AC 2008-1402: IMPLEMENTATION AND ASSESSMENT OF AN INTERDISCIPLINARY NSF/REU SITE ON WATERSHED SCIENCES

Vinod Lohani, Virginia Polytechnic Institute and State University

VINOD K. LOHANI is an associate professor in the Department of Engineering Education and an adjunct faculty in Civil & Environmental Engineering at Virginia Polytechnic Institute and State University (Virginia Tech). He received a Ph.D. in civil engineering from Virginia Tech in 1995. His areas of teaching and research include engineering education, international collaboration and hydrology & water resources.

Tamim Younos, Virginia Polytechnic Institute and State University

TAMIM YOUNOS is a research professor in the Geography Department and also serves as an associate director of the Virginia Water Resources Research Center at Virginia Tech. He earned a PhD in environmental engineering from Univ. of Tokyo. His major areas of research and teaching are in watershed assessment and sustainable water and energy systems.

Implementation and Assessment of an Interdisciplinary NSF/Research Experiences for Undergraduates (REU) Site on Watershed Sciences and Engineering

Abstract

Authors' experiences of implementing a successful NSF/REU site (2007-10) on watershed sciences and engineering at Virginia Tech, a large research university, are discussed. Research mentors representing civil engineering, environmental engineering, geology, biology, crop and environmental sciences, water resources, environmental chemistry, engineering education, and academic assessment disciplines made a significant contribution in the success of the site. The site received funding in authors' 3rd attempt. A summary of reviewers' comments during unsuccessful attempts and authors' proposal modifications are presented to demonstrate strategies that led to successful funding of the site. The goal of the site is to provide a diverse group of undergraduate students a stimulating interdisciplinary environment, where critical research questions within watershed sciences and engineering are addressed and their analytical skills and creativity as future scientists and engineers are nourished. To achieve this goal, eight highly qualified students (five female, three male), hereafter referred to as REU fellows, were recruited in summer 2007. Fellows came from a variety of disciplinary backgrounds including chemistry, ecology, geology, environmental engineering and electrical engineering. Fellows' 10-week long research projects included: ecological stoichiometry, microbial source tracking, watershed instrumentation, cycling of metals in aquatic environments, drinking water chemistry, and water-energy nexus. Fellows also attended weekly forums and discussion meetings conducted by VT experts and attended a national conference that was held on Virginia Tech campus. Fellows made periodic presentations of their research, prepared a final research report, and also submitted a reflection essay about their experiences. Four fellows returned to Virginia Tech late fall and presented their research papers at a regional water research conference. Assessment of NSF/REU site outcomes was conducted with the help of two external experts in education research and academic assessment. Assessment tools included online /in-class surveys, pre- and post test questions, and a focus group interview. This article includes a brief description of program assessment tools, a summary of assessment results and recommendations, and some excerpts of self reflections of REU fellows.

1. Introduction

One of the recommendations made in the 2005 report of the National Academy of Engineering *Educating the Engineer of 2020* is[1]:

> *Engineering schools introduce interdisciplinary learning in the undergraduate environment, rather than having it as an exclusive feature of the graduate program.*

The objective of this article is to introduce successful (and unsuccessful) proposal preparation for funding an interdisciplinary undergraduate research site that has goal to meet the recommendations made such as in the NAE publication listed above. Our

research site deals with the interdisciplinary research in watershed sciences and engineering. The article provides a summary of our NSF/REU site, proposal preparation and reviewers' comments, overview of first-year accomplishments, and program assessment. We expect the readers to gain valuable knowledge from our experience about critical evaluation criteria for proposal submission and the importance of program assessment for developing successful NSF/ REU sites.

The 2004 National Academy of Engineering publication entitled "*The Engineer of 2020*" emphasizes the fact that water supplies would affect the future of world's economy and stability. Further, the report highlights the need for implementing ecologically sustainable practices to preserve the environment for future generations[2] . To face the large-scale environmental challenges in the 21st century, the National Research Council outlined the need for fundamental knowledge of: (a) the sources of contaminants and how they are linked to different types and levels of human activities; (b) the persistence, transport processes and degradation mechanisms of these contaminants; and (c) the risks they pose to the environment and society[3] .

This aim of our site is to provide an interdisciplinary forum of faculty and students to train future professionals on critical elements of watershed-based approach to sustainable management of water resources. This approach has been recognized as a viable approach for efficient management of water resources[4]. An interdisciplinary watershed-based approach integrates various disciplines such as chemical sciences, biological sciences, hydrological sciences, engineering, and ecology. It interfaces with various technologies such as field and laboratory instrumentation, geographic information systems and geospatial analysis, remote sensing, computer engineering and electronics, and data transfer and storage and management system. The site is expected to expand the potential pool of future graduate researchers and professionals in watershed sciences and engineering. The interdisciplinary research activities at our site are designed to facilitate lifelong learning experiences, and nourish analytical skills and creativity of future engineers and scientists in a diverse environment consistent with "*The Engineer of 2020*" vision. In our proposed recruitment plan, at least 60% of the REU participants will be students who belong to under-represented groups in the academia and those from smaller colleges/universities with who have few research opportunities at their home institutions. We were successful in meeting this target in our first year of implementation.

2. Proposal Submission and Reviews

The authors submitted the original proposal in 2004 and resubmitted in 2005 and 2006. The 2006 submission was successful. This section documents panel summary and individual reviewer's comments on our successful (final submission) and unsuccessful proposals. Major evaluation criteria include proposal intellectual merits and broader impacts. Unedited reviewer comments were downloaded from the NSF fastlane website. Table 1 describes critical issues pointed out by the reviewers and actions taken by the authors to address the issues.

Table 1. Summary of Reviewers' Comments and Authors' Response

2004 Submission; Amount: $389k; Duration Proposed: 5 years	
Critical reviews from NSF panelists	Authors' response
The panel was concerned that the various projects, thematically centered on "water," seemed only tangentially related to one another. The program would benefit from a tightened, more cohesive focus showing how the projects/students/faculty interact and interrelate intellectually. The research project descriptions were uneven in quality, with some being too brief. There is also a need for clarification in several of the research projects to show that they are hypothesis-driven.	The authors brought this to the attention of various research mentors and made sure that all proposed projects are interrelated in some logical way and are described adequately. The keywords that describe the focus of the site were also included in all project descriptions.
The dissemination plan for the project and overall program need to be better expressed.	A separate section on "dissemination" was added describing the proposed plan clearly. For example, we added plans to make presentations in conferences like this conference.
2005 Submission; Amount: $488k; Duration Proposed: 5 years	
The panel felt that for an initial proposal, a 3-year program would be more appropriate than a 5-year one. Description of the research facilities not provided.	For the next submission, the authors reduced the duration of site to 3 years. Authors feel that research facilities were adequately described.
Stipends seem low, $300/week; it is not clear whether students will have to pay for meals on their own or whether they will be provided. This may hurt recruiting efforts. The program is 'primarily intended' for students from under-represented groups, but it is not clear what is intended and how it will be implemented.	The authors had provided a provision for the subsistence allowance in the budget but may not have described it clearly in the budget justification. This was made very clear in next submission The authors clearly stated in next submission that they would have 60% participation rate from the under-represented groups. They also removed "underrepresented" word from the title of the project since the site wasn't proposed 100% for underrepresented students.
2006 Submission (Proposal was funded); Amount requested: $368k; Duration Proposed: 3 years; Amount approved: $300k	
	-Authors advise that initially it's a good idea to go for a 3-year long REU site. -Make sure your stipend level matches the national average -Authors always made sure that they discussed the modification made with the NSF program official before making the submission.

3. Overview of First-Year Accomplishments: http://www.vwrrc.vt.edu/nsf_reu.html

To achieve the goal of our site, as discussed above, planning began with recruiting qualified students, placing them in a research environment that matches their interests, and facilitating unique professional experiences that encourage professional growth. The program for summer 2007 was announced in late February with application deadline of March 15. Successful applicants were informed on April 13, 2007.

The program began on May 21, 2007 (orientation) and ended on August 3, 2007. A diverse group (five female, three male, one African-American, one Asian-American, one Mexican-American) of highly qualified students, hereafter referred to as REU fellows, were recruited for our interdisciplinary REU site. Home institutions of REU fellows included: University of Nevada-Las Vegas, University of Missouri-Rolla, Rowan University, West Virginia University, Carnegie Mellon University, Marshall University, Hampton University and Virginia Tech. REU Fellows came from a variety of disciplinary backgrounds including chemistry, ecology, geology, environmental engineering and electrical engineering. Fellows were placed in different academic departments at Virginia Tech. Fellows' research projects included: ecological stoichiometry, microbial source tracking, watershed instrumentation, cycling of metals in aquatic environments, drinking water chemistry, and water-energy nexus. A brief description of research projects for each REU fellow is given below.

Fellow #1: Research Topic: An Investigation of the Ecological Stoichiometry of *P. Gentilis* and Resources: This study explored how consumer-resource imbalance affects the physiological processes of that organism such as excretion and assimilation.

Fellow #2: Research Topic: Solubility as a Mechanism for CSMR Effects on Lead Leaching: In this study, the solubility of lead with chloride, sulfate, and phosphate at low pH is used to explain the mechanism of increased lead leaching in systems with a relatively high chloride to sulfate mass ratio (CSMR).

Fellow# 3: Research Topic: Managing Manganese in Drinking Water: An Assessment for Microbes and Metals: In this study, five microbial strains recovered from the filtration and sedimentation basins of a water treatment plant in Blacksburg, Virginia were used to study oxidation and reduction of manganese by microbes.

Fellow# 4: Research Topic: Determination of the Taste Threshold of Iron in Water: This study determined the taste threshold for ferrous Iron at near neutral pH. This is of particular importance for the drinking water industry, which provides water at or near pH 7.0 and attempts to avoid customer complaints from aesthetic problems.

Fellow #5: Research Topic: Determination of Antibiotics for use on *Escherichia coli* in Antibiotic Resistance Analysis: In this study, seven antibiotics: ampicillin, cefalexin, doxycycline, gentamicin, lincomycin, penicillin, and trimethoprim were used in

Antibiotic Resistance Analysis to help create a clearer distinction between isolates of *E. coli* from humans and non-humans.

Fellow# 6: Research Topic: The Hydrology of the Timber Ridge Quarry Site, Botetourt County, Virginia: The objective of this study was to determine areas of significant groundwater flow and to evaluate the optimum placement of pumps in the event of quarry operations.

Fellow #7: Research Topic: Developing a Small Scale Wireless Data Collection System for use in Watershed-Based Research: The objective of research was to develop a prototype for the wireless data collection system for hydrologic studies within VT campus and an understanding of the workings of microcontrollers and of the user interface software LabVIEW.

Fellow #8: Research Topic: A Study of Energy Consumption by Water Supplies and Wastewater Infrastructure in Blacksburg, Virginia: The objective of this research was to estimate energy use for water and wastewater treatment, water distribution and wastewater discharge in Blacksburg, Virginia.

In addition to the research work, NSF/ REU fellows attended weekly forums and discussion meetings conducted by VT experts. Fellows made periodic presentations of their research, prepared a final research report, and also submitted a reflection essay about their experience. Final research papers were compiled in a Proceedings of Research. In addition, fellows attended a National Conference of Association of Environmental Engineering and Science Professors (*AEESP*) that was held on Virginia Tech campus during last week of July 2007. On-campus residential housing increased social interaction among fellows and others. Program Assessment results show that the program was overall a great success. Essays on personal and professional experiences contributed by participating NSF/ REU fellows also confirm the overall program success (see some unedited excerpts below). Complete program overview, NSF/ REU Fellows' research reports, and participant reflections are posted on the NSF/ REU website: http://www.vwrrc.vt.edu/nsf_reu.html.

4. REU Fellows' Reflections

Fellow # 1: *"I know that the professional aspect of what I experienced in my REU at Virginia Tech will continue to have an impact throughout my career. Skills such as public speaking, teamwork, and insights into how to start my career in the academic world will doubtless prove invaluable. However, I also hope that my social and personal experiences at Virginia Tech will continue to have an impact, and that the relationships that I have built with my advisor, fellow group members, and the other REU fellows will continue long past the end of this program."*

Fellow # 2: *"The program set up was ideal, in my opinion. The Friday meetings and seminars were most helpful and for the most part I enjoyed the speakers tremendously. The chance to present on our research topic every two to three weeks was extremely helpful in the development of my presentation throughout the summer and provided convenient stepping stones in the progression towards our final presentation. Those various presentations also allowed us ample practice with public speaking and presenting, which is a necessary skill in this line of work."*

Fellow # 3: *"And thanks to the NSF-REU program at Virginia Tech, I can add a summer research experience to my repertoire. The program was a complete success for me to grow and learn academically. I feel as if I can survive at the graduate level in school. I was very thankful and blessed that I could be apart of this experience because I know programs like the NSF-REU program are very scarce for undergraduates. Also, I feel very confident in myself that I can accomplish anything. This summer, I did a ton of reading, very detailed experimentations, and even received a chance to my research paper published! But I have learned throughout my life that with good, there is always something bad that follows closely."*

Fellow # 4: *"The methods and lessons I learned from working in the lab this summer are invaluable to my application to grad school. While I have worked in a lab before it was only a few hours a week. This summer, however, I was in the lab every single weekday (and some weekends too). I knew the basics of performing research but actually performing it brought the whole idea of it full circle. This summer experience has shown me what graduate school is really like, and that I definitely want to continue my schooling after I get a bachelor's degree."*

Fellow # 5: *"All of the fellows chosen to be a part of the program are amazing people and we are all similar in that we are ambitious students who want to learn and want to get as much experience as possible. I think just meeting them and spending a summer with them was one of the best parts of the program. I enjoyed the suite-style living arrangements and how that meant we were all together. It made it easy to get together and plan activities."*

Fellow # 6: *"My NSF-REU experience at Virginia Tech has undoubtedly been the most influential experience of my collegiate career. I made lifetime friends and colleagues and learned much more than I could have anticipated. It has been an invaluable experience and as one student said could be summed up as "practice grad school." I am very thankful for Drs. Younos and Lohani who with positive attitudes have overcome setbacks and provided a brilliant and beautiful program students interested in science. I feel that I certainly have found my "calling." Now, it is evident that I, too, have the "affliction of curiosity," to use the words of Dr. Marc Edwards. Perhaps now you can see why I say with clear confidence that this program has changed my life."*

5. Program Assessment

Assessment of program and individual participant is an important component of our NSF/REU site. Assessment of NSF/REU site outcomes was conducted with the help of two external academic assessment experts in education and engineering education research (i.e., Dr. Muffo from Ohio Board of Regents and Dr. Trenor from University of Houston).

Assessment tools included online /in-class surveys, pre- and post test questions, a focus group interview, and fall review. On May 15, 2007, one week prior to the beginning of the summer NSF REU program, Dr.Muffo met with the program directors and senior personnel to discuss basic ideas involved in developing effective assessment questions. Based on a discussion of program's goal and objectives, he developed 20 questions to conduct pre- and post-test. In addition, some free response questions were developed. Pre-test was given on the first day of program (May 21), all except one REU fellows completed pre-test. The post- test was given on August 03, last day of the program. Dr.

Julie Trenor reviewed the projects reports supplied by project PIs and met with PIs on November 19, 2007.

Below are Dr. Muffo and Dr. Trenor unedited reports submitted to principal investigators.

5.1 NSF REU Interdisciplinary Watershed Sciences and Engineering; Virginia Tech, Summer, 2007; *Assessment Report;* By John Muffo

The following is an independent assessment of the level of success of the program conducted during the summer of 2007. My role was mainly to develop the entry and exit survey, to conduct the surveys, and then to conduct the focus group at the end of the summer. I had no contact with the faculty and students during the rest of the time when the students were at Virginia Tech.

Entering Survey: There were eight students who were enrolled in the program during the summer of 2007. There was entry and exit data only for seven of the eight students, so only those data are reported below. For those seven, of the seventeen survey questions that they were asked upon entry, their responses are below, in order of the highest to lowest responses. (The questions were developed in cooperation with the faculty who were the Principle Investigators for the project.)

Using the following scale: 1=Strongly Disagree; 2=Disagree; 3=Neutral/No Opinion; 4=Agree; 5=Strongly Agree, the entering students provided the following responses upon entry:

- I have an appreciation for the role of faculty in advising students. – 5.00
- I have an appreciation for the role of faculty in research. – 4.86
- Studying water is interesting. – 4.57
- I am interesting in going to graduate school. – 4.57
- There are many opportunities for employment in the water field. – 4.00
- I am aware of many ways in which scientists serve with their communities. -- 3.43
- I can communicate scientific concepts effectively to a scientific audience. – 3.29
- I can communicate scientific concepts effectively to a non-scientific audience. – 3.29
- I am aware of the many ways in which scientists from different fields interact with each other in conducting research in watershed sciences. – 3.14
- I have a good understanding of the role of ethics in scientific investigations. – 3.00
- I am confident that I understand how to conduct scientific research. – 2.86
- I know everything that I need to know to conduct scientific research in the library. – 2.71
- I understand the processes used to monitor water quality. – 2.57
- I plan on going to work after graduate school. – 2.43
- I can visually examine a quantity of water and tell whether it's safe for drinking or not. – 1.86

- There are winners and losers in environmental conflicts; it's as simple as that. – 1.86
- The use of statistics is not important in monitoring water quality. – 1.29

The students also answered the following open-ended questions; these were shared with the faculty.

- What suggestions do you have for improving the application process for this NSF/REU program?
- Do you have any concerns about the program that you are beginning now? If so, what are they?
- List the top three things that you would like to learn during this 10-week long NSF/REU program.

Exiting Survey: At the completion of the program the students completed the same survey with the same questions. Their responses are below, again in order from the highest to lowest.

- I have an appreciation for the role of faculty in advising students. – 5.00
- I have an appreciation for the role of faculty in research. – 5.00
- I am aware of the many ways in which scientists from different fields interact with each other in conducting research in watershed sciences. – 4.86
- I am interesting in going to graduate school. – 4.86
- There are many opportunities for employment in the water field. – 4.71
- I am aware of many ways in which scientists serve with their communities. – 4.57
- I am confident that I understand how to conduct scientific research. – 4.43
- Studying water is interesting. – 4.43
- I have a good understanding of the role of ethics in scientific investigations. – 4.00
- I can communicate scientific concepts effectively to a scientific audience. – 3.86
- I know everything that I need to know to conduct scientific research in the library. – 3.71
- I can communicate scientific concepts effectively to a non-scientific audience. – 3.57
- I understand the processes used to monitor water quality. – 3.29
- I plan on going to work after graduate school. – 2.43
- There are winners and losers in environmental conflicts; it's as simple as that. – 2.00
- I can visually examine a quantity of water and tell whether it's safe for drinking or not. – 1.86
- The use of statistics is not important in monitoring water quality. – 1.00

The students also answered the following open-ended questions.

- Please comment on social activities during the 10-week program. Your suggestions for next year are most welcome.

- Please comment on the weekly seminars you attended during the past 10 weeks. Feel free to list the topics you liked and didn't like. Suggestions for next year are most welcome.
- Please comment on the frequency of presentations you made during the last 10 weeks.

Change over the summer: One of the more interesting aspects of the survey data is to look at the change over the summer or the difference between the exit responses versus the entrance ones. Of course there are some complicating factors such as ceiling effects, i.e., there is no way to increase a score that is a 5.00 on a 5.00 scale upon entrance, but for most questions one can still look for areas in which the students changed over the ten weeks of the program. Below are listed the questions in order the magnitude of the change in their responses between the time that they began and exited the program. (Note that the numbers in parentheses are negatives.)

- I am aware of the many ways in which scientists from different fields interact with each other in conducting research in watershed sciences. – 1.71
- I am confident that I understand how to conduct scientific research. – 1.57
- I am aware of many ways in which scientists serve with their communities. – 1.14
- I have a good understanding of the role of ethics in scientific investigations. – 1.00
- I know everything that I need to know to conduct scientific research in the library. – 1.00
- There are many opportunities for employment in the water field. – 0.71
- I understand the processes used to monitor water quality. – 0.71
- I can communicate scientific concepts effectively to a scientific audience. – 0.57
- I am interesting in going to graduate school. – 0.29
- I can communicate scientific concepts effectively to a non-scientific audience. – 0.29
- There are winners and losers in environmental conflicts; it's as simple as that. – 0.29
- I have an appreciation for the role of faculty in research. – 0.14
- I have an appreciation for the role of faculty in advising students. – 0.00
- I can visually examine a quantity of water and tell whether it's safe for drinking or not. – 0.00
- Studying water is interesting. – (0.14)
- The use of statistics is not important in monitoring water quality. – (0.29)
- I plan on going to work after graduate school. – (0.57)

To summarize, the greatest reported gains over the summer were in the areas of understanding how scientists from different fields interact with each other, understanding how to conduct scientific research in general, becoming more aware of how scientists serve their communities, better understanding the role of ethics in scientific investigations, and becoming more confident in using the library to conduct scientific research.

Focus Group Results: At the end of the program, at the end of the summer, a focus group was conducted of seven of the eight students who participated in it. One was absent due to a death in the family. They were asked a series of open-ended questions by the evaluator. No faculty or other staff was present. Below is a summary of their responses.

1. What did you like about the program that you just completed?
    - Everything!
    - Lab experience
    - Range of people met
    - Experience of the labs and publishing a paper
    - The social experience
    - The seminars were interesting, with experts in the field; it was a good program; some were boring, but overall it was very good; it does depend on the presenter and the topic; I liked the ones where activities were involved and/or where I could see an application of some kind, where they were more tangible; the first couple were dry but necessary
    - Liked the field visits; saw things in action, depending on one's field
    - We learned a lot; the whole thing was a new experience
    - I got to learn what graduate school would be like, to simulate graduate school
    - Experience with graduate school
    - Doing a presentation for the first time for 15 minutes; I did work up to it gradually, which was good
    - It was a great residence hall experience, in suites; there was a strong social element, the interaction; we would have preferred to be even closer in distance within the residence halls

2. What concerns do you have about the program just ended?
    - The evaluation forms for the oral presentations would have been better if they had been open-ended; they were not well-designed
    - The evaluations of the oral presentations were done too early; they should have been done after at least two weeks; they could be done more frequently, e.g., every two to three weeks, but begin later in the process
    - Two or three of the advisors were not sure about communications with the Principle Investigators of the grant; they did not seem to be clear how their research projects tied to the grant, what the students should be taking away from the grant project; it should be clearer what the grant objectives are, clearer about the vision of the grant goals and objectives
    - A list of goals should be provided for students and faculty before the start of the grant
    - Samples of student projects from this year can be provided for next year to help prospective students and faculty better understand what to expect from the program
    - In one case, one student was limited by the logistics of the situation as to accessibility of working on the research project

- However, they liked going to the environmental engineering conference, regardless of their own field, especially given that they are still undergraduates

3. List the top three things that you learned (within and outside of your discipline) during this program.

- Important – Should have a presentation on how to give presentations, i.e., PowerPoint, Communications
- Bacterial source tracking and methodology
- Presenting research
- How broadly something like water uses the skills of so many academic fields
- Research in general as what I want to do
- How to go about research
- How to present
- How to write a research paper
- Learn about a new area of a field (geology)
- Learning to present chemistry to non-chemists
- Presenting more pictures than text

4.a. How many of you are motivated to go to graduate school now?

- 5 graduate school
- 1 law school
- 1 don't know

4.b. How many of you intended to go to graduate school at the beginning of the summer?

- 4 graduate school
- All reported being more motivated for further study as a result of the summer program experience

5. How do you think that your communication skills improved as a result of this program?

- I am more confident now
- I now have more experience in talking one on one with experts
- Scientists are very focused; as a presenter, I now realize that I am the expert on the topic on which I am doing the presentation

6. How satisfied were you with your living environment at Virginia Tech? Your social/cultural environment?

- We loved the suites; hated the ants; liked the kitchen on the floor; liked everyone being together; would have preferred to be even closer physically; all should live in the dorms
- It's a good location, closed to downtown
- Enjoyed the Unitarians
- Ended up in some awkward social functions/luncheons with other groups (MAOPS) that did not make much sense
- Enjoyed the cookout with the faculty and graduate students

- Would have liked canoe trips and hiking with others also once or twice

7. Other comments?
   - We liked the size of the group, i.e., 8-9
   - Get the word out early
   - Advertise on Facebook
   - Get flyers to department heads and engineering outreach offices
   - Use e-mails also
   - Use the alumni from this summer as resource people to advertise the program next year

5.2 External Evaluation Report: Virginia Tech Research Opportunities in Interdisciplinary Watershed Sciences and Engineering, NSF Award# 0649070 by Julie Martin Trenor, Ph.D., November 19, 2007

Drs. Younos and Lohani are to be congratulated on a successful REU program during the summer of 2007. The popularity and impact of the program from the students' perspective is evident in the post-program surveys and focus group discussion. In addition to providing a positive professional development and social experience for the REU fellows, the program succeeded in creating valuable mentoring experiences for participants. The high quality of the research conducted by fellows is evidenced in their final presentations and reports. Another particular strength of the program was its emphasis on exposing REU fellows to a professional conference experience. Several recommendations and suggestions for continued success are made in this report.

Recruitment & Selection Recommendations:

1. In the application materials, offer suggestions (3—4 bullet points) for faculty writing the letters of recommendation regarding the criteria by which applicants will be judged. This will help ensure that information provided in the letters is relevant to the research experience and program goals.
2. Include an item in the application that asks applicants how they heard about the program—this will help guide future recruitment efforts by determining the most effective means of communication.
3. Utilize various diversity programs and organizations in recruitment. While the WEPAN listserv was used this year, it would also be helpful to advertise through the women and minority engineering program offices at target institutions, as well as through the faculty advisors for student sections of organizations such as: National Society for Black Engineers, Mexican American Engineers and Scientists, Society of Hispanic Professional Engineers, Society of Women Engineers.
4. Utilize past participants in the recruitment process by making them aware of new deadlines and asking them to spread the word to their contacts.
5. Add an item on the application asking applicants to rate possible projects. This will help ensure a good match of match interests in the final selections.

Program Elements Recommendations:

1. Consider moving some of the required elements of final paper to earlier in the summer by having various sections due throughout the summer.
2. Offer additional organized social events, ideally with a VT student social coordinator.

Assessment Recommendations:

1. Further utilizing a mixed-methods approach to program assessment by having fellows complete weekly journal entries and individual post-program interviews is recommended. This approach would offer additional insights about the "hows" and "whys" of the quantitative data, and would have the potential to better distinguish issues surrounding "ceiling effects" found in survey data this year. Journal entries will encourage REU fellows to regularly reflect on their own learning, and will allow program organizers to monitor their progress and track their growth as a function of time. It will also program organizers to identify potential problems early, even if a student is too shy to verbalize his/her concerns. Interview data will allow fellows to describe the program's impact in their own words, and will offer program organizers the ability to track individual gains and learning outcomes as a result of the summer experience. Additional insights about program assessment will likely be possible when quantitative and qualitative data is triangulated.
2. Potential collaborations with the UH REU Innovations in Nanotechnology program during the summer of 2008 would result in additional assessment data and co-authored publications comparing the two sites. A potential collaboration might include:
    a. Using the same guiding research questions at both sites
    b. Administering the same quantitative pre- and post surveys at both sites
    c. Conducting post-program interviews at both sites using same interview guide
    d. Having students complete journal entries using the same questions at both sites
    e. Recommended journal questions and interview guide to be used in such a collaboration are given in a separate appendix not reported here.

6. Conclusions

Overall we had a very successful program in the first year implementation and the evidence is shown in the program assessment and NSF REU participant reflections' sections of this article. As a result of the first year of this program, at least one research article (Sustainable Water and Energy Infrastructure: Integrating Sustainability Dimension into Undergraduate Research and Education by Vinod K Lohani, Tamim Younos, Jennifer Mullin and Teresa Chen) is under peer review for publication in a refereed journal (Journal of Water Resources Planning and Management, ASCE). Also, one NSF REU participant (Christopher Burrell, Hampton University) received the Best Undergraduate Research Paper Presentation Award at the Virginia-West Virginia Water Research Symposium that was held end of November 2007 at Virginia Tech.

For 2008 announcement, second year of our NSF REU program, we have incorporated changes based on our first year experience and what was recommended in the program assessment. Other recommendations related to program implementation will be executed during summer of 2008.

Acknowledgements

The success of our NSF REU program is attributed to very constructive contributions from research mentors (Drs. Dietrich, Edwards, Burbey, Hagedorn, Schreiber, Little, Webster, Kachroo, Vallet), members of program management team (Drs. Sanders, Muffo and Trenor). Also acknowledgements are due to several graduate students and laboratory personnel, and those who provided support for social activities. The program success to a great extent is the result of NSF/ REU fellows' enthusiastic participation and work ethics. The NSF/ REU program is supported through the NSF grant No. 0649070.

This article is dedicated to the memory of late Dr. G.V. Loganathan who was an active participant in NSF/ REU proposal development and 2007 NSF / REU participant recruitment and selection but unfortunately on April 16, 2007 lost the opportunity to be a research mentor.

Bibliography

[1] NAE, 2005. Educating the Engineer of 2020, National Academy of Engineering publication, Web Site: www.nae.edu

[2] The Engineer of 2020, 2004. National Academy of Engineering publication, Web site: www.nae.edu

[3] National Research Council. 2001. Envisioning the Agenda for Water Resources Research in the Twenty-First Century. The National Academy Press, Washington, D.C.

[4] Born, S.M. and K.D. Genskow. 2001. Toward Understanding New Watershed Initiative. A Report from the Madison (NSF-EPA) Workshop. Madison, Wisconsin. 24 pp.