The U.S.-China REU Program On Marine Science and Engineering

Hung Tao Shen, Hayley Shen

Department of Civil and Environmental Engineering
Clarkson University, Potsdam, NY, USA 13699-5710

Qianjin Yue

Department of Engineering Mechanics,
Dalian Univeristy of Technology, Dalian, China 116023

Peifung Guo

College of Environmental Oceanography
Ocean University of Qingdao, Qingdao, China 266003

Introduction

Scientific research and technological enterprise are increasingly global. It is important to provide opportunities for engineers and scientists to develop the international experience and capabilities at early stages in their careers. This paper presents the experience from a NSF-REU (Research Experience for Undergraduates) Program on Marine Science and Engineering in China. This program is the first REU Program in China sponsored by the NSF Division of International Programs. Over 30 students from different universities across the United States participated in this Program in the last two years. The students spent 10 weeks during the summer in China to conduct research projects under the supervision of Chinese mentors at Chinese universities. Research topics cover all areas of marine science and engineering. The participants came from different majors in engineering and science, including civil engineering, mechanical engineering, computer engineering and science, environmental engineering and science, physics, chemistry, oceanography and meteorology. Despite culture and language barriers, and differences in educational approach, the program has been well received by the students as well as the mentors. Students gained first-hand appreciation of a different culture (both socially and academically) in addition to the experience of doing research on advanced topics. Mentors have the opportunity to gain a better understanding of the differences in the training between students from the U.S. and from China. This paper will review the development, planning, organization, implementation, and results of the program.

Program Development

The National Science Foundation has a long history of supporting domestic REU (Research for Undergraduates) programs. With the increasingly global nature of scientific and technological enterprise it is critically important to develop international experience and capabilities for U.S. scientists and engineers at early stages in their careers. The implementation of the International REU by the National Science Foundation addresses the need for providing the training of young scientists and engineers for a globally competent workforce. The East Asia and Pacific Program (EAP) of the National Science Foundation is strengthening its support for workforce development through a number of efforts collectively referred to as AWARE (American Workforce and Research and Education). The REU Program on Marine Science and Engineering in China was developed by Clarkson University, jointly with Dalian University of Technology (DUT) and Ocean University of Qingdao (OUQ), with the support of EAP. To develop an effective international REU program, it is important to maintain the strong research component in addition to the international experience. Other considerations include the close research link between the U.S. program directors and the host institutes, local living condition and accommodations, support of the administrations of the host institutes, and international experience of mentors in the host institutes. These are important considerations for setting up a REU Program in a developing country with non-Western culture. The two host institutes in China, DUT and OUQ, were selected for their strong programs in marine science and engineering and close research exchanges with the Program Directors. OUQ is the leading university in ocean science in China. It has strong programs in physical and environmental ocean sciences. DUT with its State Key Laboratories in Coastal and Offshore Engineering and Structural Analysis and Industrial Equipment is one of the top technical universities in China. Both universities are experienced in international exchanges and are enthusiastic about the REU Program. Both cities, Dalian and Qingdao, are modern port cities, which provide good living environments for REU students.

Planning and Implementation

From our own experiences advising undergraduates in research projects, we have observed that there are two aspects of research projects that increase the benefits of participating in a summer research project: 1) students should work within a research team on a comprehensive research project; and, 2) students should be assigned a self-contained project that can be completed in the summer program. Working as part of a larger research team provides the students with greater appreciation for the overall benefits of research in general and the importance of graduate school in achieving the research objectives. Thus, faculty mentors are committed to identifying projects that are part of larger research efforts, requiring undergraduates to work closely with a vertically integrated team, while at the same time requiring each student to generate, interpret, and communicate his or her own research results. In addition to the importance of undergraduate research experience, we also observed that the international experience gained by some of our graduate students has greatly enhanced their interest in pursuing research career and their ability in broadening their outlook on research through international cooperation. The REU site program is built around critical research and mentoring experiences with additional program opportunities intended to broaden students' professional perspective and international experience. Activities include:

Research Projects: Each student is assigned to a faculty mentor; complete a self-contained research project; participate in research team meetings and presentations; and, write a paper summarizing their research effort.

Orientation and Seminars: Students participate in a one-week orientation program before leaving for China and immediately after arriving China. The orientation program includes a 3-day workshop at Clarkson before leaving for China, and an orientation program, including culture tours, immediately after arriving China. Additional weekly seminars/exchange activities on Chinese and U.S. history, culture, social-economical development, and industries are conducted while in China.

Research Symposia and Workshop: An interim workshop with oral progress reports is conducted during the 5th week to review students' research progress. During the last week in China, students present their research results at an undergraduate research symposium with the participation of Chinese students.

Community Building and Culture Activities: Field and culture trips and social activities are included to enhance students' international experience and foster student-student communication. These activities increase their appreciation for belonging to a multicultural group. Each year, students design web pages to describe their research projects and experience in China. This group project brings the students into a closer post-program tie. The web pages generated are used for recruiting purposes and provide information for students in the following years.

Follow-up Activities: Students communicate with their faculty mentor and the program directors throughout the year to finalize research results and provide continued dialogue and advice related to graduate school decisions.

Recruitment and Selection of Students

Recruiting for the Program is made through posters and web site. Announcement of the Program is made via poster and web site distributions to professional societies such as the American Society of Meteorology, American Geophysical Union, and university consortiums, such as the Great Lakes Research Consortium and Association of Environmental Engineering Professors are used for recruiting. The web site describes the overall goals of the program, the research and living environment at the two Chinese universities, the financial incentives, highlights of research projects and cultural activities, as well as the web pages prepared by past participants. Students can apply online from the web site.

Experience with recruiting undergraduate students for other summer research programs at Clarkson suggests that very targeted recruiting through established contacts is more effective than mass mailing information regarding the program. A two-pronged approach is taken for recruiting through both marine science and engineering channels, and those channels appropriate for specifically targeting underrepresented populations. Posters and emails describing the program are mailed to colleagues at institutions across the U.S., especially those have marine

science and engineering related programs, with a request that they pass the information on to their most promising students. Colleges and universities without graduate programs are also targeted. Recruiting of underrepresented populations is conducted. Information required for the selection of suitable students is requested in the application package. Telephone interviews with potential candidates are useful to determine the suitability and level of interest of the candidates.

Table 1. Summer 2000 Research Projects

Project Title	Student	Mentor
Survival of E.Coli in Marine System	Shanon Coulter-Burke, UC Berkeley, Env. E.	J. Bai/ Qingdao
The Role of Atmospheric Input of Nitrogen on Marine Ecosystem	Gage Choat/U. Alaska, Chemistry	H. Gao/ Qingdao
SPM (Suspended Particulate Matter) Transport in the Bohai Sea	Tracy Anderson/ Michigan Tech., CEE	W. Jiang/ Qingdao
Satellite Image Analysis of Wave Height	David Ing/U. WA. Oceanography	J. Tian/ Qingdao
Exchange of Nutrients between Sediment and Water in Coastal Seas	Heather Lamb/SUNY Fredonia, Env. Sc.	S. Liu/ Qingdao
The Circulation in a Continental Shelf Sea	Stephen Rouch/Vassar Coll., Comp. Sc.	W. Sun/ Qingdao
Numerical Modeling of Storm Surge Flooding	Noa Naftali/Barnard Coll., Env. Sc.	J. Wang/ Qingdao
Water Exchange in Different Areas of Bohai Sea	Emmelene Lee/U. Penn., Bio. Eng.	H. Wei/ Qingdao
The Effect of Sewage Discharge to the Inter-tidal Ecosystem	Adam Klein/ Illinois, Civil & Env. Eng.	X. Zhai/ Qingdao
Noise Data in the Inverse Analysis of Viscoelasticity	Cristina Rhodes/Staten Is. Coll., Bio. Infor.	H. Yang/ Dalian
In-situ Ice Data Collection in Liao Dong Bay using Computer Networks	Ti-Jay Erikson/ Clarkson, Comp. Sc.	Q. Yue/ Dalian
Dynamic Ice Force on Vertical Compliant Structures	June Shen/ Cornell, Mech. Eng.	Q. Yue/ Dalian
Wave-Induced Pore Water Pressure	Lu Gan/Missouri, Rolla, Civil Eng.	Z. Sun/ Dalian
Numerical and Experimental Study of Low Frequency Waves	Darren Spratt/Illinois, Civil & Env. Eng.	Z. Zou/ Dalian
Impact of Wave Slamming on Coastal and Offshore Structures	Seth Kassels/Colorado Coll., Env. Phys.	Y. Wang/ Dalian
Dynamic Analysis and Optimization of Complex Structures	Keith Epstien/ Cornell, Mech. Eng.	Y. Gu/ Dalian

The considerations of selecting students include:

- High motivation levels to conduct research;
- Potential of benefiting from international experience;

- Diversity of the group composition; and,
- Compatibility of student and faculty mentor areas of interest.

Table 1 shows the research projects and students of summer 2000. The 16 students include 6 White males, 5 White females, 3 Asian females, 1 Black male, and 1 Eurasian male.

Program Administration

The administrative tasks include developing and distributing recruiting materials and web site, student selection, mentor assignments, travel arrangements, coordination with host universities, and follows up evaluations during the academic year. Clarkson's Undergraduate Graduate Research Coordinator provides administrative support. The Program Directors from the U.S. side are closely involved in all of the above activities. They accompany the students to China during the summer, work with the mentors to bridge the communications with the students, review research progress and final reports, and coordinate culture tours. The first two weeks of the summer research program is the crucial period that requires special attention for the Program Directors to work closely with the Chinese mentors and the students to clearly define the scope of their research projects, so that it can be accomplished within the 10-week period with good results. A research proposal workshop is conducted within 10 days after arriving at the research sites. Each student is required to give an oral presentation to outline his or her research plan. An interim review workshop with oral progress reports is used to ensure the progress of each research project. Writing a technical report/paper is an important training for students. The U.S. Program Directors work with the students and faculty mentors on the preparation of the final research papers. The final papers are compiled in References [1] and [2].

Program Evaluation and Results

Evaluation and improvement of the REU program is an on-going effort for the Program. The critical measure of success is the improvement of students' research and international experience. Much of this information is compiled through student and mentor surveys. These internal assessments are used to improve the program each year. The survey forms are presented in Appendices I and II. Figures 1 and 2 show the survey results. In general, these results indicated the enthusiasm and satisfaction of both the students and mentors with the Program. The mentors felt that the U.S. students are very good students, even though a little weak in mathematical and theoretical background. They observed that the students learned new material for their research very quickly. Students are very independent, self-initiative, and creative. The faculty mentors also indicated that the experience with the REU students gave them the first-hand experience on the product of the U.S. education system, which will help them to reform their teaching methodology. Students felt the research projects are interesting and challenging. They liked the experience of working with Chinese graduate students, who can provide assistance in addition to that from the mentors. They also felt the international experience enabled them to gain the confidence to work with foreign researchers and engineers. Participation in the Program allowed them to gain new understanding and respect for another culture. Many of them expressed interest in continue their education in graduate school, and possibly working in Asia in the future. Students were satisfied with their on campus accommodations as well as the living environment in Dalian and Qingdao. Overall, the Program successfully achieved its objectives. It enabled students' to gain or enhance their research ability

and interest, and developed their capabilities to participate in international scientific and engineering activities.

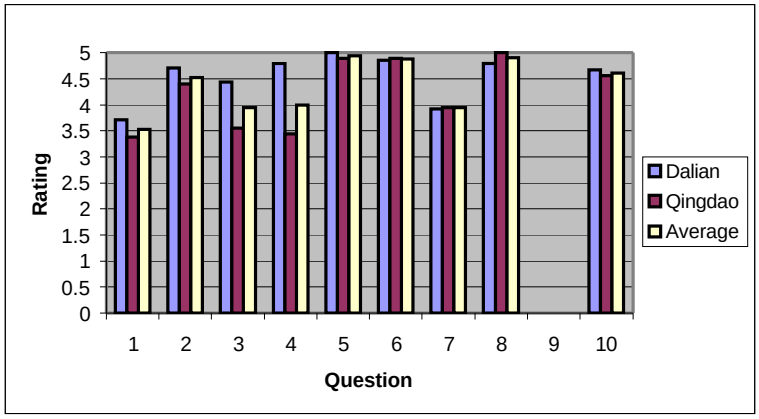

Figure 1. Student Survey Results

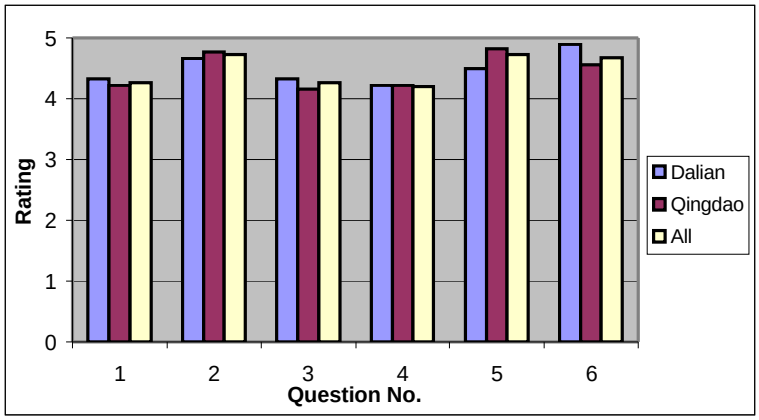

Figure 2. Mentor Survey Results

Acknowledgements

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Appendix I – Student Survey Form

REU in China 2001 -Student Survey **July 2001**

Student's Name: _____ Mentor: _____

Research Topic: _____

Please provide your evaluation using the scale of 1 to 5, with 5 being the most descriptive.

1. Background /ability (Is your background/ability sufficient for the project?)
   1 2 3 4 5

Comments:

_____

_____

2. Project (Is your project challenging? Is it interesting? Did you gain good research experience?) **1 2 3 4 5**

Comments:

_____

_____

3. Advising (Did your receive sufficient advise and help from mentor and graduate students?)
   1 2 3 4 5

Comments:

_____

_____

4. Research Facility (Adequacy and quality of laboratory and field equipment?)
   1 2 3 4 5

Comments:

_____

_____

5. International experience (Do you think the REU in China is a worthwhile experience? Will this experience help you to work with Chinese or other international researchers in the future?) **1 2 3 4 5**

Comments:

_____

_____

6. Life in China (Considering that China is a developing country, are you satisfied with the living accommodations? Did you enjoy your visit in China? Do you think you have gained a better understanding of China? **1 2 3 4 5**

Comments:

_____

_____

7. Group experience (The group experience with your fellow REUers) **1 2 3 4 5**
Comments:

_____

_____

8. The team experience with Chinese graduate students, if applicable.) **1 2 3 4 5**
Comments:

_____

_____

(10.) Overall rating of the Program: **1 2 3 4 5**
Additional comments (positive and negative), and suggestions to this REU Program and the Program Director. (Please write on the back of this page, if you need more space).

_____

_____

Appendix II – Mentor Survey From

REU in China 2001 -Mentor Survey **July 2001**

Mentor: _____ Student's Name: _____

Please provide an evaluation of your advisee:
(Using the scale of 1 to 5, with 5 being the most descriptive.)

1. Background /ability (Is the student's background/ability sufficient for the project?)
1 2 3 4 5
Comments:

_____

_____

2. Self-initiativeness (How is the student's working attitude? Is he/she self-initiative? Did the student work diligently and creatively?) **1 2 3 4 5**
Comments:

_____

_____

3. Results (What is your evaluation of the student's research results?) **1 2 3 4 5**
Comments:

_____

_____

4. What is the potential of having the results published, with the student as a co-author?
1 2 3 4 5

Comments:

_____

_____

5. Is this a worthwhile effort on your part as a mentor to a student from the US?
   1 2 3 4 5

Comments:

_____

_____

6. Over all performance (Please give your over all evaluation of the student.)
   1 2 3 4 5

Comments: _____

_____

_____

- Please provide your comments (positive and negative) and suggestions to this REU Program. (Please write on the back of this page, if you need more space.)

Biography

Hung Tao Shen is a Professor of Civil and Environmental Engineering, Clarkson University. He is an expert in Cold Regions Engineering. He has conducted joint research with Chinese researchers since 1985. He is currently the Chair of the Ice Engineering and Research Committee of IAHR, and a recipient of the Harold Peyton Cold Regions Engineering Award and Can-Am Civil Engineering Award of ASCE.

Hayley Shen is Professor of the Civil and Environmental Engineering, Clarkson University. She studies the flow of granular materials, and its role in Sea Ice dynamics. She was awarded the ASCE Walter L. Huber Research Prize for her work in granular flows. She has also received the Outstanding Advisor Award of Clarkson University.

Qianjin Yue is a Professor of Engineering Mechanics and Associate Director of the National Key Lab. on Structural Analysis and Industrial Equipment, Dalian University of Technology. His research interest is in the area of offshore structures and ice-structure interaction. He is current conducting field and analytical studies in the Bohai Sea, and is a principal investigator on the EU funded NEST Project on ice forces on offshore structures.

Peifang Gou is an Associate Dean of the College of Environmental Oceanography, Ocean University of Qingdao, in charge of educational activities. His research interest is in the area of remote sensing applications in oceanography. He is conducting research in this area on projects founded by the State Oceanic Administration, China.