# AC 2009-2238: RESEARCH, COLLABORATION, AND INTERCONNECTED OUTREACH FOR UNDERREPRESENTED GROUPS

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#### Research, Collaboration and Interconnected Outreach for Underrepresented Groups: Success from RET and REU Collaborations

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#### Abstract

Recruitment and retention of underrepresented groups in STEM education continues to be a national challenge. Accordingly, the National Science Foundation (NSF) has required award recipients within the NSF's Division of Engineering Education to create pipeline opportunities for underrepresented students to enter university STEM programs. Outreach through Engineering Research Centers (ERCs) is one such effort. This paper describes a mixed methods research endeavor that addresses this engineering challenge and one engineering research center's response to recruiting underrepresented groups into biomedical engineering using two broadly defined pipeline efforts: (1) teachers in K-12 via a Research Experience for Teachers program and (2) undergraduate students via a Research Experience for Undergraduate Program. This research involves providing collaborative research and training opportunities for middle and high school teachers in urban settings and undergraduate engineering and science students from institutions with underrepresented students and the assessment of learning from this collaborative experience. Four assessment metrics were used to judge the success of this collaborative project: (1) A STEM efficacy scale, (2) a collaborative research and leadership measure, (3) a rubric for laboratory presentations and lessons and (4) a collaborative focus group interview. Findings from these metrics indicate that both the undergraduates and the K-12 educators became more efficacious from the collaborative research (mean increase = 1.94) and training effort. Both groups also measured having capacity interdisciplinary research opportunities and shared leadership as well as high quality research practice. Additionally and qualitatively, the groups reported significant benefits from the experience. The groups gained a mutual understanding of the needs of underrepresented groups in research settings. Further, the teachers gained an understanding from the undergraduate students of what it takes to guide underrepresented students in to engineering and science fields. The undergraduates gained leadership and presentation skills as they were mentored through this by the K-12 teachers and university faculty. This experience proved to be highly impactful for both students and teachers and is beneficial in providing insight for university faculty regarding guiding underrepresented groups into STEM education at university levels in addition to retaining them in STEMs programs and careers.

# Keywords: teachers, teacher efficacy, underrepresented groups, engineering educational outreach

#### Introduction

Recruitment and retention of underrepresented groups in STEM education continues to be a national challenge. Accordingly, the National Science Foundation (NSF) has required award recipients within the NSF's Division of Engineering Education to create pipeline opportunities for underrepresented students to enter university STEM programs. Outreach through Engineering Research Centers (ERCs) is one such effort. This paper describes a mixed methods research endeavor that addresses this engineering challenge and one engineering research center's response to recruiting underrepresented groups into biomedical engineering using two broadly defined pipeline efforts: (1) teachers in K-12 via a Research Experience for Teachers program and (2) undergraduate students via a Research Experience for Undergraduate Program. This paper answers the following research questions: (1) What role does the collaborative REU-RET research experience play in providing teachers and undergraduate engineering science students from underrepresented minorities (URMs) with exposure to and experience with innovative biomedical engineering research? (2) What are the impacts of a collaborative RET-REU program on undergraduate STEM students' and STEM teachers' professional and educational experiences? (3) What metric comparisons can be made between REU and RET experiences?

#### **Motivation and Background**

This collaborative research experience for teachers and undergraduates program's focus on biomedical engineering is motivated by our desire to use engineering to develop a research effort that advances biomedical technologies with the goal of improving world health. As physicians and engineers, we believe that a most of the solutions for this must emerge through biomedical engineering research. One purpose of this collaborative REU-RET approach is to establish a strong outreach program at USC that enables undergraduates and urban teachers to both understand and fully participate in potentially world changing research that offers solutions for seemingly unsolvable problems in engineering and medicine.

Two essential strengths of the REU-RET collaborative program are the fact that it has attracted non-traditional engineering students into engineering research and it has made urban teachers aware of the importance of embedding this research in their classroom curriculum. Students from all backgrounds readily understand the importance of developing advanced biomedical technologies to improve world health. Our REU-RET program has a problem-based focus with health related solutions at its core. We have identified additional characteristics of biomedical engineering research that we believe makes it a compelling and beneficial research focus for undergraduate students and for urban STEM teachers. Biomedical engineering research is interdisciplinary, encourages communication, is collaborative, has a bioethics focus and is solutions focused. Biomedical engineering research addresses global concerns, encouraging international collaboration, and ethical and contributory behaviors in students and teachers.

The field of biomedical engineering is a significant need. The United States Department of Labor reports, "The number of biomedical engineering jobs will increase by 31.4 percent through 2010---double the rate for all other jobs combined." <sup>3</sup> Overall job growth in this field will average 15.2% through the end of the decade. The U.S. Department of Labor report attributed the rapid rise in biomedical engineering jobs in part to an aging U.S. population and the increasing demand for improved medical devices and systems. Specific growth areas cited in the report included computer-assisted surgery, cellular and tissue engineering, rehabilitation, and orthopedic engineering. Accordingly, it is essential to increase the number of K-12 and undergraduate students in to this important engineering field. This can happen at two levels, by recruiting undergraduate students from other colleges and universities to join biomedical engineering (BME) graduate programs and by training teachers to inspire their students to enter biomedical engineering through exposing them to excite BME research.

We believe that locating the REU-RET collaborative biomedical research opportunities for undergraduates at a major urban research university is important for several reasons. The campus is located in the center of a vibrant, multi-cultural urban environment, which makes it appealing to students with a wide range of backgrounds. Examples of state of the art practice in biomedical engineering and health are readily available in the region via our industry and community partners. Many engineering research opportunities exist locally for students in the program. Our industry partners working with our ERC contribute during the program and provide opportunities for employment after REU students complete their engineering program and provide real life examples of engineering practice for RET teachers to bring to their classrooms.

#### **Our Collaborative Approach**

As previously described, this paper describes a mixed methods research endeavor that addresses the challenge of recruiting engineers to the field and one engineering research center's response to recruiting underrepresented groups into biomedical engineering using two broadly defined pipeline efforts: a Research Experience for Teachers program and a Research Experience for Undergraduate Program, our REU-RET collaborative. This research involves providing collaborative research and training opportunities for middle and high school teachers in urban settings and undergraduate engineering and science students from institutions with underrepresented students and the assessment of learning from the collaborative experience.

# **Essential Elements-The Research Experience for Undergraduates**

Our biomedical REU program is organized to address goals consistent with both the intent of the NSF REU requirements, as well as the educational and research philosophy of the engineering research center in which the undergraduates participate in research. It has three major programmatic goals: (1) To provide biomedical engineering research training experiences to talented undergraduates, with an emphasis on training women and members of underrepresented minorities, to develop a diverse, internationally competitive, and globallyengaged biomedical engineering workforce. (2) To provide hands-on laboratory experiences for undergraduate student participation in cutting edge biomedical engineering research facilitating the learning of research methods, laboratory skills, and problem solving in premiere research labs with BME foci. (3) To facilitate learning beyond biomedical science with community-based outreach foci with training on issues related to research ethics, organizational skills and oral and written communication. The engineering research activities and associated outreach enable REU students to build skills useful in the summer and for years to follow in areas including BME, communications, ethics, and problem solving. We provide an opportunity for international, interdisciplinary collaboration at our university, and we insure that students recognize that biomedical engineering technologies apply across spectrums of human activities including personal lives, STEM careers, K-12 outreach, and overall societal health improvement.

The program provides students nationally with the opportunity to work with individual scientists on projects central to the research activities at our University's School of Engineering and School of Medicine sharing a well-defined common focus. We have designed the REU program to provide a coherent group research experience within and beyond summer sessions, together with high quality educational experiences that develop students' community responsibility via leadership, ethical behavior, and BME engineering knowledge. The program utilizes an interdisciplinary problem-based, community focused approach. This provides students with understandings that engineering research applies to real-world problems requiring Interdisciplinarity and providing community impact for improving health and wellbeing. Figure 1 illustrates our interdisciplinary research focus and connection to the ERC, engineering education, and local communities nationally.



As a part of the application process for the REU, students are guided in their selection of research areas and they are matched to Ph. D. student-mentors and K-12 teachers in their chosen specialty. When the REU students arrive at USC, at the start of REU program, they are identified as a group that is working together on a challenging, interdisciplinary biomedical engineering problem. Throughout the program, collaborative meetings will ensure that the students understand how their specialties in relation to the larger challenge.

REU students meet on a weekly basis with a program coordinator and faculty members to debrief and offer feedback on the previous week's activities. Weekly meetings are scheduled so that the REU students can share with their colleagues the knowledge and skills they have gained in biomedical engineering and technology and share their research experiences activities. During the final week of the summer program, the REU students give a presentation of their research experience. They work with their mentor and K-12 teacher partner to create this presentation. All REU student-mentors, PIs, K-12 RET teachers and senior researchers attend these presentations.

Essential Elements- The Research Experience for Teachers

Our RET program leadership team selects a cohort of middle and high school STEM teachers from partnering inner-city area schools which primarily serve disadvantaged and minority students. A total of 6 teachers have been selected each year to participate, with between 2 and 4 teachers recruited from any one school, in order to nurture sustainable teams. Teams of two teachers were placed, based on research interest, in a university engineering laboratory that is conducting research using societally relevant health related biomedical engineering technologies. Research in biomedical engineering, telemedicine, and prostheses are examples of such societally relevant engineering research aimed at alleviating societal challenges including health outcomes and disability.

Organizationally, each two-teacher team is matched with a Ph.D. student and an REU student in the given laboratory, for direct daily interaction, and for facilitating bi-directional expertise transfers between the teachers and the Ph.D. student mentors. Graduate student mentors undergo a two-day orientation to prepare to work with the pre-college teachers and REU students prior to their arrival to the program. The orientation used the guide Advisor, Teacher, Role Model and Friend: On Being a Mentor to Students in Science and Engineering published by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (1997), to familiarize the graduate students with features that are common to successful mentoring relationships, especially for mentoring in the science and engineering fields. The goal is to encourage mentoring habits that are in the best interests of both parties in the mentor relationship. Undergraduate students pair with engineering graduate students to develop shared expertise in preparation the REU-RET.



Figure 2: Teacher Lesson Study

The RET teachers' research experience consists of a structured six-week summer program in the School of Medicine and Engineering laboratories, with teachers directly immersed in NSF-sponsored research activities, collaborating with faculty members, REU students, Ph.D. students on appropriate aspects of their

investigations. To facilitate this teacher-lab matching process, the teachers participating in the RET program were sent pointers to web sites

summarizing the participating research projects one month before the start of the program. The 6-week RET summer program commences with a 2-day teacher orientation. Day 1 begins with the teachers being introduced to the participating engineering laboratory principal investigators, REU students, and graduate student mentors. The participating engineering faculty will showcase their respective areas of research. Baseline data critical to the assessment and evaluation of the RET program is collected in the afternoon of Day 1. On Day 2, teachers tour the RET faculty research laboratories. Following the tours, teachers are matched with engineering faculty, REU students and laboratories, and paired with graduate students based on the teachers' research interests. In the afternoon of the second day, teachers go through a training course in laboratory safety. Besides working together in the labs, the teachers, REU students, and Ph.D. students mentors meet regularly to review, network, compare experiences, and address issues. The RET teachers also meet separately (weekly) to engage in collaborative lesson study and curriculum planning. Weekly time is also be allotted for helping the teachers to develop best practice pedagogy towards teaching science in their respective schools, under the supervision under the supervision of a curriculum team. The teachers have weekly meetings for planning how their research experiences will be translated into K-12 curriculum modules which introduce their students to societally relevant health related engineering and relate lesson plans and activities to state and national science and math standards using a lesson study approach. Lesson study, according to James Stigler (2005), refers to a professional development process whereby teachers closely examine their lessons with a focus on addressing student need via data-driven decision making, creating powerful and relevant curricula and reformed designed lesson creation. Lesson study goes beyond collaboration to co-planning and observing actual lessons with a focus on student thinking. In the lesson study model, teachers learn together. Participants plan, observe, and refine "research lessons" designed to make real their long-term goals for student learning and development. A key, concrete component of lesson study is the observing and teaching of lessons, which are improved collaboratively. This compels teachers to examine their own practice in depth in the context of student learning, connects them with their students and their professional community, and inspires them to improve continually. This model of teacher professional development has been applied widely and successfully in Japan and has

recently been initiated by teachers at many sites across the U.S. For the purpose of the summer experience, participant teachers "study" lesson exemplars using the lesson study cycle. Figure 1 illustrates the lesson study cycle (Stigler 2006).

Two major lesson structures are utilized for the curriculum planning and lesson study. These are the learning cycles approach and inquiry based learning, both approaches that are powerful pedagogical structures in teaching. Anderson and Krathwohl's (2001) learning taxonomy is used to guide instructional objective creation and pedagogy development. The teachers also utilize principles from Bransford's (1999) How People Learn to develop scientific curricula that are theoretically aligned to learning principles. As a follow-up structure, the RET program has developed a comprehensive web portal where participating teachers engage in "virtual" lesson study and post their research activities, summaries of their experiences, and implementation plans for translation to the K-12 classroom. The web portal includes instructional materials where K-12 teachers nation-wide can engage in interaction related to the research that the SRET-RET teachers participated in directly during their summer experience.

#### Collaboration Between the REU and the RET

Primarily, collaboration between the RET and REU students occurs both in the laboratories and in industry and other collaborative site visits and associated social experiences with both groups. The REU and RET participants are paired with shared Ph.D. mentors in labs. Collaboratively, they explored and participated in compelling and innovative biomedical engineering research. They discussed communication strategies and discussed critical elements of their research presentations. They also visited industry partners so that they could experience engineering practice in action. They discussed these important visits. Additionally, they had some social experiences including lunches and other field trips that allowed them to get to know each other outside of the labs.

#### Assessment of the Collaborative Experiences: Measuring Impact

Various assessment instruments for this collaborative REU-RET experience were devised to (1) create a profile of the two participant groups and to (2) provide a means by which the participant outcomes could be measured and compared when appropriate across groups.

Four assessment metrics were used to judge the success of this collaborative REU-RET project:

- Focus Group Interview The interview serves as a posttest measure of the participants' perceived success of the program –focus is on changes in reaction, attitudes, and knowledge, and plans to implement curriculum resulting from the experience in addition to the teachers' and students' judgments of the program's success.
- Science Teaching Efficacy Beliefs Instrument (STEBI): This instrument is a teacher only metric and is a measure that assesses the teacher's efficacy in teaching science to middle school and high schoolers. It includes personal science teaching efficacy and science teaching outcome expectation, delivered post-test to all RET teacher participants and compared to non-participant science teachers that match the participant teachers demographically. Control teachers were recruited as volunteers from the participant teachers' school sites.
- Biomedical Engineering Efficacy Instrument- This is a student specific metric and measures students' self-perception of potential for success in biomedical engineering. (situation specific) Adapted from Computer Science Efficacy Scale (Quade, 2001), this instrument

aligns with and correlates to students' retention rates and success in coursework. It employs a 6 point Likert type scale and has 25 items that are clustered in six subscales: Problem Solving Confidence ( $\alpha = 0.79$ - based on adaptation;  $\alpha > 0.70$  indicates reliable measure); Trouble Shooting Confidence ( $\alpha = 0.84$ ); Career Encouragement ( $\alpha = 0.71$ ); Career Exploration ( $\alpha = 0.72$ ); Course Anxiety ( $\alpha = 0.78$ ).

- A Collaborative Research and Leadership Measure- This is a 6-point Likert type scale provided to both the teachers and the undergraduate students that measures multidisciplinarity, power of research experience and leadership. It is aligned to the National Academy of Engineering's Grand Challenges and the NAE's Engineers for 2020.
- Rubric for Laboratory Presentations and Lessons- This rubric, also aligned to Engineer's for 2020, assesses the teachers' and REU students' research presentation (and in the case of the teachers, their lesson plan quality.

# Results

This paper presents results of the RET and REU program in two areas: the participant teachers and their perceived impact on the students that they teach. At this point in the data analyses, due to the fact that the program is in year 3 of implementation with few participants (N=8 teachers and 16 students), multiyear comparisons and multivariate analyses are not yet possible and will not be presented as the sample size is still relatively small and not all data sets have been collected. Accordingly, descriptive statistics and qualitative analyses associated with the available data sets are illustrated and described.

# **Teacher Related Results**

# Science Teaching Efficacy

The Science Teaching Efficacy Beliefs Instrument (STEBI) is an instrument based on Bandura's definition of self-efficacy as a situation-specific construct. The instrument was developed by Riggs and Enochs <sup>7</sup> to measure efficacy of teaching science. The STEBI consists of 23 statements which are divided to provide two sub-scores, which are randomly embedded in the instrument. Thirteen of the statements yield scores for the Personal Science Teaching Efficacy (PSTE) subscale, which reflect science teachers' confidence in their ability to teach science. The remaining ten statements yield scores for Science Teaching Outcome Expectancy (STOE) subscale, which reflect science teachers' beliefs that student learning can be influenced by effective teaching. Participants used a five-point Likert-type scale to respond to each of the 23 statements by selecting one of the following responses: strongly agree (5), agree (4), are uncertain (3), disagree (2), or strongly disagree (1). Negatively worded statements were scored by reversing the numeric values. The possible range of PSTE scores is 13 to 65 while that of STOE scores is from 10 to 50. It is worth noting that scores of the PSTE and STOE do not add up to a total score, as they measure different aspects of science teaching self-efficacy. Reliability coefficients for the two scales were .82 and .75 for the PSTE and STOE, respectively.

All eight of the teachers enrolled in the first year of the RET program took the Science Teaching Efficacy Beliefs Instrument (STEBI). The STEBI measures teacher personal and professional teaching efficacy in science. In studies using STEBI, the professional characteristics were defined for teachers with high-and low self-efficacy beliefs. Teachers with high personal teaching efficacy (PSTE) were found to spend more time teaching science, demonstrated a high

level of personal relevance in science, and enjoyed performing science activities outside the classroom <sup>8</sup>. Teachers with low PSTE (measured during a year-long professional development program) spent less time teaching science, used a text-based approach, received weak ratings by outside observers, and made fewer positive changes in their beliefs about how children learn science.<sup>8</sup> In this study, using our year one and two data, we compared the science teaching efficacy of the eight RET participants to eight demographically matched non-participants at the school sites of the participants. Mean scores were compared across groups.

Results: Science Teaching Efficacy Beliefs Instrument (STEBI)

BMES ERC RET Participant Teachers					RET Teachers- STOE: 14.66 ûm RET Teachers- STOE: 14.66 ûm Non-Participant Teachers/Demographic Match from Same School			
Туре	Min. Score	Max.Score	Sum Mean	SD	Min.Score	Max.Score	Sum Mean	SD
PSTE	43	56	53.47	6.25	35	42	39.60	2.70
STOE	31	39	38.86	4.93	21	28	24.2	2.80

PSTE: Personal Science Teaching Efficacy STOE: Science Teaching Outcome Expectancy 4 Study National Comparisons PSTE: m = 46.76 STOE: m = 35.11 Table 1 Number and types (subject area) of teachers were matched to the greatest degree possible. Table 1 provides means comparisons across groups. As noted by descriptive these statistics, the mean score both in personal science teaching efficacy and science teaching outcome expectancy is in the RET greater participant teachers than is it in the nonparticipant teachers. These results suggest

(when compared to the literature on science teaching efficacy<sup>7</sup>) that the participant teachers will be better able to get positive results from their science learners in middle school and high school. These descriptive results should be cautiously used as a measure of success of the RET experience as there are numerous additional factors that affect teachers' perceptions of their competence as educators. It is for this reason that the faculty leading the RET program has been and will continue to collect and analyze additional data sets to create a profile of the teachers in the RET program in addition to measuring the impact of the RET experience on urban high school and middle school learners. While we collected efficacy data on the REU and RET students, we did not compare them statistically, as the two scales were different and measuring different yet related constructs and sub-constructs.

# Focus Group on Program Success

A second data set that has been collected analyzed from the RET program is teacher focus group data. This data was collected in a single setting with six of the eight participant teachers in year one and two of the RET program and was facilitated by two university faculty who worked closely with the teachers during the 6-week summer lab experience. While the potential that the teachers might be cautious in revealing information about the program, we felt that it was best to have familiar faculty facilitate the focus group because of familiarity with the teacher participants.

Conducting focus groups involves the facilitation of informal discussion among a small group of people, selected according to a predetermined set of criteria. Focus group members are asked to express their viewpoints or opinions on a particular topic about which they have special expertise or experience. Qualitative research methods in general, and focus groups in particular, are a useful way of revealing underlying value structures and learning about people's attitudes, beliefs, and behaviors in relation to sensitive <sup>9</sup> subjects. The objective of focus groups is to explore experiences and beliefs rather than to reach consensus. They are particularly useful in encouraging participants to provide candid, complete, and in-depth responses. Their dialogue creates a synergistic effect, allowing a wider range of insight and information than is possible with an individual interview. They are also particularly useful when working with individuals who have a history of limited power and influence.

A carefully crafted focus group protocol was crafted to collect the RET focus group data. The focus group data was audio recorded and transcribed using a computer-based interface, HyperTranscribe<sup>®</sup>. The data was then qualitatively coded using a grounded system of codes in an effort to identify significant themes in the data. Ideas or phenomena were first identified and flagged to generate a list of internally consistent, discrete categories (open coding)<sup>10</sup>, then fractured and reassembled (axial coding) by making connections between categories to reflect emerging themes and patterns. Finally, categories were integrated to form a grounded theory (selective coding) that clarified concepts and allowed for interpretations and conclusions. The goal of analysis was to identify patterns, make comparisons, and contrast one aspect of the data with another. HyperResearch<sup>®</sup>, a coding interface was utilized to create frequency distribution comparison amongst the coded data.

Five macrothemes were noted from the transcription review. The themes include: the need for collaboration, hands on experiences, mentorship and support, new learning in biomedical engineering, application to K-12 science. These macrothemes are not all unique to this data set as research in teacher professional development has identified collaboration application and mentorship as dominant needs identified for teachers in professional development.

The table that follows (2) provides a frequency distribution of the five themes with exemplars provided as excerpts taken directly from the focus group transcripts.

Category	f	%	Categorized Example
Collaboration	13	25	"RET teachers in close proximity - learning communities- deliberate time to share what they learn."
Hands on Experience	7	13.4	"Working on devices and chemical reactions were really helpful."
New Biomedical Learning	9	17.3	"I learned a lot about the bion how it was used."
Mentorship and Support	16	30.8	"There are so many ways to make it (RET) bigger and better we can be a starting point to help mentor other new teachers."
Applications to K-12 Curriculum	7	13.4	"We can make time plan to make it part of curriculum. We could have an <i>RET</i> student club."
TOTAL	52	100	

Results: analysis of RET Participant Focus Group

It is clear from the focus group data analysis that mentorship and support is a dominant need identified by the RET teacher participants. This is identified as a primary need in the literature on science teaching professional development as well. Mentorship and support is highly correlated in the teacher efficacy research as playing a role in increasing teacher efficacy. While we are not presently prepared to correlate the

two data sets presented in this paper together with such a small sample size, we are hoping to make these connections over the course of this RET project with its multiyear, multi-measure focus.

#### **REU Results**

In addition to collecting data from the RET teachers, we collected data from the REU students. These were designed to create a profile of the REU students for comparative purposes.

#### **BME Efficacy**

While we collected engineering efficacy data from this group, we did not compare this data set to the teaching efficacy because the metric measures different but related constructs and subconstructs. Figure 3 that follows illustrates the means for each of the described subscales



Results: REU Engineering Efficacy

(under the assessment section of this paper).

Results of this metric reveals that the REU students had a mean biomedical engineering efficacy of 4.23 on a six point Likert type scale. The area of strength in terms of efficacy for the students is in problem confidence (m=5.1). solving They were least efficacious in the subscale of career encouragement (m=2.73). This subscale asks the students to rate both their parents' and teachers' encouragement to choose biomedical engineering careers.

These results indicate a and underscore the important need for K-12 and parent related informational outreach so that students are encouraged in to engineering field s at young ages.

# REU Success in the Lab

In addition to measuring the REU students' BME efficacy, we measured their perceived success of the laboratory experience. We utilize an electronic survey of this reviewing students' perception about preparation for the research environment, multidisciplinary activities and research support using a 6-point Likert-type scale. The NAE Engineers for 2020 and applicable Grand Challenges descriptors were used to create the survey items and subscales. Results are reported as figure 4 (below). The mean for overall research lab success was 4.23 with leadership support being rated highest by the REU students, (m=4.89) and preparation for the research environment second highest, (m=4.28). These results suggest that not only did the students perceive the overall experience quite successful, they were most impressed and impacted by the leadership support that they received. These results underscore the importance of mentorship and collaboration in the labs and encourage us to continue with the collaborative model for future RET and RET years.

#### **Comparative Results- REU versus RET**

In addition to assessing the impact of the two programs separately, we used a rubric to measure the program's impact comparatively between REU and RE participants. These results revealed impactful results. Specifically, our rubric measured comparatively the participants' knowledge of research content, their presentation of the research content and their communication ability. A



the knowledge of content was nearly equal with the teachers (m=3.01) scoring slightly lower than the students (m=3.26) on this metric. This finding suggests that teachers and university students are knowledgeable of engineering content even if their efficacy may not predict this. In



five point score was provided for each participant in each area. Additionally, the teachers were also judged on their pedagogical approach in their lesson plan. Comparatively, the teachers scored higher on communication (m=3.83) than the REU students (m=2.91). This finding suggests that the teachers are better able to communicate content in their presentations. This result should not be too surprising, teachers are "veterans" however, at communicating knowledge to their students while undergraduate students are often novices in communication. Additionally,

terms of presentation of content, the RET teachers (m= 3.64) out did the REU (m=3.07)students suggesting that presentation is a strength of teachers perhaps due to their teaching skills. Finally, on pedagogical approach (a metric only for the teachers) the mean score was 4.12. These comparisons provide valuable information to us about the importance of collaborative multidisciplinary experiences for teachers and students. Although these quantitative results reveal interesting findings, anecdotal information throughout

the experience provided us with further support for the collaborative REU-RET program.

#### **Conclusion/Discussion**

Figure 5

Findings from these metrics indicate that both the undergraduates and the K-12 educators are efficacious about their collaborative research and training effort. Both groups also measured having capacity multidisciplinary research opportunities and shared leadership as well as high quality research presentation skills and communication. Additionally and anecdotally, the groups reported significant benefits from the experience. The groups gained a mutual understanding of the needs of underrepresented groups in research settings. Further, the teachers gained an understanding from the undergraduate students of what it takes to guide underrepresented students in to engineering and science fields. The undergraduates gained leadership and

presentation skills as they were mentored through this by the K-12 teachers and university faculty (per the metrics). This experience proved to be highly impactful for both students and teachers and is beneficial in providing insight for university faculty regarding guiding underrepresented groups into STEM education at university levels in addition to retaining them in STEMs programs and careers.

# **Future Work and Impact**

In terms of broad impact, we expect that this program will inform not only the broader teacher education community particularly the professional development community, it will inform K-12 and university based programs nationally who are struggling to support and meet the needs of K-12 students particularly at middle school and high school levels in guiding them into STEM majors and eventual careers. Additionally, attrition of science teachers continues to be great. This RET program may serve as a professional development model nationally that will support science teachers, positively effect teacher retention, and ultimately improve urban students academic outcomes.

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