgeable of industrial practice, experienced in advancing technology, adept at working in highly functional teams, and effective communicators. An additional goal for Gen-3 ERCs is to deliver graduates who also are creative, innovative, and entrepreneurial and are experienced working in non-U.S. research cultures.

Given this guidance, the university education program must identify the key characteristics and skill sets its undergraduate and graduate students will possess upon graduation. The center should strategically design a set of programs, research training, and other experiences for their students to acquire these desired characteristics and skill sets. The ERC's foreign collaborations will serve as the basis for the overseas laboratory experiences for the students. The university education program impacts the curricula at the lead and partner universities. Based on the center's research, new courses and course modules/content for insertion in new and existing courses are developed. Although not required, the ERC may design and deliver a new degree program and/or certificate programs. If a Nanosystems ERC or an open topic ERC develops nanoscience and nanoengineering courses, course modules, lectures, etc., suitable for hosting on the cyber platform of the Network for Computational Nanotechnology¹ (NCN), those materials will be delivered to the NCN, where a broader community will have access to them in an open source mode for educational purposes.

The university education program will be carried out in collaboration with the ongoing education programs of the domestic partner universities. The program will be structured to involve ERC engineering and

¹ <http://nanohub.org>

associated discipline students at the B.S., M.S. and Ph.D. levels and will be carried out in coordination with the center's Research Experiences for Undergraduates (REU) programs. The ERC may also coordinate university education programs with appropriate outreach to local community colleges and veterans groups for broader impact.

The goals of the ERC's Precollege Education Program are to stimulate student interest in engineering careers and increase the diversity of domestic students studying engineering at the college level. The program will form long-term partnerships with up to five precollege institutions (i.e., school districts or individual schools). These institutions must be involved in the planning process to ensure that projects proposed will meet their students' needs as well as to facilitate implementation and adoption.

Opportunities for precollege institutions to work with the center include:

- (1) Involving their STEM teachers in structured ERC research and education programs;
- (2) Providing opportunities for research internship experiences for veterans who are teachers at the ERC;
- (3) Providing engineering learning and activity experiences for their students;
- (4) Integrating new course modules based on ERC research into precollege curriculum;
- (5) Developing strategies to involve underrepresented groups, both teachers and students, in engineering experiences with ERCs;
- (6) Developing general outreach programs to involve precollege students in the ERC's activities; and
- (7) Enabling talented high school students to pursue research experiences in the ERC's laboratories through a Young Scholar program (Gen-3 requirement only).

Through innovative teaching methods and inquiry based-learning enabled by the ERC, these precollege teachers can inform precollege students about the excitement of engineering and technological innovation, and in turn, stimulate them to choose engineering degree programs in community colleges, colleges, and universities.

Although not required, community college and/or technical college faculty and students may be included in center activities to strengthen the skills of the technical workforce and stimulate some of these students to pursue B.S. degrees and beyond in engineering.

It is expected that the ERC's faculty and students will participate in the full scope of the precollege education program and that their mentoring efforts will be recognized and rewarded by their home institutions.

4.2.2 Strategic Planning

In planning an education program, the center's Leadership Team must take into account the following:

- *Center Mission Statement.* An ERC is a unique organizational team that has three mandates from NSF: (a) cutting-edge research, (b) technology transfer of the results of the research, and (c) preparation of the next generation of engineers and scientists. The mission statement should recognize the education component of the center that produces engineering graduates who will be highly effective in industrial practice and creative innovators in a global economy. The ERC's culture evolves through a platform of transformational research and education programs in partnership with industry and other practitioners. It is essential to develop an Education Program Mission Statement as a component of the center's broader mission, to address NSF's mandates.
- *Education Program Goals.* Program goals must be specified at the beginning of the planning process. The Center Director, the Precollege Education Director, and University Education Director must develop the goals in conjunction with input from the center's Leadership Team. (*Please note:* All of these functions are known by different titles at different centers.) This step will ensure integration of research, technology transfer, and education (a hallmark of the ERC

Program) and implementation of the program. These goals should be consistent with the center's mission statement and must address the scope of the program, the mechanisms for integrating center research and education, and mechanisms for industry-student interactions. The requirements for precollege educational outreach must be taken into account. Because ERCs have a particular mandate to ensure adequate representation of women and underrepresented minority students, recruiting measures to meet this mandate must be included. The goals will determine the scope and range of the ERC's education programs.

- *Organizational Considerations.* Initial planning must include the human resources that will be needed. The Director(s) of the Education program(s) should be a professional at the same level on the organizational chart as the research and technology transfer directors. It is recommended that a full-time professional be engaged at the outset and included in the planning stages of the program. While some centers rely on part-time faculty members to serve in this position, employing an individual with an education programming background will allow the center to implement a more complete and effective program.
- *The Actual Strategic Plan.* Given the limited lifespan of an ERC, the center's management must give strategic planning a high priority, beginning in the initial stages of a center's proposal. Strategic plans are dynamic documents that guide allocation of limited resources. They must be revisited annually to ensure that they are able to react to changes in the research and industrial environment and to allow for the exploitation of opportunities that arise during the year.
- *Budget.* The education program should include resources that match the proposed plan. While supplemental funding (e.g., from foundations, NSF, and industry) for particular programs may be available, center core funding resources should be earmarked to support the fundamental components that allow the center to meet its core educational goals. In FY2013, ERCs on average spent \$488K each on their education programs (including restricted and unrestricted funds, see Exhibit G in the Introduction Section 4.1).
- *NSF/Center Interface.* NSF has an important guidance and support role to play in the development and growth of ERC education programs. NSF Program Directors and Staff are a resource to the ERC Education Directors in addition to their role in program oversight.

The strategic planning process for education is conducted in different ways at different centers, with a variety of participants, including the Education Director/Coordinator(s), the Center Director and Leadership Team, the center's Diversity Director, an Education Advisory Committee and/or the center administration, and possibly industrial stakeholder/partner or university involvement. See example 4.3.1.1 in Appendix 4.3 for a description of one ERC's planning process.

Some ERCs involve faculty from all of its departments of engineering or representatives from industry in the strategic planning process, as appropriate to the ERC's scope of research. Knowing the state of the art in your ERC research areas provides a base from which to modify and develop courses. Several ERCs use the activities of annual report planning and preparation as the time to review education program strategy and make changes. Some ERCs give the Education Director/Coordinator and staff leeway to make initial plans and decide on strategies, which are then reviewed by the Center Director and/or appropriate committee. Other ERCs form teams consisting of the Education Director/Coordinator, Center Director, some faculty members, and sometimes a graduate student representative. Another means of student input employed by centers is a Student Advisory Committee. Often the membership of such a committee is drawn from the center's Student Leadership Council. (See Best Practices Ch. 8² for information on these vital ERC student organizations.)

ERC Education Directors/Coordinators can consult their counterparts at other ERCs for ideas in constructing the initial plan, and they can meet with their Center Director, Industrial Liaison Officer/Industrial Partnership Coordinator, and senior center faculty to gather input on ERC education needs and issues. In addition, the Education Director/Coordinator must become familiar with the curricula

² http://erc-assoc.org/best_practices/chapter-8-student-leadership-councils

at his or her particular school of engineering and other relevant departments within the university. Multi-university ERCs also must accommodate requirements of their affiliated universities' curricula.

The following is a general model of the process of developing a strategic plan:

Overall Goals/Objectives: The first step is to develop a statement of the overall goals/objectives of the education program, keeping in mind the center's vision (what you want the vision to be) and mission statement (what you do to implement the vision). Such a statement should include what you want to do, whom you want to affect, and how you intend to accomplish it. For example, an education goal/objective might be "to develop and deliver *innovative educational initiatives to prepare scientists and engineers* for the challenges of the emerging biology-based industries, *in order to produce a generation of engineers and scientists with a cross-disciplinary team perspective.*" The strategy to accomplish this goal could include "a major outreach effort to middle and high school students and teachers."

Initiatives and Actions: Next, one must develop specific initiatives (specific, focused activities) and the actions for carrying them out. (Actions should be stated in measurable terms.) Initiatives might be planned in the areas of precollege outreach, undergraduates, graduate students, lifelong learning, and curriculum development. A few ERCs also include opportunities for elementary school students and teachers. For example, "K-12 initiatives will provide opportunities for middle and high school students and teachers to understand the center's research field and goals." This initiative might be supported by actions such as "Maintain a program of yearly demonstrations to X number of schools" and "Develop a web module."

The education strategic plan also should provide for developments over time. A plan appropriate for an ERC in its early years should change as the center matures, and will change even more as the center works towards self-sufficiency.

The center's program objectives and goals can assist to determine the scope of the program's offerings and to clearly identify projects and activities that consistently achieve ERC program objectives. Each project, activity, initiative or event should meet the following objectives:

1. Motivate diverse citizens to navigate the STEM pathway to expand and promote a talented STEM workforce.
2. Promote the awareness of *<specific area of research>*-- its technology, applications and career opportunities -- through positive, authentic experiences in informal precollege, undergraduate, graduate and industrial contexts.
3. Infuse *<specific area of research>* research and innovation into evaluated curricula and programs in informal precollege, undergraduate, graduate and practitioner offerings.
4. Create a culture that integrates research, education, and industrial practice for undergraduate and graduate students across the center.

The scope of the ERC's Education Programs is broad. It is useful to categorize programs by targeted specific audiences. Typically, as noted earlier, a center's Education Programs are divided into two main thrusts—University Education and Precollege Education—although a center may want to enhance its programs by providing public and professional/practitioner education programming.

Each program proposed under the two main thrusts should touch on one or more of the ERC Program's objectives. Specific programmatic elements of the Education Program portfolio include:

- Undergraduate research opportunities during the academic year in teams with graduate students
- Research Experiences for Undergraduates (REU)
- Research Experiences for Teachers (RET)
- Precollege outreach experiences for students in ERC activities
- Young Scholars research opportunities (Gen-3)
- Innovation and entrepreneurship experiences (Gen-3)
- Foreign laboratory experiences (Gen-3)
- New and modified curricula
- Research Experiences for Veterans/Teachers (NSF ENG/EEC Supplement opportunity)
- Other projects and programs.

Successfully meeting all of these expectations in the first year is not required; instead a focused effort in establishing the core program elements of the Program is recommended in the start-up phase. In fact, the site visit merit review criteria are phased depending upon the age of the center. (See the merit review criteria on this webpage.³) Following the first year, a phased approach works best. The University Education Program Director and the Precollege Education Program Director should strategically identify the respective programs that have the highest likelihood of success and sustainability and the appropriate timing of their implementation. A focused effort to design and implement the essential (required) elements of the program at the start-up phase is important. Shortly after the program is established and procedures and protocols, management, and organization are in place, the Education Leadership Team can begin to creatively design and implement programming specific to the needs of the center, its students, its stakeholders, and its researchers. The Education Leadership Team should assess components of the Education Program for risk and reward (success and sustainability) with anticipated timeframe and effort needed to coordinate, launch, and resolve. In the first year, a focused approach is recommended, rather than a shotgun approach. There are a variety of ways the Program could be phased and staged, and each center has unique resources, needs, and stakeholders. The Education Leadership Team should have a clearly devised strategy on how to phase the Program—its programming, its alignment with what's leveraged, and the needs of the center.

4.2.3 Planning for Sustainability

An important issue in strategic planning is the impact of the ERC's 10-year life cycle. Some program components are amenable to institutionalization, but others depend on supplemental funding that is not likely to be continued after ERC core funding ends. Courses that have been added to the curriculum by the center and any associated certificates, minors, and/or majors should be integrated in the university's curriculum prior to the end of the center, thereby becoming part of the continuing engineering education programming of the university.

As a center approaches the end of the NSF ERC Program funding cycle, these concerns come into sharper focus. NSF intends that the culture of ERC education will continue in the center; but without continuing support from the university, industry, or other programs at NSF, it is likely that most of the ERC's education programs will end. ***The center's Education Director/Coordinator should work with the center leadership to develop a self-sufficiency plan from the outset. This plan can include soliciting education funding from the university, foundations and the private sector (notably industry).*** It is recommended that programs and projects that have a high likelihood of sustained funding and/or support after the 10-year ERC Program funding cycle ends be identified in the initial phases of the ERC's development. It is visionary to consider who the long-term supporting stakeholders will be at the "graduation" of the ERC from ERC Program support, what programs may fulfill the future stakeholders' needs, and might those programs have a 10-year development phase in the ERC in order to provide value and justification to the future support of the center?

See section 4.7 for a more extensive discussion of sustainability of education programs.

The following are a few examples of best practices in the start-up phase that may help strategically align ERC education programs for long-term sustainability. The common theme for success is working to develop productive and lasting relationships from the very start of the center:

- Make the development of the engineering workforce through an ERC's education and research programs as critical to the center's mission as research, innovation, and entrepreneurship. This will create a sustainable education program that will be integrated within the research program, rather than a program independent of the center's research initiatives.
- Form meaningful, long-term relationships with K-12 schools. Over the lifetime of the ERC, outreach programs should become institutionalized at partner schools.
- Establish relationships and collaborations with other ERC Education Directors at the ERC Program's biennial meeting, during the monthly teleconference calls, and during special ERC Education Directors' retreats.

³ <https://www.erc-reports.org/public/library>

- Search out and build partnerships with existing entities on your campus that have permanent funding to leverage already existing and institutionalized programs.
- Ensure that multiple educational pathways are represented in the program (e.g., use K-12 programs to feed the undergraduate and graduate programs).
- Assess the needs of current and future stakeholders. Example questions include: “What are the needs of industry now and anticipated for the future?”, “How can we fulfill those needs?”, and “What can we uniquely offer that answers to that need?”
- Institutionalize ERC education through new coursework, programs, and degrees. How can these be aligned across partner institutions? Understand curricular development and approval processes early for smoother integration and quicker implementation.
- Study what it takes to be successful in gaining site awards from the NSF REU and RET programs.

4.2.4 Understanding Needs, Context, Stakeholders, and Resources

Leverage Existing Infrastructure: In many cases, there are pre-existing programs, resources, and infrastructure at institutions associated with the ERC that can be leveraged to simplify the start-up process. Identifying and collaborating with these entities can save time and resources, allowing faster implementation of a variety of education programs, and facilitating the sustainability in the long run.

Identify Opportunities and Barriers: The assessment of opportunities for collaborating in education programs should be balanced with the needs of the center and any obstacles to success. While some programs offer the ease of “plugging in” to an existing infrastructure, it is important to ensure the student experience is unique and the educational content is tailored to the mission of the ERC.

Inventory Existing Resources: Some examples of resources that other ERCs have leveraged are listed below. These opportunities are highly dependent on resources available at each institution.

- Many outreach programs are extensions and specializations of prior existing programs. Also, ERC programs can be tied to existing programs by offering expertise and/or opportunities that were made possible through the ERC.
- Example partnerships include:
 1. CalTeach, a UC-Berkeley teacher training/development program, provides professional development workshops to teachers in an RET program at the Synthetic Biology ERC (SynBERC).
 2. The Transfer Alliance Program (TAP) at UC-Berkeley provides transfer advising services to Center community college REU students.
 3. The California Institute for Quantitative Biosciences has co-partnered with SynBERC to develop and run Lab Bootcamps for Undergraduates, a traveling one-day symposium called "What You Can Be With a Ph.D", and a summer industry internship program for undergraduates;
 4. A K-12 robotics camp was successfully integrated into the ERC K-12 program at the Quality of Life Technologies (QoLT) ERC; and
 5. Aligning a center REU program with existing university-wide summer undergraduate research programs allowed the Biomimetic MicroElectronic Systems (BMES) ERC to leverage the many activities being provided to REUs by the University of Southern California, Viterbi School of Engineering, and encouraged students to become immersed in a large and diverse REU community. Many other centers, such as the ERC for Collaborative Adaptive Sensing of the Atmosphere (CASA), based at the University of Massachusetts-Amherst, the EUV ERC at Colorado State University, the Smart Lighting ERC at Rensselaer, and the FREEDM Systems ERC at North Carolina State University, have done the same thing.

4.2.5 Engaging Engineering Education Specialists and Evaluation and/or Program Assessment Experts as “Intellectual Partners”

From the start of the program it is good practice to either engage with, or have on staff, engineering education specialists and evaluation and/or program assessment experts. This communication will ensure that the education program's mission, vision, and program goals align well with the proposed programs and desired outcomes. These experts may also recommend surveying the current and future stakeholders to determine if the elements of the education program meet the needs of industry or other stakeholders.

Best Practices and examples of what others have done include:

- Approach education programs from a research perspective and aim to collect data suitable for publication.
- Utilize assessment experts who are familiar with NSF programs (such as REU and RET) and can bring expertise about what works and what doesn't to the table. This will save immeasurable time and money!
- Hire experienced education evaluators and researchers. For example, when putting the team of precollege leadership together, the BMES ERC put College of Education faculty on the leadership team. Similarly, the FREEDM Systems ERC works with other non-engineering faculty to conduct their precollege and college assessments. The ERC for Revolutionizing Metallic Biomaterials (ERC-RMB) at NCA&T State University has an evaluator who is on the faculty of the NCA&T School of Education. Her role is broad in scope, providing assessment overview for precollege education and outreach, as well as for shaping evaluation research in university education.

4.2.6 Role of Partner Institutions

Clearly defining the roles of partner institutions within the workforce development and education programs is a very important issue, one which has no prescriptive solution. There are many organizational schemes that have been successfully implemented in different centers. For example, the lead institution may centrally oversee the education program activities and manage the budget, with only a single faculty member at partner institutions to oversee progress. Alternatively, partner institutions may have individual education leaders and budgets to implement their own programs within the scope of the overall ERC education program mission and objectives. There is likely a range of solutions that lie between these two extremes. It is important, however, that all partner institutions be involved in these activities.

A few best practices and lessons learned from current and graduated ERCs include:

- The SynBERC ERC has an East Coast and West Coast hub, with one faculty member designed to oversee education program activities at campuses on either coast. All efforts are centrally coordinated at UC-Berkeley, but having faculty responsible for overseeing programs on each coast has been a great help.
- As you decide on the roles of individuals at partner institutions, be aware that it may be challenging to arrange Institutional Review Board Certifications (IRBs) across universities.
- The graduated Virginia Tech ERC, CPES, pioneered multi-university ERC partnership, developing cross-campus articulation agreements that enabled students from one partner campus to take a course at another campus and earn credit on the home campus.
- It is useful to form consortia within or across ERCs for large shared proposals, e.g., equipment.

4.2.7 Developing Partnerships Across the ERCs

Education leaders from other ERCs can be a key resource for centers in their first years. Partnering with other centers to leverage each other's pre-existing infrastructure, or simply seeking advice from someone with a few years of experience navigating the workforce development program landscape can be quite valuable.

Some examples of best practices in collaboration include:

- Attending conferences or seminars where education program representatives from all the existing ERCs will attend. This can be useful for collaboration and network building.

- Using other ERCs as a resource for recruiting teachers and undergraduates for RET and REU programs.
- Sharing a variety of programs, curricula, and assessment tools with partners at other ERCs.
- Partnering with other ERCs to co-sponsor a booth at recruitment conferences. This is an efficient use of resources.

4.2.8 Role of NSF

The Professionals of the Engineering Education and Centers Division are resources to serve the ERC Education Directors/Coordinators in developing and enhancing their education programs. They have the experience to provide guidance and to identify others who might serve as resources to assist in strengthening the education programs. NSF also provides publicity to industry and works through other NSF programs to support the centers.

NSF ERC core funds and supplemental funding based upon competitive proposals serve as a nucleus for developing strong education programs. Recognition of the importance of ERC education programs in the ERC biennial meetings and conferences and during site reviews help Education Directors/Coordinators strengthen their respective education programs. NSF support is philosophical as well as financial and is critical for developing strong ERC education programs and ensuring that education is an important aspect of the centers.

Some examples of NSF's support to ERC education programs include:

- Monthly teleconference calls among the University and Precollege Education Directors and NSF Program Directors responsible for ERC education efforts, hosted by NSF at ERC_E-O@LISTSERV.NSF.GOV.
- Continual emphasis by NSF Program Directors on the importance of education and educational programs in the ERC. In this way, NSF Program Directors emphasize to the leadership and faculty of the ERC the significance of these programs. This greatly helps the education endeavors at the centers.
- Providing opportunities for additional NSF sources of funding and publicizing these funding options to the centers.
- Emphasizing the significance of collaboration between centers and encouraging these collaborations verbally and through funding sources.
- Providing critical insight to centers through annual site visits that help improve center programming.
- Providing guidelines that define the programs, performance criteria that define excellent and poor performance, and reporting guidelines that document annual progress, as well as cumulative progress at renewal and at "graduation."
- Laying the groundwork for the development of education programs with a strong industrial element, by mandating an industrial component to the center's architecture. This component benefits both undergraduate and graduate students,
- Promoting innovative programs that allow cutting-edge technology to be developed to the point where it can be utilized by industry and benefit the general population, through funding of the ERCs. Center education programs are an essential vehicle for disseminating these new technologies into industry, by means of the center graduates and center outreach.

A strong relationship with the NSF ERC Program Leadership, and especially the NSF Program Director who is responsible for the oversight and review of your ERC, will enhance the development and implementation of an ERC education program.

4.2.9 Funding

Budget

The initial budget for education should include funding for start-up, advertising and recruiting, and other efforts to ensure a successful beginning for the program in addition to stipends for undergraduate students (e.g., for center research fellows, summer research programs, and other activities), research assistantships for graduate students, and appropriate staff support. Because ERC education programs must collect data and make extensive reports to NSF, data management and report writing capabilities must be planned for at the outset.

The initial budget may include some costs (such as travel) that support the development of relationships with the partner institutions and other undergraduate and minority institutions. Once these relationships have been developed, budgets may be partially reallocated to other purposes. Some centers use education budgets only for stipends and student support, with staff and travel budgeted in other center funds.

The education budget or the overall center budget must include funds for the leaders of the education programs to attend annually, either the ERC Program Education Retreat or the Biennial ERC Program Meeting.

As the center matures, NSF supplemental funding and leveraged support from other sources, as well as industrial funding, should increase. Ideally, after the first few years, it should not depend entirely on internal ERC core funds.

As the center approaches graduation, the most likely scenario for continuation of the education programs is through leveraged support via additional funds from the university, foundations, industry, and state programs as well as through NSF REU and RET site and other NSF education programs.

Education budget decisions allocating overall resources should be made by the center Leadership Team—including the Director, Deputy Director, Education Director/Coordinator, Thrust Leaders, and Industrial Liaison Officer. In some ERCs, Education Directors/Coordinators submit proposals for funding along with research thrust proposals, and all proposals are considered by an ERC funding committee. Some ERCs have a budget for program development, which includes scholarship/fellowship stipends and seminar and travel expenses. It is recommended that there be an amount, a set-aside for the education programs, that is respected by the other members of the leadership team, many of whom will have competing research proposals in line for funding.

The education program should include resources that match the proposed plan. While supplemental funding (from foundations, NSF, and industry) for particular programs is available, center core funding resources should be earmarked to support the fundamental components that allow the center to meet its core educational goals. In FY2013, ERCs on average spent \$488K each on their education programs (including restricted and unrestricted funds, see Exhibit G in the Introduction Section 4.1). Items that should be in the education budget include:

- Administrative costs (e.g. faculty, staff, overhead, printing, and data collection/management)
- Graduate student support
- Support for Student Leadership Council (SLC) activities
- Funding to support the academic year undergraduate research program
- Funding for precollege outreach
- Programmatic funding needs
- Travel (for recruiting, dissemination, and annually to either the ERC Program Education Retreat or the Biennial ERC Annual Meeting)
- Assessment personnel and program
- NSF Requirements
 - ✓ Minimum of \$42,000 spent from the core ERC budget on the ERC's REU Program, regardless of whether or not there are REU site awards.

- ✓ Minimum of \$42,000 (Classes of 2006-2012) or \$87,000 (Class of 2015) spent from the core ERC budget on the ERC's RET program, regardless of whether or not there is a RET site award.

Other Funding Opportunities

Funding for educational activities may be derived from a number of sources. Specifically, there are occasional opportunities for competitive supplemental funding from the ERC Program, education/outreach awards from other divisions and directorates of NSF, RET and REU site awards, special grants from industry members of the center, funds from the university for diversity-promoting activities, education grants from philanthropic organizations, and possibly state sources. Opportunities should be pursued to leverage the funding received, using non-federal ERC funds for matching. Some centers have been quite successful in leveraging their education budgets with university, state, and other federal resources. External foundation (not NSF) funds may be used for matching funds with NSF-supported activities.

Opportunities from NSF include:

- ERC Program supplemental funds—these are provided for special initiatives, such as the Research Experiences for Undergraduates (REU), Veteran's Research Supplement Program⁴, outreach to Historically Black Colleges and Universities (HBCUs), technical schools, and international programs, as well as other special supplemental funds. Such programs significantly strengthen ERC education programs. They provide a focus for center education activities and serve as a fulcrum for leveraging support from other sources, including industry.
- Division of Engineering Education and Centers Active Funding Opportunities
- Research Experiences for Undergraduates Site Award
- Research Experiences for Teachers (RET) Site Award
- Starting in FY2014, the EHR Directorate's Research Traineeship Program (NRT)
- Historically Black Colleges and Universities Undergraduate Program (HBCU-U).

Industry: There are opportunities for supplemental funding from special grants from industry members of the center to sponsor outreach activities or events, capstone design projects, sponsored research under the center's Education and Outreach Programs. Industry associations are eager to support educational initiatives for the potential workforce.

Other Sources: Other creative routes in leveraging educational and outreach support include garnering investment from other local, state and federal governmental agencies committed to educational development. Examples include:

- U.S. Department of Education
- U.S. Department of Energy
- U.S. National Institutes of Health
- U.S. National Aeronautics and Space Administration
- Local school districts, associated initiatives, partnerships
- National student organizations and local student chapters

Fellowships: Assisting students to apply for fellowship support can greatly leverage the research funding for the ERC, and enhance the student's profile and prospects post-ERC.

Leveraging: Programs that allow for multiple purposes to be satisfied simultaneously are obviously desirable, which is highly dependent on pre-existing alignment, stakeholder needs, and funding. Alignment with other programs was discussed previously, and stakeholder needs should be part of the assessment regarding opportunities and barriers. Leveraging of funds can and should be conducted in the pre-proposal stage, by negotiating a percentage of the indirect costs, space, equipment funds - often as part of a cost-sharing arrangement.

⁴ See Dear Colleague Letter No. NSF 13-047.

4.2.10 Program Management

Initial planning must include the human resources that will be needed. Each component of the ERC's education programs, University Education and Precollege Education, should have an appointed faculty or senior administrator to direct the program. Cooperatively, the program should be led by a team ("Education Leadership Team" or "Education Task Force") consisting of the Education Director and administrative personnel, including those from the partnering institutions. The Education Leadership Team could consist of other representatives in the center, including the Center Director, faculty not appointed to the education program, the Industrial Liaison Officer, members of the Industry Advisory Board, the evaluation/assessment expert, Student Leadership Council (SLC) members, etc. It is critical to have many perspectives assisting to lead the ERC's education programs. The Directors of the University and Precollege education programs should be professionals at the same level on the organizational chart as the research thrust and Industrial Liaison Officer/technology transfer directors. It is recommended that full-time professionals be engaged for these roles at the outset and included in the planning stages of the program.

Personnel

The choice of Education Coordinator/Director, and the appropriate positioning of this person as a member of the center's Leadership Team, will determine the success of the center's education programs. Both the University Education Director and the Precollege Education Director should be part of the ERC's Leadership Team to demonstrate the importance of these programs to the center. NSF requires that the University Education Program be led by a faculty member to elicit the full respect and cooperation of faculty in programs that directly affect their students and the integration of their research into ERC curricula. This is especially important for curriculum development. The Precollege Education Program may be led by a staff person with expertise in this field and sufficient professional standing to also elicit full respect within the center. The primary focus should be on identifying an individual with an appropriate background to be responsible for the education activities of the center. His or her interest in interacting with students should also be a major selection factor. The University Education leader may be part-time but the Precollege leader should be full-time. Someone who is interested in mentoring students and working with REU students must be a member of this team.

Education Directors/Coordinators are responsible for writing up all aspects of their education programs for the ERC annual report and other documents. They also develop and write grant proposals of many types to expand their education programs. Therefore, strong communications skills and an ability to prepare successful proposals are important.

It is recommended that an Education Advisory Committee be established to give center faculty a mechanism to provide input into center education programs and to provide support for them. The composition of this group can include center faculty, external faculty, and industrial partners as is deemed appropriate.

A variety of organizational structures can lead to successful education programs. In some centers the Center Director monitors the Education Director/Coordinator, to provide oversight, input, and knowledge of the education programs. In other cases, the Education Director/Coordinator has more latitude to manage the education programs with limited oversight. The appropriate management style will vary from center to center.

The organizational structure of the entire education program may creatively reflect the unique arrangements between the lead and partner institutions of the ERC. Some centers operate from the center's headquarters and maintain all administrative and leadership functions of the education program at the lead institution, and distribute the programs, projects and activities across the partner institutions; but the coordinated effort is in one location. One disadvantage of this model is that the challenge of carrying out all education activities is a multi-campus effort, rather than being central to the lead institution. Other centers distribute their education program direction, leadership, and functions across multiple campuses.. However, this may pose a problem in cohesiveness and ensuring that the entire

program drives impact by adhering to the education program objectives. Whatever structure is selected, all partnering institutions share equal responsibility for implementing the program.

Evaluation, Assessment, and Research Inquiry

Effective assessment tools are necessary to incorporate feedback from assessments and/or evaluations into the education programs to improve program content, ensure program sustainability, and deliver on program goals. Using an expert in program design, implementation, and effectiveness will ensure the program is meeting its goals and objectives and the center is accomplishing what it has been tasked to do. This expert in program evaluation can assist in mapping the ERC program objectives across all education program goals and will help to determine the success and potential for each project. In addition, plans are to be in place to disseminate outcomes and curriculum/outreach products of the college and precollege /community college programs to the participating partner and outreach institutions and beyond.