
AC 2011-2496: USING EXPERIENTIAL LEARNING TO INSPIRE, EDUCATE, AND EMPOWER UNDERREPRESENTED UNDERGRADUATES IN STEM

Mary R Goldberg, M.Ed., Department of Rehabilitation Science and Technology, University of Pittsburgh

Mary Goldberg, M.Ed. coordinates the Education and Outreach programs for the Department of Rehabilitation Science and Technology at the University of Pittsburgh and the Quality of Life Technology Engineering Research Center. Ms. Goldberg facilitates the Research Experience for Undergraduates program, a new initiative entitled ELeVATE to transition veterans with disabilities to higher education, and continuing education activities to name a few. Ms. Goldberg is pursuing a PhD in Administration and Policy Studies in Education from the University of Pittsburgh investigating the outcomes of education and outreach programming.

Rory A Cooper, University of Pittsburgh

Rory A. Cooper, Ph.D. received the B.S. and M.Eng degrees in electrical engineering from California Polytechnic State University, San Luis Obispo in 1985 and 1986, respectively. He received the Ph.D. degree in electrical and computer engineering with a concentration in bioengineering from University of California at Santa Barbara in 1989. He is FISA & Paralyzed Veterans of America (PVA) Chair and Distinguished Professor of the Department of Rehabilitation Science and Technology, and professor of Bioengineering, Mechanical Engineering, Physical Medicine & Rehab, and Orthopedic Surgery at the University of Pittsburgh. Dr. Cooper is Founding Director and VA Senior Research Career Scientist of the VA Rehabilitation Research and Development Center of Excellence in Pittsburgh. He is also the Co-Director of the NSF Quality of Life Technology Engineering Research Center, a joint effort between the University of Pittsburgh and Carnegie Mellon University.

Dan Ding, Dept. of Rehabilitation Science and Technology, University of Pittsburgh

Dan Ding, Ph.D., is Assistant Professor in the Department of Rehabilitation Science and Technology with secondary appointments in Bioengineering (BioE), and McGowan Institute for Regenerative Medicine at the University of Pittsburgh. She is the Education Co-Director of the NSF Engineering Research Center on Quality of Life Technology (QoLT) since 2006, She also directs several training projects including the NSF REU program on QoLT, the Advanced Rehabilitation Research Training Program under the Department of Education's National Institute of Disability and Rehabilitation, and a Long-Term Training Program on Rehabilitation Technology under the Department of Education's Rehabilitation Service Administration. Dr. Ding received her Ph.D. degree in mechanical and automation engineering from the Chinese University of Hong Kong in 2001. She had her postdoctoral training in rehabilitation engineering.

Alicia Koontz, Human Engineering Research Laboratories

Using Experiential Learning to Inspire, Educate, and Empower Underrepresented Undergraduates in STEM

Abstract

The vision of the Quality of Life Technology Engineering Research Center (QoLT ERC) is to transform the lives of people with reduced functional capabilities due to aging or disability through intelligent devices and systems. Through the ERC mechanism, a comprehensive education and outreach program has been developed to inspire, educate, and empower students, especially those with disabilities. Through a well-established experiential learning initiative, the QoLT Research Experience for Undergraduates (REU) program, we have transformed students from dependent to independent thinkers, given them a sense of accomplishment and exposure to potential end-users, and provided experience on a project that has a genuine fit to an ongoing ERC project. The benefits of this program have resulted in personal gains of participants, an increased number of underrepresented students in STEM graduate school programs, and the creation of a new program designed to transition veteran students with disabilities into STEM education, the National Science Foundation (NSF) funded Experiential Learning for Veterans in Assistive Technology and Engineering (ELeVATE).

Students are active participants and innovators in projects which address real-world problems with systems-level engineering efforts, serving as a natural attractor to the discipline. Facilitating the programs collaboratively is in itself a best practice; it allows for an enhanced cohort, peer-to-peer mentoring, and maximization of resources for a sustainable training program designed to increase the retention and promotion of underrepresented undergraduates in STEM disciplines.

Though ELeVATE will only begin in the summer of 2011, its foundations are deep rooted in the success of QoLT's REU program which has advanced underrepresented students through the STEM pipeline and delivered a promising model. Assessment efforts developed through the REU program will be adapted to evaluate this cohort with the goal of contributing towards the bodies of literature surrounding experiential learning, veterans in STEM education, and retention and promotion of underrepresented students in STEM.

Introduction

A recent study conducted by NSF has shown that the Research Experience for Undergraduates (REU) program has a significant impact on students' opinions of pursuing an advanced degree.¹ Prior to participating in a REU program, 37% of students expect that a bachelor's will be the highest degree they will obtain as demonstrated in Figure 1. After participating in research, that number decreases to 4%, suggesting that the students now believe they will obtain a MS (37%) or a PhD (49%). The flow chart in Figure 2 suggests that of the 73% of students who did not expect to earn a PhD prior to completing research, 30% have new expectations after their experience signifying the profound role research plays in defining students' educational plans. This number, added to the 19% of students who still want to earn a PhD (those who believed

they wanted a PhD prior to research), results in 49% of students who expect to receive a PhD after their REU experience.

This number was used for the QoLT REU as a benchmark for the percentage of students who believe they will go on for a PhD based on the REU intervention. If the goal of NSF is to use REU programs to retain and excite students to continue on for an advanced degree, it was believed the same could be done for veteran students transitioning back in to college. Through various tactics the QoLT REU has demonstrated successes in recruitment, retention, and encouragement of underrepresented students to pursue advanced degrees in engineering and technology domains. Through workshop series, career events, symposia, ties with minority mentors, and engaging research projects, dramatic transitions in all, but notably, underrepresented students' attitudes and confidence towards succeeding in school have occurred—be that undergraduate or graduate degrees.

Figure 1: Highest Degree Expectations: Percentage Who Expected That Degree Would be The Highest They Received

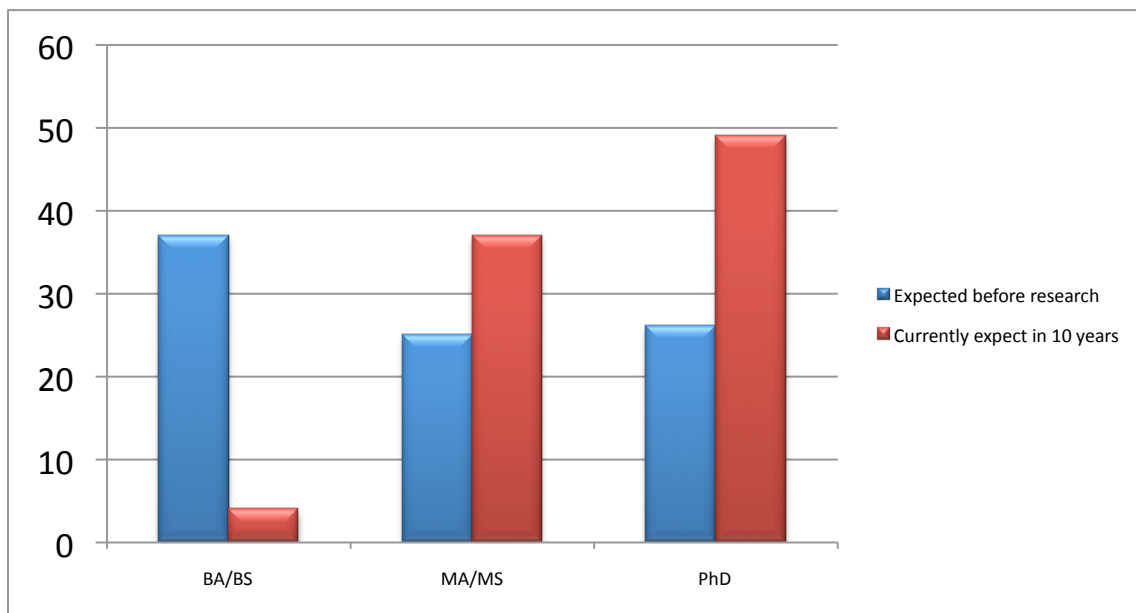
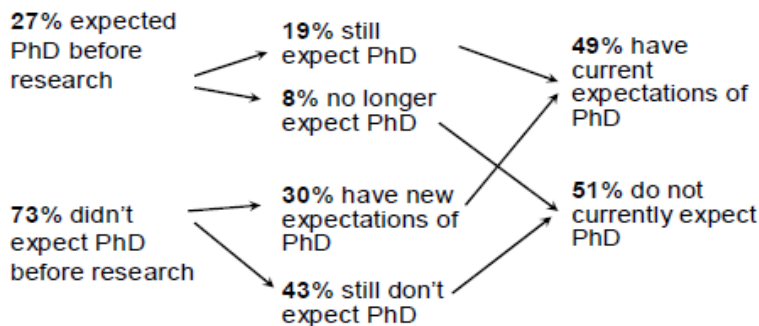


Figure 2: PhD Expectations Flow Chart for REU Researchers



The QoLT Center itself is an attraction to students—it is an Engineering Research Center (ERC) funded by NSF and a collaboration between Carnegie Mellon University's (CMU) Robotics and Human Computer Interaction Institutes and University of Pittsburgh (Pitt) Department of Rehabilitation Science and Technology (RST) and Institute on Aging. The goal of the QoLT ERC is to transform the lives of people with reduced functional capabilities due to aging or disability through intelligent devices and systems. In contrast to pure technology domains, QoLT is all about human-machine ecology. Its breadth and relevance to real life serves as a natural attractor to a diversity of students including female students and students with disabilities. Altogether, 46 students have participated through a one-year NSF REU supplement in 2007 and a three-year REU Site awarded in 2008. Targeted recruitment efforts have resulted in a high representation of minority participants including 41% female students, 35% African-American and Hispanic students, and 20% of students with disabilities. Post-internship follow-up efforts showed that 60% of 20 students who have graduated are pursuing advanced degrees, four of whom are currently pursuing graduate programs at CMU and Pitt.

The objectives of the QoLT REU program are to:

1. Enroll a highly motivated and diverse group of undergraduate students and excite them about technology and engineering as disciplines and as tools to be influenced and authored, especially with respect to helping people and improving society.
2. Engage undergraduate students in cross-disciplinary research in QoLT to gain an understanding of how to relate human functions (physiological, physical, social and cognitive) to the design of intelligent devices and systems that aid and interact with people.
3. Increase the number of undergraduates who are well-prepared for graduate studies and professional careers in QoLT-related fields.
4. Employ targeted recruitment efforts to achieve exemplary participation of underrepresented groups; in particular, students with disabilities and students from racial and ethnic minority groups.

For QoLT systems to be successfully accepted and adopted, they must be developed so that they will be integrated in all contexts of life—body, personal, and community. The QoLT adoption strategy stems from two important beliefs: diversity in the incoming student body makes these students particularly valuable to the researchers precisely because this technology is meant for a diverse audience; and the theme of quality of life knows no boundaries of race, gender, or function and therefore provides ample personal connection across many backgrounds. Recruitment efforts are placed on undergraduate students from traditional engineering disciplines and from rehabilitation science, psychology and clinical science who work with engineers to ensure viability and adoption of the new QoLT systems. Preference is given to students who: 1) have not had exposure to QoLT research previously; 2) are from underrepresented groups; and 3) express an interest in pursuing a career or advanced education in QoLT.

About the program

A central theme of QoLT research is to make intelligent systems that work with people and are safe, person-aware, and environment-aware. This is in contrast to much of the current work in robotics, where the goal is to replace human labor. All QoLT research projects have the benefit of systems-wide context, with stakeholders that are directly involved from multiple disciplines, caregiving groups, and end users and their families. Therefore, the REU projects emphasize and

teach Participatory Action Design (PAD), a process of identifying, translating, and integrating contextual constraints into the conception and development of QoLT systems with the involvement of the diverse stakeholders.² The REU students learn this technique during project development, and the identity that they form as engineers is thus woven into the context of the complete design and analysis cycle. This pedagogical approach to hands-on research makes the QoLT REU program a powerful tool for the development of research identity and thereby future research impact.

REU students are assigned a research project encompassing ongoing and/or pilot research in the QoLT ERC. Providing ‘ownership’ of a project enables students not only to adopt a sense of responsibility for accomplishing project tasks, but also develop effective communication with other team members.³ Together with a primary faculty advisor and graduate-student mentor, each student is an active member of a research team that includes other graduate students in engineering, clinical, or social-psychological fields, medical students, clinical professionals, machinists and technicians, and other PhD and MD faculty. In some cases, REU students will be involved with field studies. The pairing with graduate students has proven to be fruitful as it also affords graduate students an opportunity to test their propensity for mentoring before they begin their careers as future scientists, professors, or researchers.

To ensure that the REU students receive appropriate and adequate guidance from their advisors and graduate-student mentors, a Mentor Orientation and Training Workshop is organized prior to the start of each year’s program, where mentors are informed of scheduled activities and program expectations, as well as best practices learned from the previous years. Mentors and REU students are required to meet at least once per week to discuss the project tasks and track progress. A dedicated REU coordinator talks with each student every week to discuss the mentoring experience and determine if further actions need to be taken. The REU students are encouraged to seek advice or assistance from their mentors and other team members as often as needed. Graduate-student mentors and/or technicians work with REU students to train them on the specific skills necessary to complete the project tasks.

Over the course of the 10-week program, students are required to attend the REU Lecture Series (see the highlighted items in Table 1). Short quizzes and evaluations given at the end of each lecture help the students better understand the topic and solicit feedback on its usefulness. The compiled feedback from students is reviewed by the Co-PIs and coordinator and also sent to the lecturers. This has resulted in changes to the course structure or materials, with activities added or deleted as a result. For instance, in prior years students indicated that they preferred for the lectures to be given early on in the program, because the background knowledge, experiences, and methods learned would have been helpful for their projects. Another recent change was the addition of a few optional hands-on workshops, including rapid prototyping and machining techniques, and fundamental electronics in off-the-shelf assistive devices. These workshops are typically led by technical staff and graduate students.

Table 1

| Week | Activity Description |
|-----------------------|--|
| Prior to start | <i>Mentor Orientation and Training Workshop</i> informs mentors of activities and program expectations, summarize the student/mentor survey results, and introduce best practices. |
| Day 1 | <i>Student Orientation</i> informs REU students of the program requirements and expectations, to familiarize students with each other and both CMU and Pitt campuses. |
| | <i>Overview of the QoLT ERC</i> covers the vision, need and background, state of art, and research, education, and industrial programs of the center. |
| | <i>Meet with individual mentors in the respective labs</i> |
| Day 2 | <i>Medical Aspects of Disability and Aging</i> provides an overview of the etiology, symptoms and functional limitations of different types of disabilities. |
| | <i>Welcome Picnic</i> provides interaction among all interns, QoLT faculty, staff, and students. |
| Day 3 | <i>Social Aspects of Disability and Aging</i> introduces approaches to identify, describe, and analyze the attitudinal, cultural, social and environmental contexts of disability and aging. |
| | <i>Technical Aspects of Disability and Aging</i> introduces a wide range of assistive devices as well as the Participatory Action Design paradigm for designing such devices. |
| Day 4 | <i>Introduction to Research Methodology</i> covers basic statistics and research design and process including institutional approval and ethical use of human subjects. |
| | <i>Technical Writing and Oral Presentations</i> analyzes the components of a sample conference paper and provides hands-on exercises to enhance students' skills. |
| Week 3 | <i>Ethics Forum</i> is organized by Pitt OEL and aimed to provide an opportunity for students to consider ethical practice in research through presentation and discussion. |
| Week 7 | <i>Career and Graduate School Workshop</i> invites representatives involved in research and industry to informally discuss their career path and strategies for achieving success. Includes a panel to address student questions regarding graduate studies. |
| Week 10 | <i>REU Research Symposium</i> gathers the REU students, QoLT faculty, graduate students, industry/testbed partners, as well as advisors of REU students from their home institutions. |

To prepare students for graduate schools and professional careers, an interactive Career and Graduate School Workshop is held where the REU students are split into small groups to spend 30 minutes informally interacting with each of the four panels of industry and academic professionals. One of the panels includes faculty from several relevant graduate programs at CMU and Pitt and specifically addresses student questions related to graduate studies such as the admissions process, how to identify an advisor/lab, and funding issues. Brown-bag lunches with graduate program coordinators at CMU and Pitt, sampling graduate-level classes in the Department of Rehabilitation Science and Technology, informal discussions with QoLT faculty,

and field trips to local industrial/testbed partners has also resulted in increased interest in engineering and technology fields and graduate programs. Each student receives a coin that can be redeemed for a chance to learn more about a faculty member's lab or career path. Students are also exposed to the Center for Assistive Technology (CAT), an outpatient community-based clinic, which provides assistive devices for mobility, hearing, speech, and other essential everyday needs to individuals with disabilities. Established partnerships with assisted living facilities, healthcare providers, and non-profits for access to potential users, and a consortium of companies that are engaged in diverse markets of medical goods and devices, assistive technology, information technology, consumer electronics and appliances, healthcare provision, and healthcare insurance broaden the students' exposure opportunities.

During the last week of the program, a research symposium is held to showcase the REU students' work. The symposium is coordinated with two other REU programs, resulting in a large cohort of students (approximately 30 per year). REU students in these programs orally present their research to their mentors and lab peers, and based on the ratings from people who attended the presentations, the top two students from each REU program are selected to deliver a 15-minute podium presentation at the REU Research Symposium. In addition, other students present their work in a formal conference-style poster session. An independent panel of judges (faculty and industry leaders not directly involved with the REU program) rate the podium talks and one student from each program receives a 'Best Presentation Award'. Students are also required to write a technical paper as part of their REU experience. These papers are judged with the primary criteria being likelihood for potential acceptance into a conference proceeding and a 'Best Paper Award' is presented at the symposium. Graduate students also participate in the symposium in the form of short 'elevator talks' about their research and project demo stations. The advisors from the REU students' home institutions and faculty from minority serving institutions are invited to the symposium. This has resulted in excellent recruiting efforts from the institutions which were represented over the past few years.

Students who exhibit a strong interest in pursuing advanced education in QoLT are encouraged to work further with their mentors on their summer research projects to prepare a paper for peer-reviewed conferences and journals. Student attendance at conferences that have accepted the submissions is sponsored by the program. Each student turned in a research paper at the end of the summer as a required deliverable. However, generally these papers require significant revision before they are in a suitable form for submitting to a scientific or engineering conference. Eight of the 46 students from the 2007-2009 programs continued to work with their mentors on their research papers after they returned to school and submitted them to professional conferences. All, but one, were accepted by the conference review committees. Two of the papers have received prestigious paper awards. This transition from student researcher to author and representative at a conference serves as one of the most empowering trajectories from dependent undergraduate to independent researcher capable of communicating unique ideas and establishing a social network in the academic field.

The REU program is run collaboratively with other REU programs sponsored by NSF and other sources, allowing for an expanded cohort to enhance peer interactions and maximize staff resources. Social activities coordinated through a regional non-profit organization include kayaking on the Monongahela River, interviews with local leaders, a Pirates game at PNC Park, and a day at Kennywood Amusement Park. This creates a sense of community, networking, and

sharing across a multitude of REUs and industry interns in the Pittsburgh region. Additional entities such as the Office of Experiential Learning (OEL) at Pitt supports the housing needs and cohort building efforts of Pitt’s undergraduate summer research programs. Housing the REU students at Pitt is of particular value because the OEL houses other concordant REU programs. The cohort effect of co-locating these interns has been successful. The OEL also provides students with free access to library and computer privileges, student facilities (exercise rooms and sports centers), parking, and discounts at local restaurants and retail stores. Each summer OEL hosts an Ethics Forum where students work in groups with a mentor to prepare and present a paper on a topic related to ethics in the workplace.⁴

Student recruitment and selection

The QoLT REU program is advertised through the internet (e.g., email, listserv, website updates), social networking tools (e.g., Facebook and Twitter), and print media (e.g., newsletters, physical posters). A one-page brochure attached to an email advertisement is sent to faculty and staff collaborators in engineering and technical departments of undergraduate universities and colleges. Each year, efforts are established to create new contacts, particularly with minority serving institutions and small colleges and universities that have limited opportunities for research activities. In addition, QoLT faculty are encouraged to take recruitment materials to promote the REU program at professional conferences. The following eligibility criteria are used to create a well-balanced and prepared cohort: students must be US Citizens or permanent residents, be enrolled in an undergraduate program as a rising sophomore, junior or senior, and have a 3.0 QPA or higher. The number of applications rapidly increased over the first award cycle (27 in 2008, 70 in 2009, and 162 in 2010), which indicates that students are motivated to pursue disciplines such as QoLT that appeal to their social conscience and concern for people, and that recruitment strategies were improved and becoming more effective. As shown in Table 2, compared with the 2008 pool, applications were received from 50 more ethnic minority applicants, 48 more female applicants, and 10 more applicants with disabilities in 2010. The percentage of relevant majors also greatly increased, broadening the pool of applicants who were competitive for selection. As the 2010 applicants were so plentiful and of such high caliber and relevance, fifteen students were enrolled as opposed to the ten which were included in the original proposal. Based on an analysis of the applications received, the overall increase in size and quality of the applicant pool, especially in 2010, is attributed to both the broad and targeted recruitment efforts, especially the substantial connections made through minority recruitment conferences and sustained collaborations with organizations and colleagues who work with students from underrepresented groups.

Table 2: Summary Statistics for the QoLT REU Applicants

| | 2008 (105) | 2009 (140) | 2010 (322) |
|---------------------------------|------------|------------|------------|
| All Applicant GPA | 3.34 | 3.36 | 3.29 |
| Minority average GPA | 3.17 | 3.12 | 3.2 |
| Number of apps below 3.0 | 12 | 26 | 76 |
| Relevant majors | 66 (63%) | 126 (90%) | 300 (93%) |

| | | | |
|------------------------------|----|----|-----|
| Minority applicants | 21 | 33 | 90 |
| Female applicants | 42 | 54 | 120 |
| Disability applicants | 8 | 14 | 20 |

Experience has shown that targeted recruitment of minority students is often more successful and yields quality applications. A sustained relationship with minority faculty and organizations/programs targeting this population is the key to success. The following efforts have been made to ensure we are targeting all underrepresented groups:

- **Women Engineering Students:** An advertisement about the QoLT REU program is posted in the Society of Women Engineers (SWE) magazines and newsletters. Through the QoLT ERC, well established relationships with several female engineering faculty at institutions having a high enrollment of minority students has resulted in successful enrollment. Based on visits to our REU program final symposium and associated activities and tours, these individuals have agreed to funnel promising female minority engineering students into the program for years to come.
- **Racial/Ethnic Minority Students:** Faculty from LSAMP partner institutions with a high concentration of minority students serve as liaisons to help disseminate information the REU program and identify potential candidates. Additional collaborations with the NSF Advancing Robotics Technology for Societal Impact (ARTSI) Alliance Project serve as a source of recruitment thanks to QoLT faculty who deliver talks in their faculty workshops and use this opportunity to promote the program. ARTSI is a partnership of several Historically Black Colleges and Universities (HBCUs) and Research I institutions, including Pitt and CMU. Relationships are formed through other NSF flagship diversity programs. For example, the QoLT REU program has agreed to host Puerto Rican students from the NSF sponsored Caribbean Robotics League. In addition, the QoLT REU program coordinator attends two conferences each year among the annual HBCU for Undergraduate Participation in Science, Technology, Engineering, and Math (STEM) conference, the Florida-Georgia LSAMP Expo, the Annual Conference of the National Society of Black Engineers, and Advancing Hispanics/Chicanos and Native Americans in Science. Program information is disseminated at those events and networking relationships are formed with interested faculty and programs.
- **Students with Disabilities:** Recruiting students with disabilities (SWDs) is challenging. Conversations with applicants with disabilities who are not local to the Pittsburgh area have expressed that although their interest in participating in the REU program is quite high, it is a hardship for them to travel to/from Pittsburgh and relocate to a new place for 10 weeks. Many of them also rely daily on family members to assist them with routine activities. Based on this, and other prior knowledge, strategies for recruiting SWDs have four foci:
 - It is ensured that support mechanisms for SWDs are in place efforts are made to create new resources. Pitt's RST program has a high concentration of persons with

disabilities; 21% of faculty and 14% of graduate students are persons with disabilities. As such, student interns with disabilities are exposed on a daily basis to people who use assistive technology on the job and in their daily lives. The Center for Assistive Technology (CAT) is also supportive of student interns with disabilities in terms of repairing, adjusting, and loaning assistive devices. All the research facilities of the QoLT ERC at CMU and Pitt are wheelchair accessible. Pennsylvania Hall, where the REU students are housed, is also equipped to accommodate wheelchair users. RST faculty identify quality caregivers who can provide personal assistance to SWDs during their internships.

- National programs and organizations serving SWDs such as the Workforce Recruitment Program (WRP) under the Department of Labor's Office of Disability Employment Policy, host a database containing 1600+ SWDs from a variety of disciplines looking for temporary and permanent employment opportunities. A similar service is provided through the Entry-Point program of the Association for the Advancement of Science, with contact information for approximately 110-120 SWDs. The NSF Midwest Alliance for SWDs, a consortium of three universities working to increase the quantity and quality of SWDs in STEM fields, shares our program information with its constituencies and offers additional suggestions on effective dissemination channels.
- SWDs are also recruited locally. By attending disability support group meetings and talking with organizations such as Easter Seals, Three Rivers Center for Independent Living, and United Cerebral Palsy, successful recruitment of SWDs has occurred. Rehabilitation engineers working at CAT who prescribe computer access devices to college-bound SWDs also share QoLT REU program information. Tech-Link, a QoLT center outreach initiative which links middle school and high school SWDs to careers in STEM through job shadowing, robotic camps, and internships with local businesses, plants a seed in middle and high school students about the REU program. Four SWDs in the past who were Tech-Link robotic campers and are now in college have participated in the REU program and solidified their career and/or graduate school plans in associated disciplines.
- Recruitment efforts to veterans with disabilities are emphasized. QoLT REU's partner internship program, ELeVATE (Experiential Learning for Veterans in Assistive Technology and Engineering), an initiative designed to re-integrate veterans with disabilities to higher education, is also funded by NSF.

Students interested in the REU program must submit the following documentation by March 1: (1) an application form; (2) a resume; (3) academic transcript; (4) an essay that describes their general research interests and previous experience/training, particular interest in QoLT, graduate school plans, and how participation in the REU program will contribute to their academic and professional development; and (5) one letter of recommendation from a faculty member of their institution. Due to the large volume of applications, the Co-PIs and coordinator first screen the applicants based on the academic background and eligibility criteria. They then organize a review committee comprised of two QoLT faculty members and three graduate student representatives from the QoLT Student Leadership Council. A scoring system is used that takes

into consideration the QPA, interest in QoLT, interest in advanced degrees, volunteer experience, minority status (e.g., female engineering student, racial/ethnic minority, SWD, student from non-research institutions such as community colleges) and previous research experience. The committee uses the scoring system and selects 2-3 candidates for each participating faculty based on students' backgrounds and their interests in the research projects provided by the participating faculty. Faculty or graduate-student mentors conduct phone interviews with the candidates and make final selections for their projects.

REU program participants

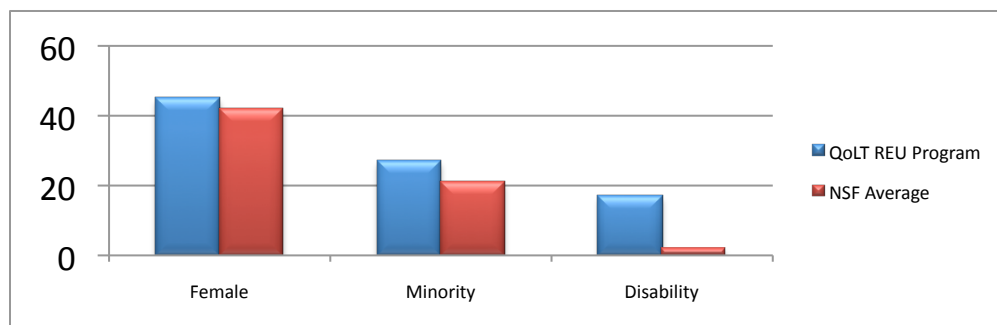
As a result of recruitment efforts, forty-six students have participated in the QoLT REU programs since 2007, with approximately 55% of them being African-American, Hispanic or a student with a disability as shown in Table 3. They represent 32 unique institutions with a majority of students from non-local institutions ranging from small colleges and universities (e.g., Rose-Hulman Institute of Technology, Slippery Rock University, Edinboro University) to large institutions (e.g., University of Illinois, University of South Florida, Arizona State University). Twenty-one (46%) students were rising Sophomores or Juniors. Thirty-two students (70%) were majoring in engineering (biomedical, mechanical, computer, industrial, or electrical) and the other students were majoring in rehabilitation sciences, computer science, math/physics, or other science fields. Although only 10 students were budgeted in both 2009 and 2010, due to increased faculty interest and so many high-quality student applicants, the REU budget was supplemented to accept six more students into the program.

Table 3: Summary Statistics for the QoLT REU Participants

| Year | Students | Females | African Americans | Hispanics | Students with Disability |
|--------------|-----------------|----------------|--------------------------|------------------|---------------------------------|
| 2007 | 10 | 6 (60%) | 2 (20%) | 2 (20%) | 2 (20%) |
| 2008 | 10 | 6 (60%) | 3 (30%) | 0 (0%) | 1 (10%) |
| 2009 | 11 | 4 (36%) | 2 (18%) | 3 (27%) | 3 (27%) |
| 2010 | 15 | 3 (20%) | 2 (13%) | 2 (13%) | 3 (20%) |
| Total | 46 | 19 (41%) | 9 (20%) | 7 (15%) | 9 (20%) |

These figures are notable as demonstrated in Figure 3 below due to the comparison between the QoLT REU program demographics and the other NSF REU programs in the Engineering domain.⁵

Figure 3: REU Program Demographics: Percentage of Females, Ethnic Minorities, and Students with Disabilities in the QoLT REU Program Compared with NSF Engineering Directorate REU Program Average



Program evaluation

Formative and summative assessments are conducted at several phases of the program including recruitment, internship training, and post-internship follow-up. In terms of assessing program awareness and recruitment, two primary questions are addressed: (1) How effective are the strategies used to advertise the REU program? (2) How successful are recruitment strategies in securing diverse students? Recruitment materials and procedures are reviewed annually; additionally, applications are reviewed for demographic data and the sources through which the applicants found out about the REU program.

The REU coordinator talks with the students weekly to ensure that they are getting the most out of their experience and that their needs and interests are being met. Throughout the internship, frequent meetings occur between faculty and graduate student mentors to ensure adequate communication is taking place between the mentors and REU students.

In terms of assessing the REU experience from the perspective of an REU student, a few guiding questions are: (1) What are the students' expectations and were they met? (2) How much the internship increased their knowledge and understanding of QoLT? (3) How well the program was organized and delivered (e.g. adequate interactions with mentors, availability of resources, educational value and usefulness of the professional and cohort activities etc.)? (4) How well the program prepared them for graduate schools or professional careers? Based on these guiding questions, pre- and post- surveys are created for the REU students. The face and content validity of these surveys are examined by collaborating faculty who are experts in survey research. The surveys are revisited annually to account for programmatic changes. The surveys include approximately 40 items. Some items appear only on the pre-survey, such as those aimed at identifying their motivation for participating in the QoLT REU, and likewise some appear only on the post-survey, such as suggested program modifications and whether they would recommend the internship to other students. Other items directed at assessing students' current sense of self, skills, and long-term goals appear on both pre- and post-surveys to determine if students' opinions have changed as a result of the program. Over the past four years (2007-2010), 96% of the students stated that the internship met or exceeded their expectations and 98% stated that they would recommend the REU to other students. Eighty-seven percent of the students stated that this internship increased their knowledge of both the field and the research process. Eighty-nine percent of the students were very satisfied with their lab resources. Ninety-three percent of the students were happy with the social opportunities between interns. Eighty-

five percent of the students felt they received adequate instructions from their faculty advisors and graduate-student mentors. Figures 4-5 demonstrate the change in students' opinions before and after and Figure 6 shows the high level of student satisfaction with the program overall.

Figure 4: Knowledge in Assistive Technology Domains: Percentage of Students' Assessment Before and After Program

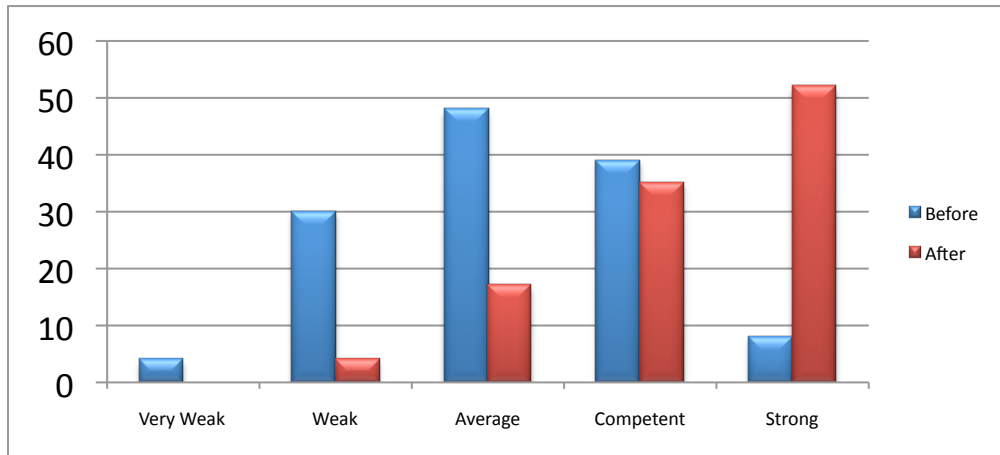


Figure 5: Confidence in Succeeding in Graduate School

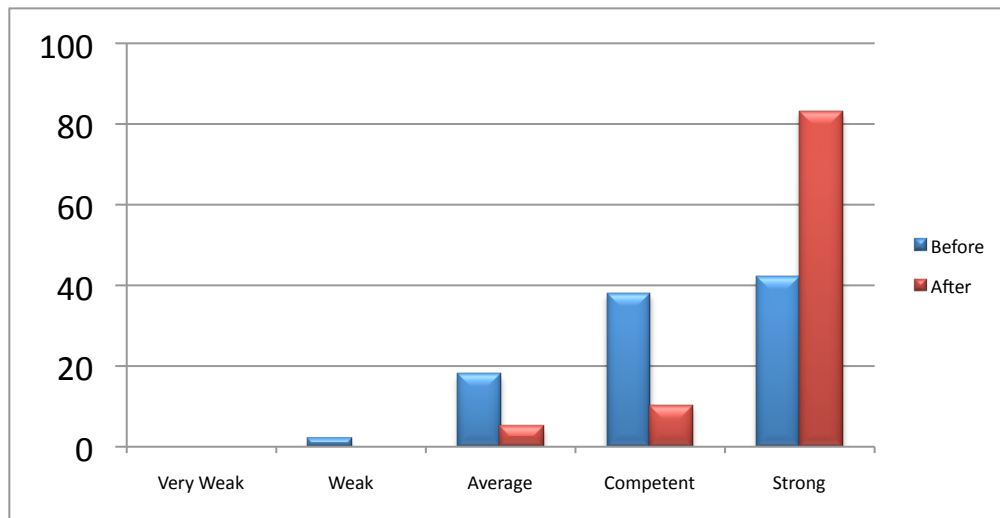
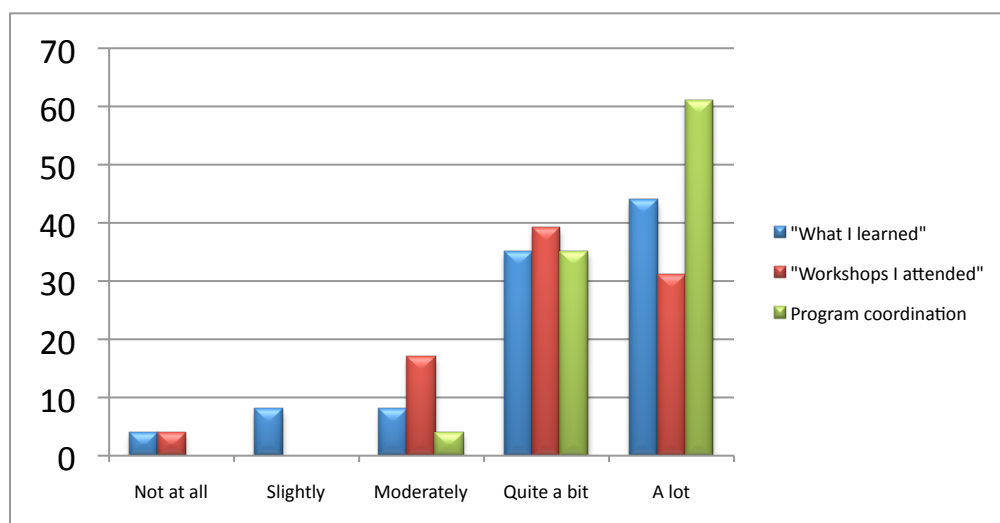


Figure 6: Students' Overall Program Satisfaction in Terms of Amount Learned, Workshops Attended, and Program Coordination



In terms of assessing the REU experience from the perspective of faculty advisors and graduate-student mentors, a separate survey is administered at the end of the program to obtain their view of the program as well as to track publications that were submitted and/or are in preparation with undergraduate student involvement, and any product designs that were developed through the REU program. All of the survey tools are web-based forms linked to a Microsoft Access Database, allowing for direct data entry, ease of tracking program outcomes, and electronically storing the data. Information gathered from these surveys are compiled and shared with the REU Directors, faculty/graduate student mentors, and other interested faculty, staff and administrators. The results (2007-2010) indicate that both the graduate-student mentors and faculty advisors were pleased with the structure of the program in terms of the frequency of workshops and assignments, as well as the time the students spent working in the lab. Most of them (85%) felt that their students were willing to try new skills and produced high quality work. Overall, the mentors felt that both the students and their final projects met their expectations at a rate of over 90%. Feedback has suggested that activities at the end of the program should be limited and deadlines should be managed in an effective way to track student progress. All mentors provided students with a Gantt chart on the milestones that should be reached. All important information such as program activities, milestones, and deadlines was incorporated into a Google calendar to which all mentors and students have access. The program has been gradually refined and improved over the past years based on the evaluation results and feedback from mentors and REU students after each summer. Several program revisions have occurred including:

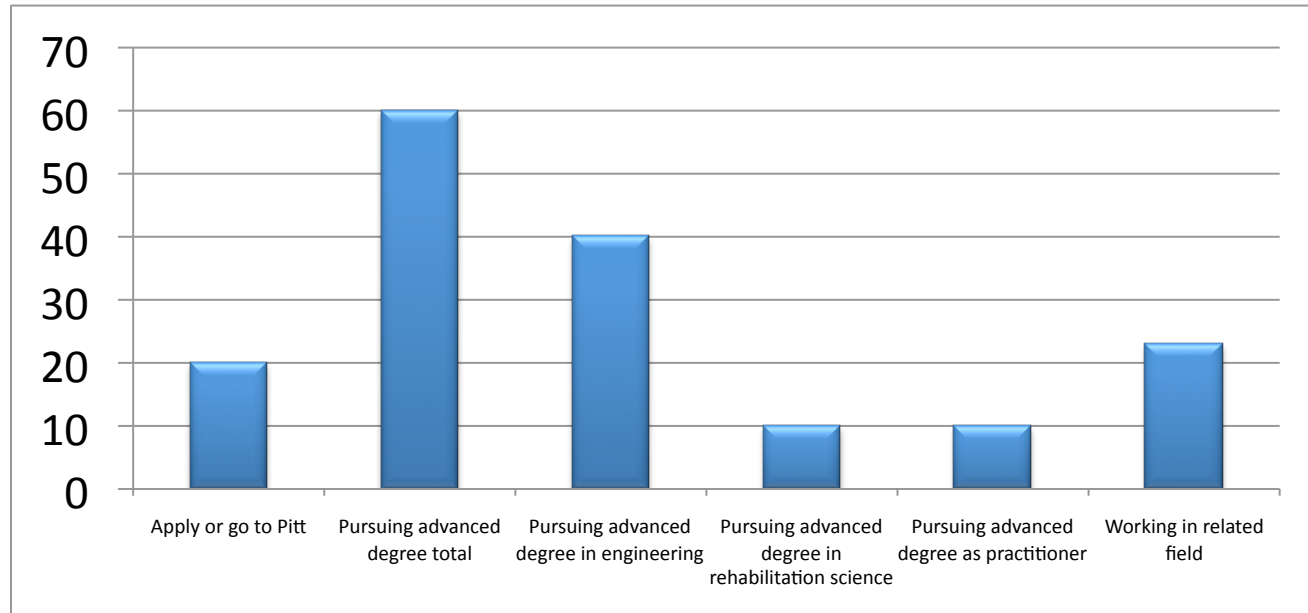
- A coordinator was assigned to the REU program starting in 2008 to monitor students' progress and serve as an immediate point of contact for the students. The coordinator is also integral to recruitment, program evaluation (including follow-up), and program reporting.
- A site visit was conducted at each research lab to ensure that students would have adequate space and resources available to them over the course of their internship.

- The method of student selection was modified to include a panel of reviewers who would select 2-3 students from the applicant pool for the mentor to review and conduct phone interviews with the students. Mentors then selected the student they wanted to work with.
- Mentors establish contact with the intern prior to arrival to discuss the expectations from both ends and provide students with preliminary information including a list of tasks to be accomplished and other materials to help them prepare for the project tasks.
- A mentor orientation is conducted prior to the students' arrival, to underscore the importance of providing students with realistic expectations and goals, inform them of the expectations of the students in terms of the REU program goals, and provide strategies for effective mentoring of undergraduate students.
- A "coin" was given to each student to increase student/faculty interaction outside of their particular research experience. Student could redeem their coins with a faculty member for lunch or a chance to learn more about his/her lab, career path, or research in general.
- A weekly REU student e-newsletter was sent to all students, mentors and others at the various research labs to inform them of the upcoming activities and deadlines. A fun fact about Pittsburgh or QoLT ERC was also included and a student was named "intern of the week" in each newsletter.
- Activities were hosted at various physical locations to allow students to spend some time at all the different research sites involved.
- The career workshop, first implemented in 2007, was modified beginning in 2008 to bring in more professionals with whom the students could network, and change the format to be more interactive. Instead of formal presentations, professionals were grouped into panels and students were split into small groups and rotated through the panels for more intimate and interactive discussions.
- All students participate in a local conference such as the International Symposium on Quality of Life Technology or the annual Institute for Rehabilitation Research conference. The students publish a summary about the events in the center or departmental newsletter.
- A more comprehensive undergraduate research symposium was organized to showcase the students' research in a more formal setting, including oral and poster presentations, with awards for best presentation and best paper. Starting in 2009, the students' advisors from their home institutions and faculty from minority-serving institutions were invited to attend. This has fostered relationship building with institutions where we previously had little or no contact.

The QoLT REU program is dedicated to longitudinal data collection and meaningful analysis of how the experience has an impact on students' self-identification with technology, engineering and QoLT-related career options. A web-based form collects follow-up information from all previous participants. The data captured include if and where they pursued graduate studies and also where they are employed if working. Before the students leave the program, they are asked to provide a permanent contact where they can be reached in the future. Every year an email with the link to the follow-up form is sent to them with a 'read-receipt' flag to notify coordinator if/when they receive it. As an additional incentive for responding, they are rewarded with a small

gift. Another effective method is sending prior REU students the QoLT Center and associated departmental newsletters, which highlight research and other activities of the center including the REU program. Students who do not respond are called and interviewed over the phone. As demonstrated in Figure 7, of the 23 QoLT REU students that have graduated to date, 20 (91%) of them have been reached. As demonstrated in Figure 7, twelve (60%) of the students are pursuing graduate degrees and four (20%) of the students are attending either CMU or Pitt for an advanced degree.

Figure 7: Previous Participants' Current Status



Notably, two of the students from underrepresented groups (one Hispanic student and one female engineering student with a disability) worked as interns under the Personal Mobility and Manipulation Appliance (PerMMA—a power wheelchair with robotic arms) project at the Human Engineering Research Laboratories in 2009 and now have become part of the PerMMA team as graduate students.

Ten (48%) of the students decided to work after completing their baccalaureate degrees as demonstrated in Figure 7. Three of these students are working in healthcare technology. One student from the 2007 cohort who worked with QoLT faculty on a safe driving system for persons with reduced cognitive functioning, reported that she received her first job based solely on the experience she gained with sensors through the QoLT REU program. She is now working at a company that develops sensing technology similar to what was incorporated into the safe driving project and, in addition, is pursuing an MS degree in Electrical Engineering.

The data reveals the profound effects our program has had on students, especially those with disabilities, and which components (e.g. role models and career exposure activities) are particularly effective. One student with a disability from the 2009 cohort considers the REU to have had a significant impact on her life and exemplifies the goals of the QoLT REU program in every aspect. Her comments about how the REU program affected her future goals are included below:

My experience in the QoLT REU was truly a unique experience for me. I had many opportunities to do and experience things I had never had before. One was an environment where disability is fully accepted and is very much part of the normal everyday experience in the lab. Being part of a much larger group and not a minority is not usually part of my experience. It was also neat to be able to have a mentor who also had a disability. He gave me someone to look up to who is doing exactly what I want to do and to truly allow me to see the possibilities. Also being able to watch him present several times taught me how to handle presentations from my wheelchair in ways that no other professor at my school could. This summer also gave me the opportunity to mentor someone else helping an intern who was just about to go off to college learn some of the independent navigation skills to be active in the community by herself.

On the technical side, I was given a chance to see the field of Assistive Technology at work and allowed me to finalize my decision to pursue AT in not only a Masters Degree level but at the PhD level. Through the work on a Smart Controller for Electric Powered Wheelchairs, I learned many new skills in the areas of Printed Circuit Board design and construction, allowing me to more efficiently build boards for the senior design project at college.

Lastly was the exposure to the disability sensitivity modules provided through the REU workshop series which gave me opportunities to transfer those methods and topics of teaching to programs I am initiating on my college campus. Currently the programs I have created are for faculty and staff and hopefully will expand into the entire campus population.

Assessment efforts have also been implemented to understand the benefits of undergraduate research in expanding students' interest in STEM graduate education and careers. In order to closely examine the impact of the program, and get more rich feedback similar to the student's above, a qualitative study on the 2009 REU cohort with the help from the Person and Society Thrust of the QoLT ERC has been conducted. A faculty member with expertise in qualitative research in that group completed semi-structured interviews with randomly selected students and mentors on their perceptions of the REU program and progress of the REU projects in the beginning, middle, end of the program, in addition to one-year follow-up interviews with these students. Data analysis revealed several themes. For example, the REU program 1) positively shapes students' interest in graduate school and careers in STEM; 2) fosters in students a heightened awareness of themselves and others, especially those who have a disability or are from a different ethnic background; and 3) effectively translates skills to benefit students beyond the REU experience including enhanced capacity in technical writing, appropriate professional behavior, and effective collaboration with others. Program components that support each theme through frequent student responses on the evaluations were identified. For example, the value of career workshops was viewed as a way to shape interest in a particular professional pathway, having persons with a disability as role models heightened the awareness of diversity among the REU students, and participating in a symposium was important for practicing professional behavior. These themes along with the identified program components ensure students leave the REU with the highlighted changes in behavior and skills.

The 2010 REU cohort participated in a R01 study "Efficacy Interventions to Promote Research Careers" funded by the National Institute of Health. The purpose of the study is to evaluate a tailored intervention based on social cognitive theory to increase self-efficacy for conducting research in minority and non-minority undergraduate and graduate students. The intervention was delivered to 12 pairs of QoLT REU mentors (either faculty advisors or graduate-student mentors) and students in one of the three formats, i.e., face-to-face workshop, online booklet, and video training in this summer, and baseline data including perceived self-efficacy for research, career goal statements, weekly logs of time spent and activities shared with mentors were collected. They will be followed up 3 months and 6 months later. The study will yield important

data on mentoring, inform mentoring practices and increase the current understanding of mentoring relationship factors that divert students from research or other careers in science.

Plans for the future: Experiential learning for veterans in assistive technology and engineering (ELeVATE)

The success of the QoLT REU program has led to the development of ELeVATE, a program designed to assist in veterans' transition to college. The program was funded in 2010 and will begin its first cohort in the summer of 2011. The foundation created by the QoLT REU program which has proven to not only increase students' self-efficacy, but also confirm interest and engagement in engineering and technological disciplines through career exposure activities will be modeled. Supplementary workshops will provide the necessary remediation to succeed in the program and beyond. New activities created for veteran students, especially with a focus on vocational and rehabilitation support, will prepare this population for their successful transition to college. The REU mechanism which in addition to the aforementioned benefits, develops a support network for students, will be expanded through the academic year for the veteran participants. Study groups, benefits assistance, and counseling opportunities will supplement the experiential learning aspects of the program. The activities are designed to increase self-efficacy and outcome expectations which will encourage participants to apply to engineering programs. Once enrolled, support activities will help participants achieve their performance sub-goals and persist through engineering degree programs which will ultimately result in enrolling in graduate school or obtaining an engineering career.

Though ELeVATE will only begin in the summer of 2011, its foundations are deep rooted in the success of QoLT's REU program which has advanced underrepresented students through the STEM pipeline and delivered a promising model. Assessment efforts developed through the REU program will be adapted to evaluate this cohort with the goal of contributing towards the bodies of literature surrounding experiential learning, veterans in STEM education, and retention and promotion of underrepresented students in STEM.

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