

2006-846: BALANCED ACTIVITIES TO INCREASE STUDENT SATISFACTION IN A MENTORED SUMMER RESEARCH PROGRAM

Tom Langen, Clarkson University

TOM LANGEN is an Associate Professor in the Departments of Biology and Psychology at Clarkson University. He has been co-director of the Clarkson REU Site Program in Environmental Science and Engineering since 2002.

Stefan Grimberg, Clarkson University

STEFAN GRIMBERG is an Associate Professor in the Department of Civil and Environmental Engineering at Clarkson University. He was co-director of the Clarkson REU Site Program in Environmental Science and Engineering 1998 - 2000, and has directed the program since 2002.

Balanced Activities to Increase Student Satisfaction in a Mentored Summer Research Program

Introduction

Summer research programs in science and engineering are an important way for undergraduate college students to experience substantive research beyond the confines of traditional coursework. Such programs also provide an opportunity for faculty, including those at teaching – intensive institutions, to closely mentor students in research during a period when teaching and service commitments are lowest.¹

The National Science Foundation (NSF) is one of the largest sources of funding for undergraduate summer research programs in science and engineering, both through awards to individual researchers and through its Research Experiences for Undergraduates (REU) Site Program. Over 120 REU Site Programs are currently funded in engineering disciplines alone. NSF's stated objective for the REU Site Program is to attract and retain promising undergraduates to careers in science and engineering research and education. This is to be achieved by funding programs that recruit a cohort of students to perform mentored research projects with a defined common focus on a coherent intellectual theme. Particular emphasis is placed on recruiting women, underrepresented minorities, persons with disabilities, and students at academic institutions where research opportunities are limited.²

In most summer research programs, including REU Site Programs, students are expected to initiate and complete a substantive research project in a short period of time, typically 8 - 10 weeks. While the research project is a student's principal activity in a summer program, there may be other organized activities incorporated into the program, including research seminars, skills workshops, graduate education and career mentoring activities, field trips, and social activities.³ Potential benefits of ancillary activities include (1) improved understanding of the relevance and multidisciplinary linkages of research projects; (2) improved attitude and

motivation to conduct research, because it is perceived as ‘fun’; (3) increased creativity based on having a variety of experiences; (4) improved leadership skills and participation in research-team collaboration, (5) better developed skill base for conducting and communicating research projects; and (6) improved understanding of the value of a graduate education, and preparation needed to be successful in attaining a graduate degree. The costs of incorporating ancillary activities in a summer research program are (1) they reduce the time available for research and interfere with research schedules, which can decrease mentor satisfaction and participant success at completing a project; (2) they increase the logistical burden on program directors; and (3) they increase the expense of funding a summer research program.

The Clarkson University REU Site Program in Environmental Science and Engineering supports ten students each summer in mentored research, and incorporates a substantive program of ancillary activities. Each year, a survey is administered at the beginning and end of the program to assess participants’ experiences and attitudes about the Clarkson’s REU Site program, about research, and about pursuing a graduate degree in science and engineering research or education. In this paper, we summarize assessment data addressing the following question: *Do themed seminars and social activities provide an important element in the success of a summer research program?*

Description of the Clarkson Program

The Clarkson University REU Site Program in Environmental Science and Engineering has been funded by the U.S. National Science Foundation for 3 three-year tenures (1998 – 2000, 2002-2004, 2005-2007). In this paper, we will focus on the last four years of the program (2002-2005), because program activities changed somewhat after 2000, corresponding with the period that we became program directors.

The theme of our REU Site Program has been solving complex environmental problems and increasing environmental sustainability through research in environmental science and engineering. Consistent with NSF’s goals for REU Site Programs ², the program’s objectives include (1) providing students who are traditionally underrepresented in environmental science

and engineering with an opportunity to conduct independent research that is mentored by an experienced scientist or engineer; (2) teaching these students how to conduct meaningful environmental research and communicate the results of that research to professional colleagues and the general public; (3) communicating to students the importance of graduate school as an integral part of the educational pipeline leading to successful careers in science and engineering; (4) demonstrating why synthetic, integrative research is necessary for understanding and solving complex environmental problems, and therefore why multidisciplinary and interdisciplinary approaches to environmental science and engineering are important; and (5) improving students' skills at analyzing and solving complex problems by working within teams comprised of diverse members, in terms of individual perspectives and disciplinary expertise. For purposes of outcome assessment, we quantify the program's success at meeting these five outcomes, and at providing an enjoyable experience to participants.

Similar to other NSF REU Site programs³, ten upper-level undergraduate students are funded to conduct ten weeks of summer research mentored by a Clarkson University faculty member. Candidates for the program are recruited nationally, resulting in a geographically diverse group of participants from both primarily undergraduate institutions and large research universities. Around 53% of participants are women and 10% are underrepresented minorities. The program is highly selective; there are over 100 applicants for the ten internships each year.

Researchers who mentor students include representatives from the disciplines of Environmental Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Chemistry, Physics, and Biology. Usually, a mentor is limited to one student supported by the REU Site program per year. Research projects are expected to contribute toward understanding and remedying important environmental problems.

Research is the primary activity of the Clarkson REU Site Program in Environmental Science and Engineering, accounting for over 85% of a participant's time (assuming a typical forty hour work week). The research experience culminates in a public research symposium at the end of the program, for which each participant gives a short talk on the results of their research. Each

participant also submits a written research report to the mentor, and a synopsis of the research is posted on the program's website.

In addition to research, the program curriculum includes a weekly seminar on environmental sustainability, several research tools seminars, and a variety of community building activities. The environmental sustainability seminar is led by an environmental philosopher (William Vitek, Clarkson University Department of Humanities and Social Sciences). Students read and discuss material on conceptual and applied issues related to environmental sustainability, and how multidisciplinary and interdisciplinary research in science and engineering may contribute toward attaining sustainable resource use. They also discuss systems approaches to science and technology, cross-disciplinarity, and potential alternatives to current systems of science, economics, and values. The theme of sustainability is intended to provide a venue for students to learn research approaches for understanding complex systems, the importance of multidisciplinary and interdisciplinary research for understanding and solving problems, and how their particular research project and other participants' projects can contribute to environmental sustainability.

A concurrent series of special topic seminars or workshops are held to improve REU participants' skills at conducting and reporting on research, and on opportunities for graduate school. Each workshop is typically a single two-hour meeting, with individualized one-on-one mentoring as follow-up. Workshop topics include framing hypotheses, statistical data analysis, presenting a scientific talk, and web page design. As a culmination of the latter workshop, participants create individual web pages to report their research findings, and a collective group site to present the summer's curricular and recreational activities.

Besides the usual informal social activities that occur 'after work' (e.g. sports leagues, barbecues), the Clarkson REU Site Program has included some formal activities for community-building and increasing awareness of the larger community. The first weekend of the program is spent at an outdoor retreat center in the Adirondack Mountains, where students participate in activities designed to build trust and multicultural awareness, and cause them to reflect on the leadership and collaborative skills needed to conduct research as part of a research team. Later in

the program, participants are taken on three field trips to view efforts at environmental sustainability in the field, for example large scale municipal composting in Burlington Vermont, and monitoring of environmental health at a Great Lakes Area of Concern by the environmental management unit of the St. Regis Mohawk.

Assessment of the Clarkson REU Site Program

Each year, before that formal start of the program and again on the program's last day, each participant completes an extensive written survey (created by Larry Compeau, Clarkson University Organizational & Consumer Studies Program) that provides quantitative data on each participant's prior expectations and final subjective evaluation of the program, relative valuation of each of the program's elements, and research experiences and attitudes about research and graduate education. Subsequent to completing the Clarkson REU Site Program, participants are tracked to determine how many actually continue onto a graduate program in engineering or science. As an additional method of assessment, at the end of the program each research mentor also completes a survey that addresses issues related to their extent of involvement with the students, their perception of the importance of the mentoring process, and the success in completing a significant research project in a ten-week time frame. A total of 38 participants completed the pre and post program surveys in 2002 to 2005.

Assessment Results

Participants were highly satisfied with the program. On a Likert scale of 1 = *Strongly Disagree* to 7 = *Strongly Agree*, the mean \pm se response to the statement *I am glad that I participated in the program* = 6.8 ± 0.08 . The response to the statement *I would recommend this program to other students* = 6.9 ± 0.04 , and the response to the statement *If I had to do it over again, I would choose to participate in this program* = 6.9 ± 0.07 .

The participants evaluated the research project and other activities as equally valuable. When asked to score the relative importance of each of seven activity categories such that the sum of the scale equaled 100, the sum of categories related to research activities = 51 ± 2.0 , whereas the

sum of categories pertaining to other activities (e.g. seminars, field trips) totaled 51 ± 2.1 . Across the seven categories, the research project rated highest but all activities were judged as valuable (Fig. 1).

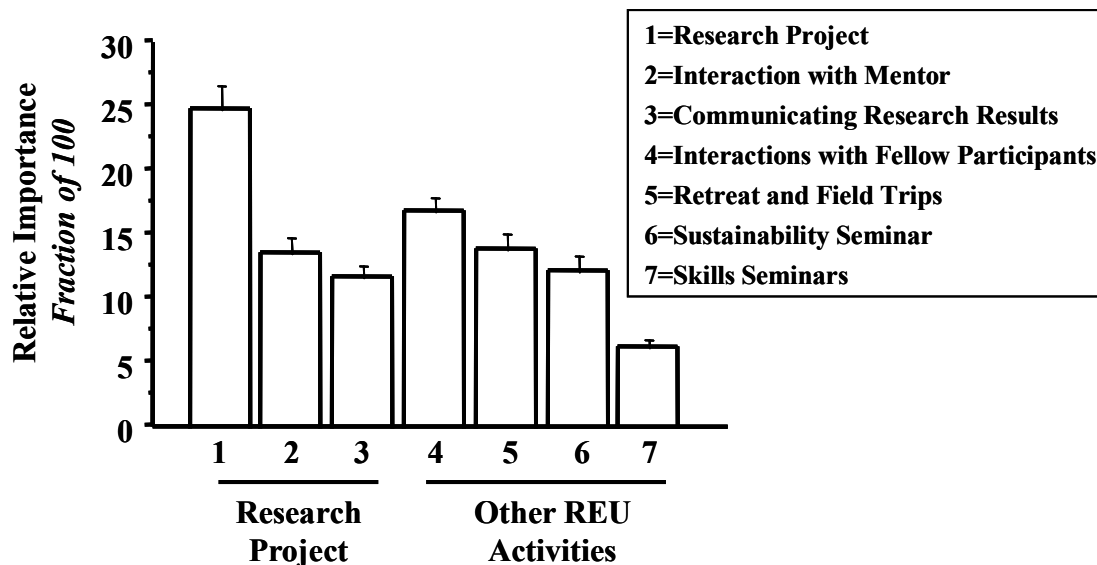


Figure 1. Participants' evaluations of the relative importance (in fractions of 100) of seven elements of the Clarkson REU Site Program in Environmental Science and Engineering. $N = 38$.

Related survey items were lumped to create summated scales. Overall success at meeting our REU program's outcomes (participant diversity, preparation for graduate study and research career, importance of interdisciplinary research and environmental sustainability), as judged by the program participants, correlated with time spent with the faculty member (Spearman's rank correlation, $r_s = 0.51$, $p = 0.002$), having had fun ($r_s = 0.41$, $p = 0.01$), and overall satisfaction with the program ($r_s = 0.51$, $p = 0.002$). Success at meeting the program's outcomes did not correlate with total time spent on the research project ($r_s = -0.08$, $p = 0.6$). Participant's overall satisfaction with the REU program experience, which is not necessarily the same as success at meeting the program's outcomes, nevertheless had similar correlates, but was much more strongly associated with participants having had fun ($r_s = 0.70$, $p < 0.0001$).

Not surprisingly, participants came into the Clarkson REU Site program with positive attitudes toward research (mean \pm se score = 5.9 ± 0.12 , where the score ranges from 1 = *Strongly disagree* to 7 = *Strongly agree* to statements pertaining to the value of research activities). However, there was no increase in positive attitudes toward research after completing the program (mean change in score = - 0.09; paired t-test, $t = 0.6$, one-tailed $p = 0.7$). Incoming participants evaluated research on the environment as important (mean score = 6.5 ± 0.17), but participation in the REU program did not increase this evaluation (mean change in score = 0.10; $t = 0.6$, one-tailed $p = 0.3$). Incoming participants' intentions to attend graduate school were high (mean score = 5.9 ± 0.17), and participation in the program did not increase this intention (mean change in score = 0.16; $t = 0.8$, one-tailed $p = 0.2$). Incoming participants' intentions to pursue a career involving research were also high (mean score = 5.5 ± 0.12), but participation in the REU program did not increase this intention (mean change in score = - 0.15; $t = 0.9$, one-tailed $p = 0.8$).

Interestingly, incoming participants' opinions on the importance of environmental sustainability were already high (mean score = 6.2 ± 0.19), but increased after having participated in the REU program (mean change in score = 0.36; $t = 2.0$, one-tailed $p = 0.03$). The sustainability seminar was judged as significantly helpful at increasing general knowledge of environmental science and engineering (mean \pm se score = 2.7 ± 0.10 , where the score ranges from 0 = *Didn't help at all* to 3 = *Tremendously helpful*), at decisions related to graduate school and future career (mean score = 1.9 ± 0.20), and at understanding how to conduct research (mean score = 2.1 ± 0.17). Participants came to understand how their particular research project contributed to environmental sustainability (mean \pm se score = 6.3 ± 0.17 , where the score ranges from 0 = *Strongly disagree* to 7 = *Strongly agree* to the statement *I understand how my project contributes to the sustainability of environmental systems*).

Discussion

We conclude that having a balanced mix of activities is important for the success of a summer undergraduate research program, and indeed enhances the research experience in ways that are consistent with the overall objectives of an REU Site Program. While the mentored research

experience is the most important element in the Clarkson REU Site Program's success, the other activities are also highly valued by participants, and appear to be essential for the program's success. A limitation of our survey data, however, is that there is no proper comparison group that had participated in a comparable research experience but without the ancillary program activities. Such a comparison might be very informative about the short-term and long-term benefits of such activities within the context of a mentored research experience.

We surmise that incorporating intellectually stimulating and fun activities within a theme that is complementary to participants' research projects enriches the research experience. It does so by improving motivation, developing skills through collaboration and team-work, clarifying the relevance and societal value of research, and enhancing the perception that research is a fun activity. In our program, these other activities result in an average 15% loss of research time (6 hours of a 40 hour week), some of which may be recouped by improvement in participants' motivation and research skills due to the ancillary activities. Although we have occasionally heard mild complaints from faculty mentors about ancillary activities taking away too much time from participant's research time, mentor quantitative written assessments of the Clarkson REU Site program have remained very good, and most mentors continue to participate in the program year-after-year.

Our assessment data also indicate that the Clarkson REU Site Program does not increase participants' intentions to attend graduate school and pursue research careers in science and engineering. Participants enter the program with a firm intention to attend graduate school and pursue a career in research or teaching, and leave the program with a similar strong intention; most eventually do enroll in a graduate program. Thus, we cannot show any significant 'value-added' in terms of this important objective of our summer research program (a similar result is reported by Lopatto⁴). In large part, this is due to the fact that applicants that are competitive for a selective program such as ours must demonstrate strong motivation and likely aptitude for conducting research; these are the undergraduates that are inherently most likely to attend graduate school. This is an acknowledged problem of other studies that try to assess the success of summer research programs at promoting graduate study and careers in science and engineering, many of which erroneously judge success at meeting this outcome merely by

assessing intentions of participants at the completion of a summer research program, or by tracking the proportion of participants that eventually attend graduate school without similarly tracking a comparable control group⁴⁻⁶. We suspect that the added value for most participants of a summer research program such as the Clarkson REU Site Program is in developing the experience, skills, and knowledge-base that facilitates acceptance and success in higher-quality graduate programs, and hence contributes to eventual success in a career of science and engineering research or teaching (as shown in Kremer and Bringle⁷).

Bibliography

1. Kardash, C.A.M. (2000) "Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors," *Journal of Educational Psychology* 92:191-201.
2. National Science Foundation (2005) *Research Experiences for Undergraduates (REU) Supplements and Sites: Program Solicitation NSF 05-592*, National Science Foundation, Washington D.C.
3. Sutterer, K., M. Brenny, J.D. Pirnia, M. Woodward, R. Houghtalen, and J. Hanson (2005) "Engineering REU sites: Designing for appropriate and valuable summer educational experiences," *Proceedings of the 2005 American Society of Engineering Education Annual Conference & Exposition*..
4. Lopatto, D. (2004) "Survey of undergraduate research experiences (SURE): First findings," *Cell Biology Education* 3:270-277.
5. Bauer, K.W., and J.S. Bennett (2003) "Alumni perceptions used to assess undergraduate research experience," *Journal of Higher Education* 74:210-230.
6. Zydney, A.L., J.S. Bennett, A. Shahid, K.W. Bauer (2002) "Impact of undergraduate research experience in engineering," *Journal of Engineering Education* 91:151-157.
7. Kremer, J.F., and R.G. Bringle (1990) "The effects of an intensive research experience on the careers of talented undergraduates," *Journal of Research and Development in Education* 14:1-5