



An REU Experience with Wireless Sensor Networks Research

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An REU-SITE Experience with Wireless Sensor Networks Research

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Introduction

Funded through an NSF REU Site grant (EEC-0755516) entitled “Undergraduate Research in Sensor Networks and Security Infrastructure,” the Departments of Engineering Technology and Mechanical Engineering at the University of Houston have hosted a group of 35 students during the summers of 2008-2010 to work on wireless sensor networks related research project for 10 weeks. Four bold goals have been identified for the REU Site project: 1) Recruit academically promising students from underrepresented populations; 2) Expand undergraduate research opportunities; 3) Increase the number of undergraduate students with research skills and experience; 4) Improve long-term student outcomes (e.g. graduate school matriculation and research related employment). The educational outcome of the project were to ensure that upon completion of the 10 week REU research project, REU fellows will have: 1) Increased familiarity with engineering and technology research; 2) Improved research skills through participation in project-based seminars and mentoring; 3) Improved written/oral communication skills; and 4) Increased awareness of real-world engineering and technology research environment.

Comprehensive project assessment was conducted by external evaluation experts via pre- and post- survey of the REU participants, focus group discussion, and follow up survey conducted in the summer of 2011. The summative project assessment results show that the REU Site project achieves all four goals and the REU fellows all achieve the corresponding four educational outcomes. In this paper, we present the details of the activities of the REU-Site project and the accomplishments of the REU fellows.

REU fellow recruitment and selection

REU participants, referred to as REU fellows in this paper, were recruited and selected from a large applicants pool from multi-disciplinary programs such as electrical and computer engineering & technology (E&T) and mechanical E&T. Each year, before the REU fellow application process started, faculty members from the two departments submitted a brief research proposal in wireless sensor network area where they needed help. Once the research projects were identified, they were uploaded to the project website, along with other application materials, towards the end of January. Applicants had until mid-March to submit their application material including their GPA in major, personal statement describing their background, career plans, their reason for applying to the summer research program, and two recommendation letters. The selection committee was formed from participating faculty members, who meet towards the end of the March to select REU fellows based on the merit of their applications.

Applicants were asked to rank available research projects based on their interest and were accommodated as much as possible to work on projects from among their top three selections. In three years, the REU Site accommodated 35 fellows, 34% of whom were underrepresented and minority students. The fellows came from universities and colleges in 18 states across the nation.

Many of these students came from historically black or minority serving universities and colleges. Figure 1 shows the REU cohorts and their faculty advisors for 2008-2010.

Methods and Activities

Besides their research projects, the fellows participated in activities to improve their research skills throughout the 10 week experience.

Once the fellows reported to campus at the beginning of the summer, they attended a half-day orientation during which time they were introduced to each other, their faculty advisor, and presented with general information about the hosting department and university. They were mandated to attend the research methodology seminars designed for undergraduate research students at the university, covering topics including writing a literature review, formulating research questions and putting together a research proposal, writing abstracts and lay-man articles, presentation and report writing, professional ethics, and



Figure 1 REU cohorts and their faculty advisors in 2008, 2009, and 2010 from top to bottom



Figure 2 REU-Site program activities. Clockwise from top left: orientation, safety around campus, group meeting, and field trip to Houston Energy Hall.

intellectual property protection.

Several field-trips were also organized to broaden their perspectives and make connections between E&T and society. Fellows had continuous access to their faculty advisor, REU-SITE project investigators, and teaching assistant. However, to ensure any upcoming issues could be identified in time, a weekly group meeting was also mandated. Fellows used this opportunity to share their research project progress and their experience in general. Towards the end of the 10 weeks, there was a presentation and poster competition. All REU fellows prepared a poster summarizing their project and gave a presentation where faculty members and their peers asked questions. The two winners had the opportunity to present their research projects at a national conference the following year. Figure 3 shows two winners from the 2009 cohort presenting their project poster in national biomedical research conference.

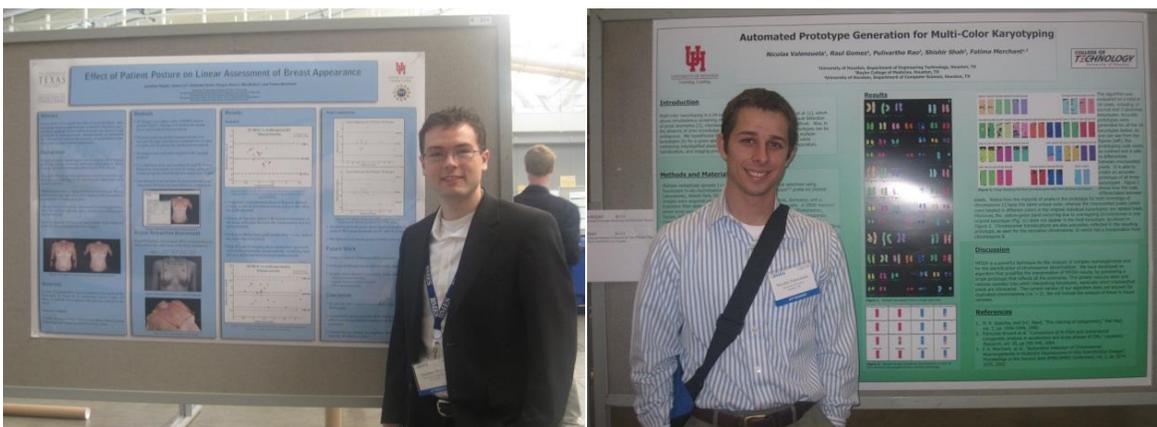


Figure 3 Poster and presentation competition winners present their research project poster at national biomedical research conference.

Research projects

Twenty nine research projects covering the interdisciplinary area of sensor networks, security infrastructure, and biotechnology-based security measure were conducted by REU fellows in three years. Some of the fellows worked in teams on one project.

Before the program started, many faculty advisors contacted their REU fellow and shared with them reading material regarding the project. Once the summer program started, an REU fellow would work in the research group of the faculty, attending regular group meetings and interacting and working with graduate students on the project. Faculty advisors met with REU fellows regularly to discuss their progress and provide feedback toward the completion of the project. Faculty advisors and their graduate students helped REU fellows develop poster and presentation slides, and guided development of the project into conference or journal papers. Figure 4 shows a sample of research projects REU fellows conducted.

Project Evaluation

Formative and summative project evaluations have been conducted focusing on three basic components: program implementation, short-term and long-term outcomes. By utilizing the appropriate quantitative and qualitative data from these components, the evaluation highlighted the degree to which the project met the four project goals. Ultimately, each of first three goals also fed into a fourth goal of improving long-term student outcomes (e.g. graduate school matriculation and technical employment).

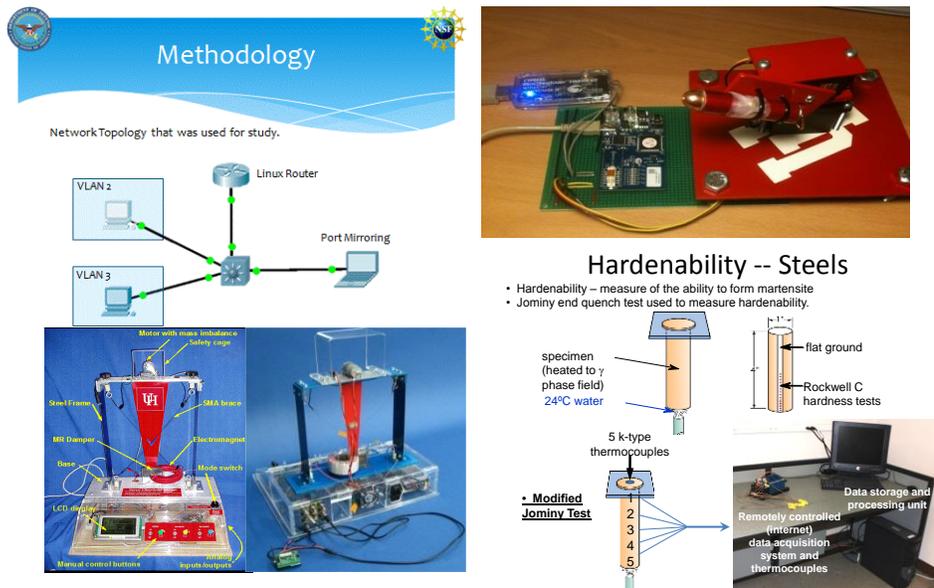


Figure 4 Sample research projects. Clockwise from top left: Network capable application processor (NCAP), dynamically reconfigurable sensor network hub via pSoC, wireless data aggregation of smart vibration platform (SVP), and steel hardenability.

Figure 5 shows the survey results, demonstrating that the REU-Site project successfully achieved its four program goals and all REU fellows achieved the four educational outcomes. During all three years, the same survey was used to gauge the benefit REU fellows acquired from the program.

In July 2011, an electronic survey was administered to all REU fellows that had participated in the program from 2008 to 2010. Among the 12 respondents, over 36% reported that they are attending graduate school. All but one fellow reported that they are either in school (finishing their STEM undergraduate degree or pursuing graduate degree) or employed in a technical field. Ninety-one percent of respondents indicated that they were either already in graduate school or considering it. Four respondents were already attending graduate school, three reported they would “definitely” be enrolling in graduate school. Four more students indicated they were considering going to graduate school. The three main sections of the survey asked former participants to rate their experiences in the REU program on a 5-point scale ranging from “no gains” to “great gains”. Section 1 presented students with 11 skill and knowledge dimensions that people had to rate in terms of gains made as a result of their participation in the program. Among the areas included: formulating a research problem, identifying basic principles and knowledge related to a research problem, and communicating research findings through writing. For each dimension, a majority of respondents felt they had made “good” to “great” gains. The learning dimensions that had the highest perceived gains included: identifying basic principles and knowledge, communicating research findings through technical posters and presentations. The second section of the survey asked former participants to rate how important—on a 4-point scale ranging from “not important” to “very important”—the 11 skill and knowledge areas were to their work. The majority of students felt that most of the dimensions were either “important” or “very important”. However, students were evenly split regarding the ability to communicate research findings through creation of a technical poster. The ability to interpret data to help solve a problem had the highest percentage of respondents rating the skill as “important” or “very important”. Referring back to the gain ratings, eight out of twelve respondents felt that they had made “good” to “great gains” in this area.

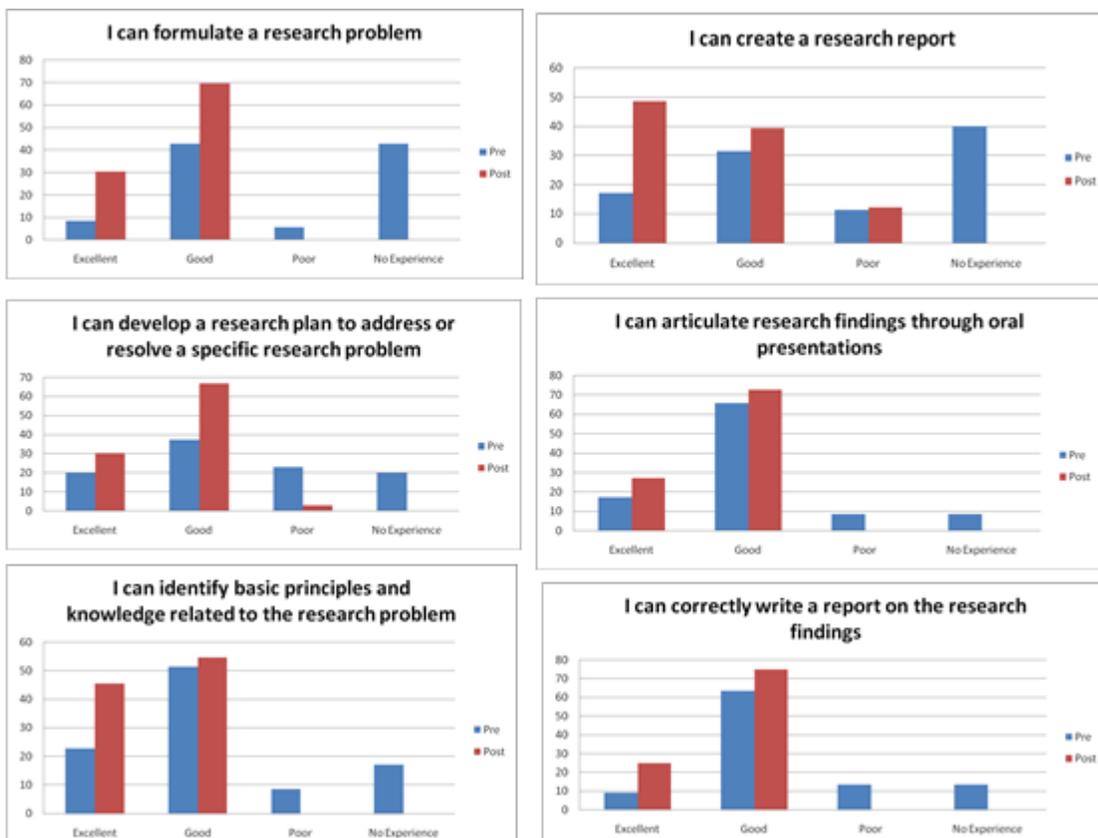


Figure 5 Pre- and Post- survey responses from all REU fellows of all three years, presented as percentage.

Respondents were also asked to indicate their level of agreement with a series of statements that described aspects of the REU experience. In this case, agreement is interpreted positively while disagreement is negative. Overall, students were positive about their experiences and the impact the program had on them. Curiously, one student strongly disagreed with each statement presented in the survey. However, after further investigation the same student stated that, “My participation in the NSF Undergraduate Research program has direct relation with my decision on attending graduate school. The knowledge and skills gained during summer 2008 are invaluable tools on my education and professional development.” Graduate student/part-time employee (participated in summer 2008). Given the contradictory nature of this person’s statement relative to the quantitative responses to the agreement scale, it seems likely that the respondent may have inadvertently inverted the scale. Regardless, the general picture of the REU experience was positive.

In addition, seven papers involving REU students were published in peer reviewed technical conferences, one of which received the best paper award in ASEE-GSW Conference. Three research projects were also awarded first and second place at university wide undergraduate research day in 2008 and 2009. Collectively, the REU-Site project successfully produced several prototype systems advancing the state-of-art for an important area of wireless sensor networks while offering a stimulating experience for undergraduate students. Assessment of the student experience showed an increase in the likelihood for these students to pursue engineering careers and to encourage their peers to consider STEM careers. All these project evaluation results clearly demonstrated the success of the REU-Site project.

Conclusion

The paper presented a REU-SITE project from 2008-2010 with detailed evaluation results demonstrating its success. From the experience, participatory faculty members all experienced the contribution undergraduate can make in research projects. In addition, participatory REU-fellows all had engaging and inspiring research experience that further encourages their pursuit in research in STEM field. The REU-SITE project also significantly changed the attitude of students towards research – from high above, far away concept to problem solving challenges that have real world impact. Taking into consideration that the host University is most diversified research university and the majority of students host department (Engineering Technology department) is serving are under-privileged and un-traditional students, we should not underestimate the potential rippling effect of this REU-SITE project. In fact, various undergraduate research programs are being set up in the host university from 2010 as university-wide effort to attract and retain STEM students and improve their graduation rate. We strongly believe that more REU-SITE programs should be funded in urban research universities which serve diversified, under-privileged, and non-traditional student population.