Section 4.4: Undergraduate Component (Core Students, REU, Community Colleges)

Although there are significant expectations for ERC education programs, there is a degree of local variation among centers. This variation arises naturally from the differences in center structure and composition. There are however, underlying similarities in what centers offer undergraduate students. This section will describe the similarities as well as the differences.

4.4.1 Core Students, Academic Year Research

Academic year core students are from the centerâ€™s lead and core-partner universities. Integrating undergraduate students in the educational activities of ERCs is mandatory, and is perhaps the single most innovative aspect of the ERC education programs. While the research focus and educational vision of ERCs may differ, active involvement of the undergraduates in research has a major impact, not only on their education, but also on those around them. A special feature of the ERC Program is the emphasis on undergraduate participation in research. This is an excellent way to integrate center research into the undergraduate curriculum. Each of the ERCs has one or more programs through which undergraduates from the centerâ€™s home institution(s) engage in research projects. See appendix section 4.4.2 for examples.

Including undergraduates in center research is the responsibility of all of the centerâ€™s partner institutions. Undergraduates become part of a center research team and may be paid a stipend or enrolled in credit as determined by each center and institution. A minimum ratio of 1:2 undergraduates to graduate students is required. These core undergraduates are joined by ERC Research Experiences for Undergraduates (REU) visiting students in the summer. (See appendix sections 4.4.3, 4.4.4, and 4.4.5 for examples.) However, it is important to note that these two types of students conducting research are distinct groups for ERC reporting, assessment, and database purposes.

A critical component of the undergraduate research experience is the mentoring that the core undergraduates and REU students receive. Mentoring relationships for undergraduates involved in ERC research may involve faculty to undergraduate, staff to undergraduate, graduate to undergraduate, and undergraduate to Research Experience for Teachers (RET) participants and precollege Young Scholar (YS) students.

Mentors should be carefully identified, with plenty of time allowed for student assignment and mentor training. Being a successful mentor is not an innate characteristic. Therefore, training is imperative. Mentorship training should include everyone involved in the Undergraduate Education program (e.g. faculty, core graduate and undergraduate students, and staff). Training can take place through workshops, seminars, and via podcasts. Suggested topics could include â€œWhat is mentoring?,â€• â€œWhy is mentoring important?,â€• â€œWhat are the different mentoring relationships in an ERC?,â€• and â€œWhat constitutes a â€œgood and badâ€• mentoring experience?â€• Importantly, specific â€œDoâ€™s and Donâ€™tsâ€™â€• related to each program should be clearly addressed. Undergraduate and REU mentor training should be done at the same time. Mentoring is a responsibility of all the partner institutions. See appendix sections 4.4.1.1, 4.4.2.3, and 4.4.3.1 for examples.

To create cohesion of the centerâ€™s undergraduate researchers, they should be involved in the ERCâ€™s Student Leadership Council and should also participate in the NSF site visits and annual retreats.

4.4.2 Recruiting Methods

Undergraduates may be recruited through presentations at student organizations such as the student chapters of professional societies like the Institute of Electrical and Electronic Engineers (IEEE), the American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers (ASCE), the American Institute of Chemical Engineers (AIChE), and through organizations like the Society of Women Engineers (SWE) and the National Society of Black Engineers (NSBE). Non-technical student organization groups may be approached to recruit for specific centers, depending on their mandates. They may also be recruited through announcements in the student newspaper, the ERC's website, printed flyers, and directly from classes and colleagueâ€™s recommendations. Also, deans and departmental and other university offices may be helpful. Additional

mechanisms such as Introduction to Engineering courses (cornerstone) and design courses (capstone) should be considered for recruitment. Participation in internal undergraduate research symposia and leveraging existing formal undergraduate research opportunity programs are also avenues of recruitment. Outreach by undergraduates to precollege schools, especially high school students, can be an important form of recruitment (see appendix section 4.4.11). Participation in contests and symposia relevant to the centerâ€™s research is another option. See appendix example 4.4.6.1.

ERCs are national leaders in including students from underrepresented groups in engineering in their programming, so there is also a strong emphasis on recruiting undergraduate students from a diverse population, including women, members of underrepresented minority groups, those with disabilities, transfer or dual-degree students, and students from post-secondary technical schools and community colleges. These students may be from the engineering disciplines most prominently represented in the center, or may be studying other fields. Thus, undergraduates who are majoring in physics, chemistry, social sciences, education, and business can be valuable and productive participants. Please note, however, that packing the undergraduate population of an ERC with non-engineering students does not meet the ERC Programâ€™s goal of preparing undergraduates to pursue advanced engineering degrees or work as engineers in industry at the B.S. level.

Centers should always monitor the diversity of the students who join the center. If the centerâ€™s group of students is not meeting the centerâ€™s diversity expectations, it is recommended that a survey of current underrepresented students at the center be conducted to see how they became involved with the center. This information may help the center to develop additional recruiting plans that will broaden the diversity of the undergraduate student group. See appendix section 4.4.10 for examples of programs to increase diversity. Example 4.4.8.1 describes a program aimed at recruiting students with disabilities.

4.4.3 Curriculum Development

Developing an ERC education program is a major undertaking, requiring substantial coordination of many faculty from different disciplines. The faculty involved in developing the ERC may already have a vision for new interdisciplinary courses or even a new degree program that can help achieve the Gen-3 ERC requirement to educate engineering students to be globally aware innovators and entrepreneurs. To that end, the ERC can help solidify the interactions that lead to course development and administration. The role of the ERC education program is that of a catalyst; the resources provided by NSF are small compared to those needed to develop and to maintain an entire academic program. Still, the catalyst serves an essential role, and there are examples of ERC education programs that have provided the necessary impetus for creation of new degree programs. (See appendix section 4.4.1.2, for example.) Degree programs may start as minor degrees, specializations, concentrations, or certificate programs and then evolve into new B.S. degree programs as the academic infrastructure grows through addition of resources from outside the ERC. The role the ERC plays in developing new degree programs at an institution depends strongly on how intellectually developed the field already is at the time the ERC is funded. If the area is new and just evolving, the ERC may lay the foundation for development of a program that comes to fruition in the latter years of the center, whereas if the ERC is funded in an area where faculty members are already offering interdisciplinary courses, a degree program may evolve more quickly.

New degree programs require substantial long-term institutional resources and commitment. Institutions have a responsibility to ensure that students are well prepared for life after the degree, and thus typically want extensive intellectual justification for how new programs will allow students to adapt to jobs in industry or academia. Before embarking on new degree programs, it is essential to arrive at a consensus of stakeholders as to what the expected outcomes of such a program would be. This process will facilitate the adoption of any new program developed. Appendix section 4.4.1.1 provides an overview of this process.

Courses (e.g., new courses, short courses, modules for ongoing courses, senior design)

A very important role of the ERCs is to enrich the core curricula in engineering through course modules for ongoing courses and new courses, particularly interdisciplinary and systems-focused courses. These courses will enrich the engineering curricula and also may provide the intellectual basis for a new degree program.

Developing new courses and/or materials for inclusion in existing courses is the first step toward integrating the ERCâ€™s research findings into the formal education process and is a key requirement for all ERCs. As a first priority, centers should look for opportunities to add modules, problem sets, and lectures to existing courses, to

create relevant online content (non-course format), or to incorporate work in capstone design or similar courses to further integrate center research into the existing curriculum. This is an important means for ERCs to contribute to engineering education in a broader way, as insertion of new materials in ongoing courses does not require the levels of approval required for new courses. The bar is lower, the overall impact is higher, and center research advances can be leveraged more time-efficiently into the curriculum. The beta test approach is important here as well.

The philosophical and administrative aspects of new course development vary widely from institution to institution. At some institutions it may be possible for an ERC staff member to serve as the primary driver. At other institutions, faculty members serve in this role. Ultimately, the university is responsible for paying faculty to teach the course, and for providing additional infrastructure if the course is a lab subject. Thus, courses must fit the overall educational objectives of the degree programs at the institution.

ERC non-faculty staff, in developing undergraduate and graduate courses, should find the following tips helpful:

- Find an interested professor to be a champion for developing the new course.
- Pay the professor and a student helper to develop the course; or arrange with the professorâ€™s department chairperson to give the professor a teaching load reduction so that he/she can have protected time to develop the new course.
- Beta test course materials.
- Work on mechanisms to offer credit for students to take the course at the other ERC partner universities.
- Find a vehicle, such as a website or book, for wider distribution of course materials.

In institutions where ERC faculty have this responsibility, they can take advantage of these suggestions, which build on years of hands-on experience in many ERCs:

- Discuss your idea for a new course with your department head or undergraduate curriculum committee. If the new course is an elective in a hot field and you can demonstrate that students will flock to this course, the department will likely be supportive of your plans to develop it. For untenured faculty, development of a signature course can be a very positive factor in your promotion case.
- If preliminary discussions are positive, determine whether you will be provided with long-term support for teaching the subject. Developing a new course requires a great deal of work, so one should make sure it can be taught several times.
- Find a mechanism for supporting your time in developing the course, and for providing appropriate support, such as teaching assistants. If there is no textbook available (likely), course development requires a substantially greater investment of time than teaching an established course does. Foundation and government grants are available for new course development, and funding opportunities can be identified by asking colleagues. Reach out to a center for Teaching and Learning, if one exists at your institution.

Appendix section 4.4.1.3 provides an example of undergraduate course development.

Degree/Certificate Programs

Minor degrees or certificates give students the opportunity to develop depth in areas outside their major degrees. The rules for offering minors, as well as student participation in minor programs, vary widely from institution to institution. At some schools, interdisciplinary minors are a means to evolve the curriculum toward a new undergraduate major by providing a testbed for courses and for development of student professional societies. If the center is in a cutting-edge research area and students are excited about a minor degree in the area, chances are that it can develop a successful minor even if there are institutional barriers. The key is to build on student interest and enthusiasm. Here are some important considerations:

- Define the intellectual content of your minor first â€"What is essential for the students to learn, and how many subjects are required? Are there subjects already offered that could fit the minor, or do you need to develop several new courses?
- Determine which academic unit is the best home for the minor, whether it be a single department, a pair of departments, a school or college, or the whole university. An academic unit will be required to handle the administrative details if the minor appears as a degree designation, and the academic unit involved needs to be extremely supportive of the minor.
- The easiest minor to develop is for students from oneâ€™s own school (e.g., engineering), because those students are likely to have taken the prerequisites (e.g., mathematics, programming skills, and biology) needed to take the more advanced courses in your minor. Some academic institutions have firm requirements that any student should be able to complete any minor, and you must be cognizant of what your institution requires.
- If you develop a minor for a cross-disciplinary student audience (e.g., including both science and engineering majors), it is helpful to define a set of preparatory engineering subjects that provide the necessary background for non-engineering students. For example, non-engineering students may need to take Differential Equations and a mainstream sophomore-level engineering subject that uses differential equations to solve physicochemical engineering problems before they can enroll in the subjects in your minor. Alternatively, courses can be developed for non-majors, but this is usually a less attractive option over the long term. Engineering faculty are generally reluctant to develop a course for students who do not have engineering backgrounds, and cannot justify teaching such courses when teaching assignments are made.
- The minor should be well coordinated with the curricula of the major degrees. One must put appropriate advising in place to ensure that students are able to plan early in their academic careers to fit all the minor subjects into their schedules. It is helpful, for example, to write up a special advising document for freshmen and sophomores, to ensure they take appropriate background subjects early on. Conduct advising seminars once per term to get the word out to a broad audience.
- A minor degree curriculum, no matter how well planned, does eat into the unrestricted electives available to students. Some students may even overload on subjects in order to complete the minor. It is thus especially important to have good advisingâ€"students must appreciate that the minor is in some sense an Honors program if it requires substantial technical work. It is a choice the student makes. Students who are weaker academic performers might be encouraged to focus on their majors first.
- Create a curriculum committee that meets regularly to review the content and administration of the minor, and invite all the advisors for the minor to serve on the committee.

- Create a community of students involved in the minor by having lunches with students and faculty once per term.

New bachelorâ€™s degree programs must be developed with a different set of considerations in mind:

- The academic affairs office MUST be involved from the beginning when considering creating or modifying a new degree (minor or major) or anything that affects undergraduate student credits. They are responsible for shepherding the degrees through governance.
- Find out what new degree program in engineering or science was most recently approved at your institution, and use that program as a benchmark. Some institutions are conservative and develop new degree programs only once every few decades in response to new disciplines.
- The faculty who teach the courses and who will be responsible for the degree program after the centerâ€™s NSF funding expires must be key drivers in developing the new degree program. Be sure to get the support of key faculty members, who can provide sustained efforts to convince the Chair, Provost, curricular committees, and other decision makers.
- Identify the constituencies for your program, and make sure you have enthusiastic buy-in. Equally important, identify any other academic programs that will be significantly affected (positively or negatively) and discuss your plans with the faculty involved. For example, if you are developing a program that depends on core science classes offered by another academic unit (such as chemistry, math, biology, or physics), they need to be involved, especially if their enrollments are likely to increase as a result of your plans.
- Make sure to contact your universityâ€™s appropriate office (e.g., the Provost) to find out what approvals are required for a new undergraduate degree program. There is no point in developing an entire program if it will not pass this first hurdle.
- Work as closely as possible with the Chairperson of your school's curriculum review/approval committee, as well as your university's Undergraduate Curriculum Committee, before submitting all of the paperwork to those committees, to be sure that they buy into your new program. Doing so can save a lot of time in getting your new program approved, because these committees frequently deny or delay approval due to incomplete forms or unclear descriptions.
- Involve undergraduates in developing the new curriculum, to understand their interests and needs from the outset. This can be accomplished by presenting a proposed curriculum at a meeting of the professional society for the area related to the program. While some universities require participation by undergraduate students during the development and evaluation stages of your new program, itâ€™s a best practice to include undergraduates, whether it is a requirement or not. Neglecting undergraduate input can cause very long delays in getting the new program approved.
- Be sure that your program satisfies criteria of the Accreditation Board for Engineering and Technology (ABET), if one of your goals is to have an accredited program. Review and update this program on a regular basis.

4.4.4 Collaboration with Industry

Industry is involved in all aspects of the ERCâ€™s education programs. Industry representatives may serve as mentors to undergraduate, outreach, or graduate students. (See appendix section 4.5.3.1.) They may present lectures, course sections, or entire courses, provide input into the curriculum, or teach courses in partnership with ERC faculty members. Industry experts may serve on the studentâ€™s masters or doctoral committee. Industry may sponsor undergraduate or graduate internships in industry (see appendix section 4.4.9.1 for an example), or sponsor studentsâ€™ undergraduate or graduate degrees in whole or in part. It is important to allow undergraduates to participate in Industrial Advisory Board (IAB) meetings and interact with industry through social media for networking opportunities. (See, for example appendix section 4.4.1.3.) These experiences provide them a window into industrial practice, and for those who wish to pursue industrial careers after obtaining the B.S. degree, involvement with industry often leads to job offers, due to the richness of the ERC experience. ERC Program-level evaluations have found that industrial supervisors of ERC alumni find them more effective in industrial practice than their single-investigator trained colleagues.[1]

ERC Best Practices Manual Chapter 5, â€œIndustrial Collaboration and Innovation,â€• has a section 5.3.5 on involvement of industry with the ERC education programs.

4.4.5 Evaluation and Assessment

The need and scope for program evaluation and assessment varies based on an ERCâ€™s education program objectives. It is suggested that a person with experience in program evaluation and assessment be identified and used.

An important component of ERC education program assessment is tracking graduates. Follow-up with former students extends the influence and value of the Undergraduate program and contributes to the participantâ€™s involvement in engineering careers and the continuation of their education toward advanced degrees. Former participants can be provided with guidance and assistance with applications for graduate school and for financial aid. Arrangements can be made with the centerâ€™s industrial partners to assist participants with potential employment opportunities. Maintaining contact with graduates requires considerable effort, but it increases the likelihood that they will continue on to graduate engineering education. Learning of their accomplishments is also rewarding. Social media such as Facebook or LinkedIn can be useful in this effort.

4.4.6 Research Experiences for Undergraduates (REU) Program

ERCs are required to offer a Research Experiences for Undergraduates (REU) Program. This provides a mechanism to extend the integration of center research to students who would not otherwise have the opportunity to conduct this type of research on their home campus. An REU program also provides an opportunity to diversify their undergraduate student population, but cannot and should not be the only diverse group of students involved in center research. These programs can also serve as a fulcrum for leveraging support from other sources, including industry. The programs go considerably beyond the traditional research-focused mandate of university research centers. Indeed, they place a substantial demand on the administrative and financial resources of ERCs. For example, the ERC must allocate a minimum of $42K to its REU program from core funds and may seek an REU Site Award to supplement that effort. However, the centerâ€™s REU Program is part and parcel of the broader mandate to develop a new and more industry-focused, product-focused culture for academic engineering and to spread that culture through education. In that sense, then, "outreach" to REU students is simply extended ERC education.

Appendix section 4.4.3 provides a number of examples of REU program planning and operation at several ERCs. Section 4.4.5 gives examples of REUs involving community college students.

REU Program Features

Students gain many benefits from their ERC REU experiences that are not normally available to their peers who are not involved in ERC education programs. REU students:

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Conduct individual or team research on ERC-related projects

- Develop teamwork skills through interaction with undergraduates, graduate students, and faculty
- Are encouraged to continue their education in graduate engineering programs
- Develop communication skills through written reports and oral presentations
- Participate in ethics and professionalism activities
- Interact with students from other universities
- Publish articles on research or give research presentations at national conferences
- Participate in industrial interactions
- Become involved in mentoring RET teachers and or Young Scholars
- Interact with a truly diverse group of students.

REU Program Structure

REU students may work as individuals or in teams, which may include the ERC's own summer undergraduate interns and even graduate students. The studentsâ€™ projects should include at least some elements of their own design and should be supervised by ERC faculty and graduate students. In many cases this environment provides first-hand knowledge of how industrial research teams operate. The total number of undergraduates involved in these summer projects from all sources at a given ERC can vary from as few as 4 or 5 to as many as 40 or 50. Some multi-site ERCs may have only a single REU program, so teaming with local students is vital. The mix of backgrounds, cultures, and approaches brought by students from different educational backgrounds is an important part of the REU experience. See appendix example 4.4.4.1. In addition to research projects, a well-rounded program of REU activities can include:

- Field trips to industrial sites
- Workshops on technical writing and public speaking
- Seminars in topics such as programming and engineering ethics
- Meetings with high school students visiting the campus
- Mentoring by graduate students and industrial residents
-

Assistance with graduate school admissions applications and scholarship materials

- Exposure to an array of center publications
- A showcase to present the studentâ€™s research project at the end of the summer program

Issues that require special planning include housing (prearranged and on campus in the same area), meal cards or subsidy for meals (to minimize the need for cash), on-campus transportation if needed, and access to institutional facilities. Careful scheduling of out-of-laboratory activities is also necessary to minimize research disruptions.

Recruitment Methods

Recruitment of REU participants can be challenging, since the main focus is on underrepresented populations, and the number of programs aimed at these populations has expanded, so there is keen competition for the best students. The ERC REU program has provided a critical outreach component to ERCs, giving them the opportunity to extend their work to many other institutions. Recruitment techniques that have proven successful include:

- Personal visits to other institutions
- Development of long-term relationships with Historically Black Colleges and Universities, Hispanic Serving Institutions, and other targeted underrepresented Minority-Serving Institutions
- Recruitment efforts by previous REU participants on their home campus
- Recruitment through national organizations (e.g. NSBE, AISES or SWE)
- Use of Women in Engineering (WIE), Minority Engineering Program (MEP) and offices that provide services for students with disabilities
- Participation in career fairs
- Internet postings
- Sharing of information about potential participants among ERC Education Directors/Coordinators across the ERC network.

As centers mature, they interact with other ERCs to help them recruit REU fellows for appropriate research areas. This exchange of applicants has been done on an individual basis, from Education Directors/Coordinators to Center Directors, and (in the past) via an e-mailed ERC Education Digest. Given the strong emphasis on recruiting REU students from a diverse population (i.e., women, members of underrepresented minority groups, students with disabilities, transfer or dual-degree students, first-generation students, and students from post-secondary technical schools), centers must develop/leverage connections with schools that serve these populations. Students may not be from the engineering disciplines most prominently represented in the center, and may not even be engineering majors. Undergraduates majoring in physics, chemistry, biology, social science, and business may be valuable and productive REU participants. Because of the burgeoning REU programs, the competition for top students obtained from traditional sources is intense. Broadening the applicant pool can help to achieve diversity while retaining high

standards, thereby attracting a new pool of students to engineering. Diversity conferences such as SWE, Society for Hispanic Professional Engineers (SHPE), NSBE, and Society for Advancing Hispanics/Chicanos & Native Americans in Science (SACNAS) are effective mechanisms for recruitment. Centers have coordinated to co-host â€œERC boothsâ€• at such conferences. This allows for greater visibility and leveraging of funds (i.e., doing so drastically lowers the cost for individual centers to participate).

REU programs may also benefit from linking with other internship programs on campus. This may allow for supplemental workshops, an expanded cohort, more diversity, and a comprehensive showcase of research projects at the end of the summer programs. One example transition program that uses research as a vehicle to introduce a diverse group of students to STEM is the ELeVATE program at the Quality of Life Technology ERC (see example 4.4.7.2). This program promotes military veteransâ€™ transition to campus by linking them with research projects and mentors to help them develop technical skills. Due to shared goals, the ELeVATE participants benefit from the REU program activities and *vice versa*. At the end of the summer, students from both programs can present their research in the same research showcase/forum. This is just one example of the type of program that a center could collaborate with across its campus.

A very effective recruitment strategy is to provide opportunities for Student Ambassadors (past summer interns) to recruit future participants at the target institutions:

â€¢ Set up information sessions and workshops

â€¢ Present research at information sessions and workshops

â€¢ Serve as guest speaker or panelists for information sessions and workshops

â€¢ Assist peers with application process

â€¢ Recommend peers for future summer internships.

Strategies for Funding

One of the best ways to leverage funding and to improve the efficient use of a centerâ€™s resources is to join with others in setting up and implementing projects. Once the fixed costs have been met, additional participants bring down the cost per participant and provide cross-fertilization of expertise. A number of ERCs combine REU programs with other programs or funding sources. The availability of supplementary funding allows field trips and extended travel to be included in the studentsâ€™ experience. Many campuses host multiple REU programs and this provides opportunities to co-host ethics and communications workshops, social events, and seminars to the mutual benefit of all of the participants. Also, the considerable expense involved in long-distance relocation has been a barrier to some gifted students, and supplementary funding can be helpful. Again, the best sources of specific information about funding opportunities for attendees are the center websites, and the websites of universities and other centers provide opportunities for co-funding of programs. Providing an interesting research, cultural, and social program for the group requires planning and supervision, but the wide availability of campus facilities in the summer facilitates this process.

Mentoring

Mentoring is a strong component of the success of REU students within ERCs. Mentoring roles for REU programs may involve faculty to REU, staff to REU, graduate to REU, existing core undergraduate student to REU, and REU to RET and Young Scholar participants. Mentors should be carefully identified with plenty of time for student assignment and mentor training.

As was noted in section 4.4.1, being a successful mentor is not innate to all. Therefore, training is imperative. Mentorship training should include everyone involved in the REU program (e.g. faculty, graduate and core undergraduate students, staff).

Given the geographic distribution of the partners of most ERCs, special attention should be given to methods to connect student REU participants at multiple campuses represented within an individual ERC. It is recommended that no less than two students be located at a given institution, to avoid isolation. Additionally, web-meeting software can provide a mechanism to support weekly research discussions of the group. One face-to-face meeting

of the group, either at the outset to introduce participants and facilitate web communications, or at an end-of the summer research poster session, is recommended.

Evaluation, Assessment, and Follow-up/Tracking

The comments made in section 4.4.5 apply both broadly and also specifically to REU programs. It is recommended to create REU cohort groups that allow messaging to the group and generating discussion among previous participants, allowing them to stay in touch with each other.

REU Lessons Learned

1. Use multiple methods to recruit diverse students into your programs.
2. Be highly inclusive â€“ leverage resources at your university (e.g., other REUs, honors programs, etc.), and at partner universities.
3. Create strong two-way relationships with your industry membership.
4. Search for ways to create community â€“ find a way to showcase undergraduate research results.
5. Mentoring is important; so train your mentors explicitly.
6. Assessment and evaluation are absolutely critical, and it is highly recommended that you partner with professional A&E teams (internal or external) to develop the A&E strategy for your center. You both need to establish the research questions, as well as ensure that the instruments and analyses will allow you to answer the questions (this includes getting human subjects clearance so that you can publish your results).
7. REUs must be U.S. citizens or green card holders

4.4.7 Community Colleges

The Nationâ€™s community colleges and technical institutes are valuable and often underused sources of technical workers. Community colleges serve a vast number and diverse population of students. Due to the flexible scheduling, modest cost, and other reasons, community colleges also attract large numbers of women and minority students. It is estimated that half of the Hispanic students attending college nationwide are at community colleges.[2]For these reasons, they are a fruitful and underutilized source of REU students (see appendix section 4.4.5).

In addition, many community colleges have historically close ties with industry. Industry-oriented or industry-sponsored certificate courses and technical training programs are often associated with community colleges rather than four-year colleges. The technicians and skilled workers of the technology industries are likely to be products of the community college systems.

For these reasons, ERC education programs should actively focus on creating links with community colleges. Again, Academic Affairs offices can help; they are resources to try to connect with and/or utilize any existing articulation agreements and partnerships. Strategies to develop such links may include:

- Provide speakers and guest lectures for community college classes, conferences, and events;
- Provide hands-on demonstrations and activities for community college classes, conferences, and events;
- Serve as an advisor or thought partner on STEM curriculum, proposals, transferring to 4-year institutions;
- Organize interested graduate students and postdocs to volunteer as judges for STEM activities and events at community colleges;
- Partner on grant proposals with community colleges, or provide letters of support for proposals submitted by community colleges; and
- Inform community colleges of STEM events at your campuses

Recruiting

A variety of methods are recommended for recruiting community college students. A starting point is to build a relationship with an academic leader (e.g., department head or program chair or senior faculty member) at target institutions. These people can provide invaluable advice on how best to reach their students.

Recruiting should be viewed as a year-round effort involving active, ongoing communication and interaction at target institutions. For example:

â€¢ Invite prospective students to STEM events at your campus;

â€¢ Attend conferences and other events that focus on the targeted population and follow up with community college representatives and students you meet;

â€¢ Host summer internship information sessions for students at community colleges;

â€¢ Host virtual information sessions and workshops through online webinars; and

â€¢ Send monthly emails to key staff/faculty contacts and student e-lists with opportunities, updates, and reminders.

Organizations or groups that can leverage your efforts include:

- MESA (Mathematics, Engineering, Science Achievement) is nationally recognized for engaging educationally disadvantaged students so they excel in math and science and graduate with STEM degrees. MESA partners with all segments of higher education as well as K-12 institutions. See appendix 4.4.10.1 for an example.
- Veteranâ€™s offices.
- Transitional programs (e.g., 2 + 2) are a powerful way of bringing community college students into 4-year research-oriented institutions. The maturity of such programs varies greatly state-by-state and therefore developing such opportunities will be highly variable amongst centers.

- Your campusâ€™ transfer office (if you have one).
- Advanced Technological Education (ATE) centers are NSF-funded centers that endeavor to strengthen the skills of technicians, whose work is vitally important to the nationâ€™s prosperity and security. In ATE centers and projects, community colleges have a leadership role, and work in partnership with universities, secondary schools, business and industry, and government agencies, to design and carry out model workforce development initiatives. Given the complementarity of the ATE and the ERC mission, ATE centers may represent a viable location for outreach to community college communities by the ERCs. Please note: The location and subject matter for each ATE center varies by geographic location, so the opportunity for development of connections between ATE centers and ERCs will be highly variable.

Mentorship & Training

Community college students may require additional mentoring to ensure success when involved in summer-research programs populated primarily by students from research-intensive institutions. Take steps to ensure mentors are well trained, and consider doing â€œboot-campâ€• or similar orientation/immersion programs to help these students adjust. Community college students are likely best served by experiences within a cohort. Therefore, we discourage sending these students to partner sites where a cohort does not support them.

Other Activities

Community colleges offer extensive opportunities for ERC educational activities. For example, community college studentsâ€”and possibly faculty membersâ€”can be participants in short-courses/workshops/RET programs/design competitions offered by the ERC. Community-college faculty/instructor participants could then become on-site recruiters for opportunities in the ERC, and student participants in short-courses can interact with center-faculty to build relationships. Community colleges may also be fertile grounds for ERC graduate student presentations and teaching.

Community College Lessons Learned

Donâ€™t overlook campus outreach and recruiting professionals, who often have budgets and staff that have expertise in community college recruiting.

4.4.8 Veteransâ€™ Opportunities for Engagement in the ERCs

NSF recognizes that veterans represent a potential underutilized workforce for the U.S. science and engineering research and industry communities. Many veterans are transitioning from active military service to civilian careers and exploring education options through the post-9/11 GI Bill. At a time when the U.S. is challenged with a science, technology, engineering, and mathematics (STEM) workforce shortage, NSF is exploring alternate pathways of veteransâ€™ engagement into STEM fields.

To better engage veterans in engineering projects, NSF is soliciting requests from their active grantees for the Veterans Research Supplement (VRS)[3]. The proposed VRS will afford veteran students, veteran 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. See appendix section 4.4.7 for examples.

1 SRI (2004). The Impact on Industry of Interactions with Engineering Research Centers. (http://erc-assoc.org/sites/default/files/studies_reports/Impact%20on%20I...)

2 See http://www.highereducation.org/reports/pa_at/index.shtml

3 See Dear Colleague Letter Number NSF 13-047.