Section 4.3: Precollege and Community Engagement

4.3.1 Purposes and Goals

ERCs have a mandate to contribute to the precollegiate education system by introducing young students and their educators to the field of engineering and the technology impacted by the center's interdisciplinary research. The purpose is to bring knowledge of engineering to middle and high schools where the emphasis is on science education, with little understanding of the field of engineering. Additionally, there is a significant lag in textbook production, so an effort to integrate center research into classrooms brings cutting-edge engineering content to students in a timely manner. ERC K–12 programs are focused on helping to encourage students to consider careers in engineering. Given the limited ERC budget, when compared to the total precollegiate education system, ERCs and NSF recognize the limits of the impact they can have and that they cannot be all things to all constituencies. It is critical therefore that each ERC determine what precollege offerings work in the context of its specific strategic plan, resources, and community relationships.

Precollege education programs can increase student awareness of engineering careers and stimulate student interest in pursuing them. A key element to all ERC precollege programming is the recognition that it is in the national interest to encourage students who are traditionally underrepresented in engineering and technology careers to become involved. Focusing on underserved populations can contribute to efforts to increase the diversity of domestic students studying engineering at the college level.

ERC precollege programs cannot succeed without partnerships with local school districts and/or individual schools. A strong relationship with these partners will create (1) STEM teachers' involvement in ERC research and education programs; (2) creation of engineering-oriented educational modules for their school teaching activities and for integration into their curricula; and (3) strong impact on diversity and broadening participation of underrepresented groups, teachers, and students into these engineering experiences. See examples of such partnerships in appendix 4.3, section 4.3.7.

Some best practices for achieving successful precollege outreach are as follows:

- To make the best use of limited resources for ERCs' precollege outreach, many ERCs work in partnership with other education and outreach programs. For maximum impact, it is best to seek out established programs to which ERCs can add significant value, or to find promising new endeavors with which to partner. Partnerships may include university programs; school and school system organizations; and/or community resources, including informal science centers and public libraries.
- Another key feature of successful programs is the involvement of graduate and undergraduate students as well as the ERC's Student Leadership Councils (SLCs) in activities. These may include school visits and student tours, as teacher or student research mentors. Secondary school students often relate well to university students, who are closer to their own age. Engaging graduate students in outreach enhances their communication and leadership skills.
- To encourage program diversity, it is useful to partner with established campus multicultural programs; for example, ERCs have partnered with chapters of the National Society of Black Engineers (NSBE), the American Indian Science and Engineering Society (AISES), and the Society for Women Engineers (SWE). Additional partners include women in engineering programs and minority/multicultural engineering programs.
- Successful outreach programs are led by teams involving university educators and education faculty, precollege STEM teachers, as well as center engineers and researchers. Each group offers different talents and specialties that contribute to outstanding programs.

- It is best to have an educator with experience in K-12 education responsible for the pre-college program at each participating ERC location. Programs can be administered from a central location, but an on-site educational leader on each campus is desirable. Forming an Education Committee or Thrust with a representative from each campus can be valuable in accomplishing this goal.

The programs described below are for both K–12 students and their teachers. They include the two that are required for all centers, Young Scholar programs (Gen-3 only), and summer Research Experiences for Teachers (RET). In addition to these required programs, centers have developed other programs such as summer camps, courses, internships, science and engineering competitions, lab tours, school visits, lectures, and science and education fairs, some of which are conducted on-campus at the ERC and others on-site at the partnering school(s).

Given the creativity of center precollege personnel at developing innovative student opportunities, and the resulting variability of programs developed, the best way to understand the range of possible offerings is to review the examples that are found in Appendix 4.3 to this section. Contact information is provided and existing center administrators will be happy to share details about any programs that they have developed. All of these programs require significant time and resources to develop and administer. It is important for the center's strategic plan to include timetables that plan for the gradual phased implementation of Education programming over time rather than attempting to bring all these types of effort up to speed in year 1.

FEATURED EXAMPLE: *The BMES precollege program has developed a comprehensive and innovative education initiative designed to integrate science and engineering principles into the curriculum of inner city K-12 and community college students. The education program introduces and enhances experiential learning that promotes understanding of and enthusiasm for basic science, engineering, and technology—particularly among individuals who traditionally have been underrepresented in the science and engineering workforce. A guiding philosophy of BMES ERC outreach is that education is a community responsibility. The Center has developed a culture of connectivity in which biomedical engineering knowledge and the motivation to engage in scientific and engineering research transfers from BMES investigators to successive generations of pre-baccalaureate students and STEM educators. Formal and informal educational opportunities have been established to expand the scope and reach of the BMES outreach program beyond the classroom to a larger audience, including the extended family members of K-12 students. Through the education and outreach program since 2003, thousands of young children, their teachers, and families have interacted with and learned from BMES faculty (including the Center Director and Deputy Director), students, and staff. They now have a greater understanding of the role that science and engineering play in their daily lives, a first-hand acquaintance with people who are innovators, and a familiarity with the process of discovery. The outreach program recognizes and builds upon the fact that education is bidirectional between expert and novice. Like the K-12 teachers and students, the university community also benefits through their participation in precollege education and outreach activities. USC faculty and students gain a deeper understanding of the opportunities and challenges of urban education and the ways in which young people are motivated and learn. University personnel also increase their communication and managerial skill set, gain significant personal satisfaction, and have the opportunity to establish long-term mentoring relationships that are especially important for underrepresented and first-generation students who often lack role models for higher education.*

4.3.2 Required Precollege Student Engagement

Young Scholars Program (Gen-3 only)

Generation-3 ERCs are required to develop and to offer a Young Scholars (YS) Program to provide opportunities to exemplar high school-age students to participate in ERC summer research programs or internships. The purpose is to get students into research labs early in their careers, in order to excite and interest them in pursuing research and in engineering careers. These programs can require significant effort from administrative and research staff. They generally involve center graduate students who serve as mentors to the students. Please note: there may be existing programs on campus that also serve these students that the ERC can leverage. (See example 4.3.4.1 and section 4.3.11 in Appendix 4.3.)

Student Competitions

Some ERCs sponsor student technology competitions or science fairs. Often, this is done by involving center researchers and graduate students as well as local partner organizations. The purpose is to involve students early on in their academic preparation in exciting engineering and science projects and research, or in fairs and exhibits displaying interesting and topical research.

FEATURED EXAMPLE: *The graduated ERC for Computer-Integrated Surgical Systems and Technology sponsors a semiannual robotics competition for local high school students. The CISSRS LEGO Robot Competition is a weekend-long competition giving high school students hands-on education and experience in engineering problem solving. The students, working in teams, design, build, and program a robot to perform a simulated surgical procedure.*

See example 4.4.6.1 in Appendix 4.4 for an international competition involving undergraduates as well as high school students. Example 4.3.4.5 describes ERC faculty involvement in a science fair that led to a high school student conducting research at the ERC.

Student Camps and Courses

Many ERCs have sponsored student camps and courses to involve K–12 students in fun, hands-on science and engineering experiences and thereby interest them in technology and careers inengineering. ERCs may also integrate center research into existing camps as a way to introduce broader audiences to engineering and science. See examples 4.3.4.2, 4.3.4.3, 4.3.4.4, 4.3.5.1, and 4.3.13.1 in appendix 4.3. Field trips and tours of ERC labs are another way to engage young students' interest. See 4.3.12.1, for an example.

In many cases, ERC students go to precollege schools, even at the middles school and elementary school level, to bring fun demonstrations to classes in order to engage young students in engineering concepts. See example 4.3.5.2 and 4.3.6.1.

4.3.3 Precollege Teacher Engagement

Research Experiences for Teachers (RET)

One of the fundamental components of ERC precollege education is the Research Experiences for Teachers (RET) program. The purpose of the RET program is to excite K-12 teachers about engineering by providing them with knowledge of cutting-edge research. Effective programs engage K-12 teachers in developing and modifying lessons to incorporate concepts learned during their research experiences. Graduate student researchers will need to be heavily involved, as they will serve as mentors to these participants. The most effective programs have students who accompany their teachers to campus during the summer and have outreach to the teachers' classrooms during the academic year by teams of faculty and students from the ERC.

See examples in appendix sections 4.3.2 and 4.3.3. Examples of precollege outreach programs that encourage greater diversity among engineering students are in appendix sec. 4.3.10.

Development of Instructional Materials

In addition to K-12 teacher-developed curricular materials, several ERCs have developed curricular materials for K-12 teachers that are based on the center's research. If it is determined that the production of classroom materials is part of the strategic plan, it will require a development team that includes members of the targeted school district, classroom teachers from the targeted grade level, and center personnel. Partnerships with Colleges of Education and the engagement of Education students may also extend these efforts. It is important that educational materials reflect all local, state and national standards and are developmentally appropriate. For example, some states require application of Next Generation Science Standards (NGSS) and the new engineering standards within them. Education Directors should consult the standards that apply in their area.

FEATURED EXAMPLE: *The NSF Nanosystems Engineering Research Center (NERC) for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) has partnered with professors of STEM education and engineers and has created nanoscale investigations that are correlated with science standards. The investigations are teacher-tested and reviewed by scientists and engineers as well as STEM researchers.*

For additional examples in the appendix, see 4.3.1.1, 4.3.4.3, 4.3.6.2, 4.3.8.1, 4.3.11.3, 4.3.11.5, 4.3.13.1, 4.3.14.1, and 4.3.14.2.

Conferences and Workshops

Some ERCs offer K-12 teacher professional development conferences and workshops. Professional development for teachers allows ERCs to multiply their efforts and to reach more K-12 students by increasing teacher interest and knowledge in science and engineering, particularly in exciting new research. Organizing these conferences can also require significant amounts of administrative and research staff effort. Participating in an existing conference requires less effort. For example, the NSF Nanosystems Engineering Research center (NERC) for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) provides professional development to K-12 teachers through on-site workshops as well as sessions for teachers at national and state teachers conferences.

FEATURED EXAMPLE: *The ASSIST NERC provides professional development to teachers through on site workshops as well as sessions for teachers at national and state teachers conferences.*

For additional examples, see appendix 4.3.3.1, 4.3.6.2, 4.3.7.3, and 4.3.14.1.

4.3.4 Community Engagement

Public events such as Science Cafés and science center presentations are effective ways to share research with adults and families in local communities. These types of outreach efforts build support for the ERC and for research. Such opportunities to participate in ongoing outreach efforts can be easy ways for ERCs to reach out to communities. See examples 4.3.6.2, 4.3.9.1, 4.3.9.2, 4.3.9.3, 4.3.9.4, 4.3.14.1, and 4.3.14.3 in Appendix 4.3.

To better engage veterans in engineering projects, NSF is now accepting requests from their active grantees for the Veterans Research Supplement (VRS)[1]. The proposed VRS will afford veteran students, veteran precollege teachers, or veteran community college faculty an opportunity to participate with active ERC grantees to conduct industrially relevant research in order to gain a deeper understanding of engineering.

4.3.5 Precollege Education Lessons Learned

To be effective, precollege outreach requires professional leadership and substantial resources. Furthermore, the outreach program should be included as a key component of the center and the Precollege Director should be included as part of the center's Leadership Team.

Center Directors should schedule regular times to meet with precollege personnel and promote inclusion of the precollege program in center activities.

In order to promote and sustain a more diverse engineering workforce, the center should strive to create an inclusive and supportive work environment for precollege teachers and students.

1 See Dear Colleague Letter Number NSF 13-047.