AC 2008-2625: ENGINEERING OUTREACH: CONNECTING BIOMIMETIC RESEARCH TO URBAN K-12 CLASSROOMS

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Abstract

In 2003, the National Science Foundation (NSF) awarded a large private research university with funds to create a Biomimetic MicroElectronic Systems Engineering Research Center (BMES ERC)- a center dedicated to the coordination of groundbreaking research in the development of biomimetic devices. The ERC brings physicians, biologists, engineers and educators together to develop microelectronic systems that interact with living, human tissues. The resulting technology enables implantable and portable devices that can treat presently incurable diseases including blindness, loss of neuromuscular control, paralysis, and loss of cognitive function. The NSF recognizes the importance of infusing NSF funded research in K-12 classrooms with the goal of providing teachers and K-12 students with access to high quality, research-based curriculum in science, technology, engineering and mathematics (STEM) areas. Accordingly, NSF has provided funds for university researchers in this ERC to engage with 6-12 grade STEM teachers through a Research Experience for Teachers (RET) Program. This paper discussed the preliminary results of an RET program focused on biomedical engineering (BME) research experiences in urban contexts. This is a "work in progress" paper that documents preliminary results of evaluative research resulting from the BMERET experience. The focus of this paper is on the RET teachers' sense of science teaching efficacy and the teachers' perceptions of the RET program's success during the first year of the BMERET experience.

The ERC has a significant education outreach effort with a focus on 6-12 grade urban education on BME applications using NSF RET supplement funding. These outreach efforts combine the collaborative expertise of an urban school of engineering, school of medicine and school of education. The BMERET program has provided middle school and high school science teachers in urban settings with opportunities to engage with premiere researchers in BME laboratory settings at a top tier research university. With the combined expertise of the BME scientists and education faculty, BMERET teacher participants are creating powerful curriculum to use in their middle school and high school science classrooms. The teacher participants have experienced greater science teaching efficacy then their non-participant teacher peers, which may be as a result of the collaborative RET experience. Sixth through twelve grade teachers have benefited greatly from bringing the BME lab experiences to their science classrooms providing them with opportunities to engage in BME related research aligned to curriculum standards per teacher report. This will be supported and evidenced by resulting high schools on state science benchmark content exams and BME related concept inventories once the program is complete.

Introduction and Overview

Urban schools are typically heavily impacted by poverty, students with limited English proficiency, and overall low academic achievement, especially in STEM subject areas.

Cultural and linguistic factors are important in science learning but are rarely considered in K-12 science classrooms [1]. Poor outcomes of students in urban schools are seen as inevitable. In a recent study, however, Von Secker [2] conducted an analysis of NAEP science data and discovered that protective factors mitigate "risk factors" for low science achievement. These protective factors included attitudes and beliefs about science, and quality of instructional opportunities.

A significant challenge facing urban science teachers is low sense of self-efficacy in teaching science content. [3] A recent large scale study of teachers in urban settings revealed that secondary teachers indicated a strong need for assistance in the areas of English language development (ELD) and content teaching in science, and that a weakness of existing professional development was lack of attention to English learners and limited long term follow up. [4] This study suggests a significant need for professional development such as the type offered in the BMERET program so that teachers and students can benefit. Intervening with teachers via professional development may be an important way of impacting student outcomes particularly in science. Low achievement in science is not inevitable for students who do not, as a group, do well. These points are essential for strategic intervention connected to professional development for teachers and are precisely the focus of the BMERET.

A large private urban research university with a school of engineering, medical school and school of education through engineering research center (ERC) has partnered with a large urban school district to deliver an NSF sponsored research experience for teachers (RET) professional development program focused on biomedical engineering (BMERET). The BMERET program is a collaborative research-based professional development effort that combines the science, engineering and pedagogy expertise of the university's faculty with inner-city educators in 6-12 grade science classrooms. This paper presents the results of "work in progress" of a supplemental program in the ERC that will continue as a comprehensive 6-12 grade outreach effort beyond the results that are reported in this paper. Although the entire program is described in this paper, the focus of results for this paper is on year one results only with a primary focus on the participant teachers' sense of science teaching efficacy and their perceptions of success of the first year of the BMERET program.

BMERET Program Design/Description

The BMERET program selected a cohort of middle and high school STEM teachers from partnering urban area schools that primarily serve disadvantaged and minority students. A comprehensive application directed the recruitment process for the program. A total of six science teachers were chosen to participate in year of the program. Teams of teachers were placed in a BMES ERC laboratory. Each teacher team was matched with a Ph.D. student and a faculty mentor in the given laboratory for most direct daily interaction as well as to facilitate multi-directional expertise transfer between the teachers, the faculty and the Ph.D. student related to the BME lab research.

The 6-week BMERET summer program was guided by the professional development work described in *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 [5], which familiarized the university researchers and teachers with features that are common to successful mentoring relationships, especially for mentoring in the science and engineering fields.

Essentially, the BMERET teachers' research experience consisted of a structured six-week summer program in university BME laboratories, with teachers directly immersed in NSF-sponsored research activities, collaborating with faculty members and Ph.D. students on appropriate aspects of their investigations. The teachers, faculty and Ph.D. student mentors met weekly to review, network, compare experiences, address issues, and plan. The lab experiences that the teachers experienced included the following research areas:

Lab # 1-Fundamental Research in Age-related Macular Degeneration (AMD)

Age-related macular degeneration (AMD) gradually destroys the macula, the part of the retina most important for central vision. In advanced stages AMD can result in the inability to read all but very large print, legal blindness with the consequent loss of driving privileges, and perhaps most tragically, the inability to recognize faces. Consequently, AMD has a severe impact on the afflicted individual's quality of life. According to the American Academy of Ophthalmology, AMD is the leading cause of central vision loss in the United States today for those over the age of fifty years. The frequency of AMD is nearly 30 percent for individuals over 75 years old. Other risk factors for AMD include smoking, obesity, race, family history and gender. Currently there is no cure for AMD. The BMES ERC, however, is developing a retinal prosthetic device that may one day restore eyesight to those suffering from AMD.

This lab's research group focuses on the response of the outer retina to injury and how this response can lead to blinding disorders such as choroidal neovascularization (CNV) which primarily occurs as a complication of AMD. The laboratory has established the central role of the retinal pigment epithelial (RPE) cell in this disorder and has demonstrated novel mechanisms for growth factor activation of these cells. The lab's team is investigating the pathologic consequences of this activation on RPE migration, proliferation and gene expression. In particular the lab is interested in how the activated RPE cell can alter the local retinal microenvironment to promote the development of intraocular proliferative membranes and neovascularization from adjacent choroidal endothelium. The laboratory has developed and validated several in vitro and in vivo models of CNV and has used these models to elucidate basic mechanisms of disease and to evaluate therapeutic approaches to the disorders, especially in approaches involving manipulation of growth factor receptors and their intracellular signaling pathway.

Lab #2- The Development of a Retinal Prosthetic Device

The overall goal of the retinal prosthesis lab is to develop a high resolution prosthetic system designed to provide vision to millions of blind people worldwide. A healthy retina has over 100 million photoreceptors. However, psychophysical tests have estimated that this number may be reduced to thousands of individual pixels if the goal is to restore low resolution vision that would enable a person who is blind to attain unaided mobility and large print reading, two important quality of life indicators. Consisting of several subsystems, the retinal prosthetic will be initially divided between implanted and external components. External components will include a camera, image processing unit, and bidirectional telemetry. Implanted components will include bi-directional telemetry, hermetically packaged electronics, and a multi-channel electrode array. The implanted electronics will perform power recovery, management of data reception and transmission, digital processing, and analog output of stimulus current.

Lab #3- The Neuromuscular Prosthesis (BION®)

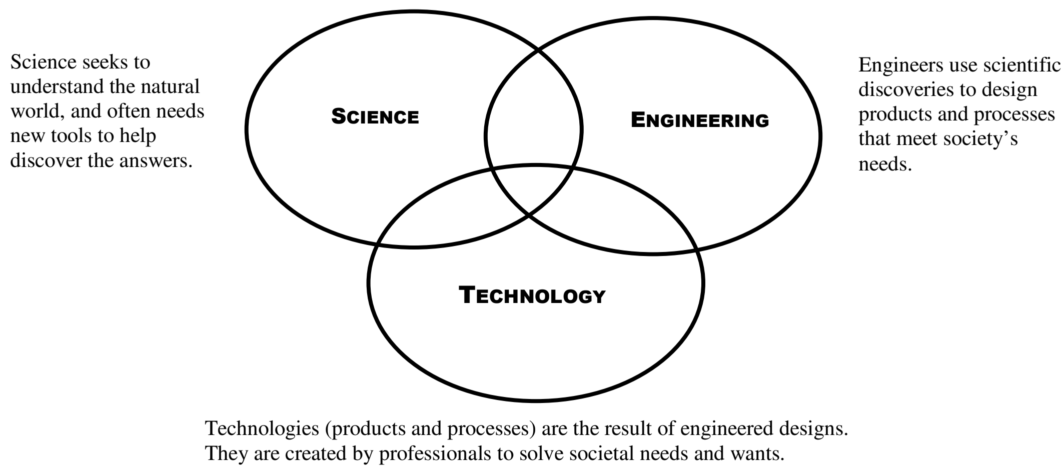
This lab's works on neural prosthetics - interfaces between electronic devices and the nervous system that are used to replace sensory and motor functions and correct dysfunctions in people with neurological problems. The research group in this lab is working on BIONs - BIOnic Neurons that are small enough to be injected into paralyzed muscles where they receive power and send and receive data by radio links with an external controller. In addition to developing and testing technology, Faculty in this lab have been active in basic neurophysiological studies of the sensorimotor nervous system in order to understand normal biological control. Computer models based on experimental data from muscles, motor neurons and proprioceptors are being developed to test new theories of control that may permit the reanimation of paralyzed limbs via functional electrical stimulation (FES).

In addition to the lab experiences, the teachers were provided with time to plan how their research experiences would be translated into 6-12th grade curriculum modules under the guidance of school of education faculty, which would introduce the 6-12th grade students to biomedical engineering and relate lesson plans and activities to state and national science and math curricular standards. Time was also allotted on a weekly basis for developing best practice pedagogy towards teaching science in their respective schools, also under the supervision of school of education faculty experts. The RET summer program culminated with teacher presentations that highlighted their research experience and showcased their curriculum development.

As a follow up for the program, BMERET university faculty developed and permanently maintain a comprehensive web portal where participating teachers post their research activities, summaries of their experiences, and implementation plans for translation of curriculum for use in classrooms. The web portal includes instructional materials where 6-12th grade teachers can engage in interaction related to the research that the teachers participated in directly during the summer RET experience.

Engineering utilizes scientific knowledge and theory and applies mathematical tools to solve practical problems through the development and use of technologies (Figure 1). By its very nature, engineering offers a powerful opportunity to demonstrate to teachers and students the relevance and importance of science and math in their everyday lives. Many K-12 teachers, however, are not trained in engineering and are uncomfortable introducing engineering into their classrooms[1].

Figure 1: Interrelationship of Engineering, Science and Technology.



By directly involving the teachers with ongoing biomedical engineering research projects and supporting their edification and success through professional development workshops in engineering, technology, and pedagogy, the RET faculty expected the participant teachers to become knowledgeable about introducing and utilizing biomedical engineering activities into their classrooms. Although there are myriad factors that influence a student's learning and interest, research has revealed that a major factor that influences students is teacher quality[6]. The weekly mentoring by the university faculty and graduate students enabled the BMERET teacher to quickly master the skills necessary to become an integral member of the laboratory's research team. Throughout the experience, the BMERET teachers investigate specific hypotheses using techniques that are well established. We posit that this will result in the teacher making an intellectual contribution to the research program and experiencing a sense of accomplishment, which contributes to their science teaching efficacy.

All BMERET projects were designed to demonstrate basic science knowledge, engineering principles and technology innovations for and with the teachers. The BMERET teachers have been able to take what they learned and experienced in their BME laboratory and make connections too specific grade-level standards in the life and physical sciences. Emphasis was placed on the broader context of the BMERET participant's project and its contribution to society. This ensured that the teacher's new found knowledge was translated into relevant classroom activities for their students.

As an example, in addition to specific grade level standards, the investigative and experimentation standards established by the California State Department of Education require that all middle and high school students understand that scientific progress is made by asking meaningful questions and conducting careful investigations. As such, it is expected that 6-12th grade students will: (a) select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data; (b) identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions; (c) formulate explanations by using logic and evidence, (d) recognize the usefulness and limitations of models and theories as scientific representations; (e) construct appropriate graphs from data and develop qualitative statements about the relationships between variables; (f) recognize the issues of statistical variability and the need for controlled tests; (g) recognize the cumulative nature of scientific evidence; (h) analyze situations and solve problems that require combining and applying concepts from more than one area of science; and (i) investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Through active participation in BMERET research projects, the teachers gained direct practice of all of the investigative and experimentation standards they teach their students. This experience facilitates the conveyance of these standards to their students and help make science and engineering interesting and relevant to them. The university faculty expect that this in turn will encourage more pre-college students to pursue science and engineering studies in college by increasing their understanding of engineering and technological innovation and getting them excited about careers in STEMS fields. We will be measuring the level of science interest of the K-12 students whom the teachers teach to measure program success over time.

Specific Experiences for RET Teachers

Each of the BME laboratories involved in the BMERET program has a tradition of and dedication to the education and preparation of postdoctoral fellows, graduate and undergraduate students, visiting scholars, visiting K-12 students and teachers.
This cohort of scientists and engineers enrich the experience of the BMERET teachers as they expand their knowledge of and familiarity with the science and engineering fields, experience the teacher can bring back to their classrooms.

In addition to the time allotted for their research projects the RET schedule included: professional development workshops in engineering and technology, visits to various laboratories to meet with faculty and students to get an overview and understanding of the interdisciplinary nature of BME, a tour of an ERC industry partner, a round table discussion on current school of engineering and ERC outreach programs and participation in an ethics workshop. The ethics workshop provided BMERET teachers with the opportunity to consider the role of the scientist and engineer in the educational, political, health and social realms, the ethical challenges facing scientists/engineers today and in the near future, and the role and responsibility of scientists/engineers to society. Throughout the BMERET program, an education specialist (faculty) from the university's school of education worked with the teachers on translating their new found knowledge and technological skills into lesson plans and classroom activities. The school of education faculty assisted the teachers in designing scientific curricula that addressed state science standards and to demonstrate to 6-12th graders the excitement and relevance of science and engineering to their everyday lives. Teachers presented their educational lesson plans and activities to their BMERET colleagues and BME faculty and students, who in turn offered feedback and advice. BMERET teachers met on a weekly basis with the program faculty to debrief and offer feedback on the previous week's activities. Biweekly meetings were scheduled so that the BMERET teachers were able to share the knowledge and skills they have gained in engineering and technology and test-run lesson plans and classroom activities with their colleagues.

Follow-up for Post-Lab Experience

As described in the overview of the BMERET program above, ensuring that the knowledge gained from the research experience is used in the classroom began from the first week of the research program and follows well beyond the end of the on-campus portion of the program. During the academic year, the university faculty have been holding monthly sessions for the teachers to reconnect with their colleagues, faculty, and Ph.D. students, to share their experiences and work through programmatic challenges. The involved faculty and Ph.D. students continue to serve as mentors and consultants to the teachers and visit the participating school classrooms to speak with the 6-12th grade students and take part in classroom activities in order to serve as role models/mentors. The BMERET university team visits each teacher at his/her school to aid in the implementation of the BMERET-generated curriculum in their classroom. The BMERET faculty continue to be resources for the teachers for the year following their on-campus RET program in order to ensure a stable web portal for the newly established program at each teacher's school, as well as to encourage creative teacher and student use of the web resources. Faculty also interface with the teachers via the web-based interface in between on campus monthly meetings.

Data Collection and Program Evaluation

Most of the data collection associated with this BMERET program is conducted in the form of post experience program evaluation. As such, for this ASEE paper, we are reporting on the results of the first wave of a multiyear RET evaluation. The BMERET evaluation design employs a comprehensive logic model and includes both *formative* information to guide "just in time" program improvement, and *summative* information to NSF as well as to other interested educators, researchers, program and curriculum developers, about the implementation and effects of this program.

The university faculty who deliver the BMERET program have developed a set of evaluative measures that are tied to BMERET's expected outcomes. The evaluation employs a mixed-design (quantitative and qualitative), formative and summative evaluation model that includes both post test measures and ongoing measures designed to inform program activities and gauge program success.

Instrumentation

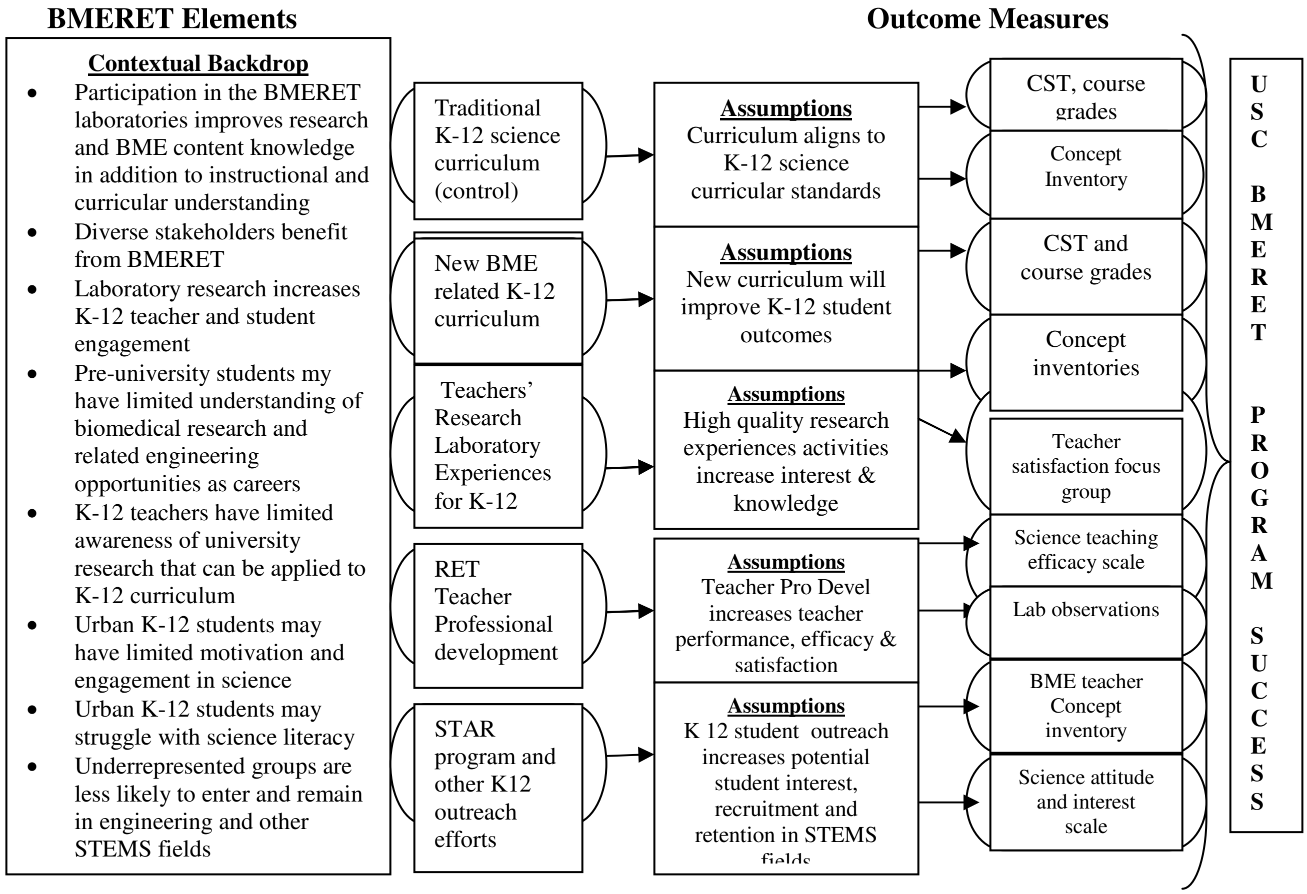
The following measures have been/will continue to be used to evaluate the success of the RET program:

- *Focus Group Interview Protocols* – The interview serves as a posttest measure of the teacher's perceived success of the program –focus is on changes in reaction, attitudes, and knowledge, and plans to implement curriculum resulting from the RET experience in addition to the teachers' judgments of the program's success.

- *Science Teaching Efficacy Beliefs Instrument (STEBI):* This instrument 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.
- *Teacher Participant BME Concept Inventory-* This is a multiple choice inventory for all teacher participants- measures knowledge gained with the professional development experience. This will be delivered during year two of the program once we have a larger group of RET participants for statistical analyses.
- *Student Achievement Data-* Student grades and achievement tests in science that will be collected annually to judge student success as a result of being exposed to the new science curriculum.
- *Student BME Concept Inventory-* This is a multiple choice inventory for all students taught by teacher participants that will be used as a comparison to those who did not have instruction from a RET teacher- measures knowledge gained with the new curriculum. We were in data collection process for this instrument at the time of this paper completion.
- *Student Science Attitude and Interest Scale-* This is a multiple choice inventory for all students taught by teacher participants that will be used as a comparison to those who did not have instruction from a RET teacher- measures increases in interest in science and science fields as a function of experiencing the new curriculum. We will collect data using this instrument at the end of each academic year.

The program evaluation employs a comprehensive logic model. Figure 2 illustrates this model.

Figure 2: BMERET Logic Model provides a visually based logic model for this project.



The logic model ties activities to assessments of success and instructional/curricular contexts. It is multimodal and comprehensive.

Procedures for Data Analyses

To evaluate the effectiveness of the RET program, the faculty is in the process of collecting seven diverse, summative and formative data sets (listed in the logic model and in the section prior to the logic model) related to the BME RET program outcomes. Quantitative and qualitative analyses have been and will continue to be conducted with these data sets. Rigorous analyses of the summative and formative teacher and student related evaluation data will be conducted to measure the collaborative research lab experiences and resulting curriculum's effect on the teacher participants' biomedical engineering knowledge and the role that introduction of laboratory research mediated curriculum plays in middle and high school students' subject area academic success and interest in science. Focus group interviews data, surveys, achievement data, and concept inventories have and will continue to be analyzed to determine program success. In terms of quantitative analyses, descriptive statistics were and will continue to be used to assess and display outcomes on the indicated measures. Where possible, nonparametric statistical procedures that do not assume normal distributions and that are robust with respect to sample size will be employed to assess relationships among variables and across the length of the program. The analyses will be carried out at critical and timely points during each program year. Statistical comparisons across the program years will be accomplished to assess program success and impact in 6th-12th grade science over time. For the purpose of this paper, to data sets are presented: Science teaching efficacy and teacher focus groups. The science teaching efficacy data was analyzed using descriptive statistics due to the small sample size. First year participant teacher focus group interview data have been analyzed qualitatively using grounded theory as a basis of analysis. Transcripts were coded using Hyperresearch. Themes emerged from the analysis. Over time, quantitative and qualitative evaluative results will be used to create a comprehensive picture of the program's successes, challenges and impact. These results will inform the BMERET program team as to improvements that will be necessary for program improvement and sustainability.

Preliminary Results

As this is work in progress paper, we are reporting on data collected at the point in which this paper is presented. This paper presents results of the RET 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 1 of implementation, 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 set are illustrated and described.

Teacher Related Results

<u>Science Teaching Efficacy</u>

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 [7] 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 six 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 [8]. 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 [8]. In this study, using our year one data, we compared the science teaching efficacy of the six RET participants to six demographically matched non-participants at the school sites of the participants. Mean scores were compared across groups. Number and types (subject area) of teachers were matched to the greatest degree possible. Table 1 provides means comparisons across groups.

Table 1: Mean Comparisons STEBI

	RET Participant Teachers				Non-Participant Teachers			
	Min. Score	Max. Score	Mean	SD	Min. score	Max. Score	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

As noted by these descriptive statistics, the mean score both in personal science teaching efficacy and science teaching outcome expectancy is significantly greater in the RET participant teachers than it is in the non-participant teachers. These results suggest (when compared to the literature on science teaching efficacy[7]) 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 BMERET 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 BMERET 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.

Focus Group on Program Success

A second data set that has been collected analyzed from the BMERET program is teacher focus group data. This data was collected in a single setting with four of the six participant teachers in year one 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 [9] 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 BMERET focus group data. The focus group data was audio recorded and transcribed using a computer-based interface, HyperTranscribe®. 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) [10], 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®, 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.

Theme	Frequency	%	Exemplar
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 a devise- chemical reaction was 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	So many ways to make it bigger and better we can be a starting point to help other teachers.
Application to K-12	7	13.4	We can make time plan to and make it part of curriculum. We could have an RET student club.
TOTAL	52	100	

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.

Direction for Future Research

At present, we are in the process of collecting data from the teacher and student BME the concept inventories. We anticipate having result of the inventories by for presentation at the 2008 ASEE conference. This data is knowledge focused and will provide comparisons between participant teachers and their students and non-participants and their students as a means of measure program success. This data will link teacher data to student data and provide a strong profile of the teachers and their effect on the students that they teach.

In terms of broad impact, we expect that this program will inform the broader teacher education community particularly the professional development community. K-12 and university based teacher professional development programs nationally are struggling to support and meet the needs of K-12 science teachers particularly at middle school and high school levels. 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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