

# Role of the Faculty Mentor in an Undergraduate Research Experience

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## ABSTRACT

Research experience for undergraduate (REU) programs are designed to recruit students to science and engineering research careers by allowing the students to conduct research with faculty mentors. International research experiences can enhance the research experience by allowing the student to conduct research in a unique environment and also provide the student with a more global perspective. This paper describes the outcomes of an international REU program in which students quantify hydrological and biogeochemical fluxes in a tropical montane forest in central Costa Rica. Having the students at a central research station location and focusing their research on a common research problem is an important aspect of an international REU program, to avoid a feeling of isolation and to ensure that the students remain safe in their research and during their free time. However, this shared experience can highlight differences among the faculty mentors and make the students evaluate their individual experience more critically. To better understand the relationship between the REU student and their faculty mentor(s), we conducted pre- and post-trip focus groups to understand the students' experience in the REU and the manner in which the faculty mentor can affect that experience and the desire to continue in research. Results of the pre-trip focus group suggest that the undergraduate students are most concerned about their projects and give little to no thought about the faculty mentor with whom they will be completing their research. Post-trip results from 2011 and 2012 suggest that mentors had a much greater impact on the experience than expected. Many students said that their future research/graduate school plans were affected by their REU mentor relationship, and that while they might not have considered the importance of faculty mentors before the research experience, they now recognize the mentor as a crucial aspect of a research project. Using a classification system commonly used in management research, the mentoring styles were classified with management classification styles as autocratic, democratic, or laissez-faire. The overall results suggest that the student-to-mentor relationship created through these authentic experiences is one of the most important aspects of REU programs, and that the mentoring style not only determines the research productivity of the student, but also appears to influence the decision of that student to conduct research in the future and/or attend graduate school. The mentoring style also affects research productivity and allows students to identify the characteristics they perceive as important to success in a graduate program. While this paper focuses on a single REU program, the results provide baseline data to examine the role of the faculty mentor across other REU programs and in decisions about graduate research by both the student and the faculty. Mentoring styles and student expectations of their mentors should be taken into consideration when developing a research experience and pairing mentors with prospective students. © 2013 National Association of Geoscience Teachers. [DOI: 10.5408/13-420.1]

**Key words:** undergraduate research experience, mentoring, study abroad

## INTRODUCTION

The Research Experience for Undergraduates programs at the National Science Foundation (NSF) started in 1987 to recruit talented students to research careers in science and engineering. The NSF (1989) states that the "involvement of undergraduate students in meaningful research...with faculty members [is] one of the most powerful instructional tools," and undergraduate research is a critical component of the agency's strategy to reform education (NSF, 2000). In response, other research experience for undergraduates (REU) programs have been funded throughout the United States to allow undergraduate students a formal opportunity to develop skills in problem solving, critical thinking, and an appreciation of the research process and the importance of communication of the research process and results. There is

mounting evidence that these research experiences help to develop originality, creativity and curiosity, and independence (Ahlm, 1997; Zydney et al., 2002a,b; Bauer and Bennett, 2003; Lopatto, 2004; Seymour et al., 2004). Through post-program surveys, participating students suggest that the research experience significantly improved their technical and problem-solving skills and increased their self-confidence (Sabatini, 1997; Kardash, 2000; Mabrouk and Peters, 2000). The perceived benefit of conducting research increases with increasing time involved in research (Zydney et al., 2002a,b).

The generally positive view of REU programs largely stems from post-program assessments that are based on the immediate perceptions of the student and faculty mentor. Comparisons between those who participated in research and their peers who did not participate in a research program suggest that there is no statistically significant difference in the development of research skills between these groups (Hackett et al., 1992). While the benefit of REU programs to the development of research skills is still not clear, there is evidence that these programs are effective in recruiting students to graduate programs (Morley et al., 1998; Schowen, 1998), particularly students from underrepresented minority groups (Nagda et al., 1998; Adhikari and

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Nolan, 2002; Hathaway et al., 2002; Barlow and Villarejo, 2004). Dobrow and Higgins (2005, p. 567) suggest that recruitment develops through the “cultivation of professional identity,” in which the students begin to recognize their potential to be scientists. A professional identity is fostered when the faculty mentor treats the student as a colleague, trusting his/her insights and contributions to the faculty mentor’s research (Baxter Magolda, 1999). A successful mentor provides the student with an “apprenticeship in which the novice learns over a period of time through hands-on experience how science research is done” (Hunter et al., 2007, p. 65). In other words, the faculty mentor who provides instruction, guidance, and direct modeling of how to be a scientist supports student learning, which allows the student to develop greater responsibility for his/her own work, demonstrate a willingness to chart the course of his/her own research, acquire a tolerance of frustrations and reversals in research, and develop an interest in science (Baxter Magolda, 1999).

Students identify a good mentor as one who has “time for the mentee” and listens to the students, while less effective mentors are not readily available to spend time with the students, which forces the students to work independently and depend on postgraduates, technicians, and other students (Behar-Horenstein et al., 2010). Specifically, the authors note that faculty mentors do not always meet on a regular basis, and the faculty are not always accessible, which is contrary to most studies that only highlight the positive aspects of the research experience (e.g., Cunningham and Eberle, 1993; Boyle and Boice, 1998; Morrison-Beedy et al., 2001). Limited mentoring does not allow the student to develop a clear understanding of his/her research and how it will ultimately contribute to the literature (Hunter et al., 2006). Students who decide not to continue in research could have either been part of a poorly designed research project or experienced ineffective mentoring by the faculty mentor and his/her graduate students (Zydney et al., 2002a). Specifically, the authors argue that the mentor is a very or extremely important factor in the decision of the student to attend graduate school, suggesting that the interaction of the student with the mentor and the style of mentoring provided is an important component of a research experience. A negative experience could also reflect a large student-to-faculty ratio, and the authors argue that research experiences should not be provided to a “much larger number of students,” without an increase in the number of willing faculty mentors (Zydney et al., 2002a). The limited number of willing faculty could reflect a lack of institutional resources and incentives (of time, money, and tenure) to integrate undergraduates into their research (Hakim, 1998). While the role of the faculty mentor can be enhanced through the interaction of undergraduate students with graduate and postdoctoral students (Zydney et al., 2002b), this interaction is not necessarily positive either.

Despite the importance of mentoring, there is a paucity of data to describe how the relationship between the student and faculty mentor affects the research experience for the student and alters the decision to pursue a career in science. The purpose of the present study was to examine the student perceptions of the relationship with the faculty and graduate-student mentors during an international REU program in central Costa Rica. Pre- and post-program focus groups are used to better understand the relationship

between the student and faculty mentor and to determine how the student’s perceptions affect his/her experience and desire to continue with research. Focus groups are an effective research method that produces “important insights to work that seek to describe and document the social world” (Cameron 2000, p. 89), such that the results of the present study will provide a nuanced description of the mentor/mentee relationship.

## NATURE OF THE PROGRAM

The Texas A&M University (TAMU) REU in Costa Rica provides 30 undergraduate students (~10 per year) with an opportunity to participate in research on the ecohydrology of a tropical pre-montane forest at the Soltis Center for Research and Education (<http://soltiscentercostarica.tamu.edu/>). The Soltis Center for Research and Education is located in San Juan de San Isidro de Peñas Blancas, about a 2.5-h drive northwest of San José, the capital city of Costa Rica. The mission of the Soltis Center is to serve as the official institutional representation of TAMU in Costa Rica and throughout Central America, and to support high-impact academic, research, and outreach programs at TAMU. This new facility provides dormitories, classrooms, and computer labs, among other modern amenities, to support research, education, and outreach activities

Fourteen TAMU faculty from four departments in three colleges assist students in collecting and analyzing rich data sets, using state-of-the-art field and laboratory equipment, and developing research questions related to: (1) multiscale climate feedbacks and climate change, (2) hydrometeorological transfers through the canopy, (3) hydrologic pathways and fluxes, and (4) biogeochemical cycling of carbon and water. Specifically, students and faculty participate through research clusters focused on precipitation, evapotranspiration, runoff/stream flow, or subsurface storage. These research areas directly address questions regarding the spatial and temporal heterogeneity of the coupling between vegetation, climate, and hydrology. Students start the program at the College Station Campus of TAMU (weeks 1 and 2) before heading to Costa Rica for 6 weeks to establish their equipment and start their research with the faculty mentors and graduate students. The REU program proceeds from a dependent relationship with the faculty mentor during the development and implementation of the research project to an independent relationship as the student demonstrates competence and comfort in the collection of data and preliminary data analysis and interpretation. It is important to note that the field and international component requires that students develop the flexibility to alter their field experiments when required by the equipment and conditions of the forest not anticipated at the start of the program. The REU program ends with the participation of the students in a campus-wide poster session for the various REU programs on the main campus of TAMU. All students are then given the opportunity to present their research at a national conference hosted by the American Geophysical Union, Geological Society of America, or the American Meteorological Society. Submitting the research results to a refereed journal is dependent on the student continuing to work with the faculty mentor after the research experience, an opportunity that varies between research clusters.

TABLE I: Management styles defined by Lewin et al. (1939) used to classify the mentoring styles experienced by the students in the REU program.

| Mentoring Style | Mentoring Behavior  |
|-----------------|---|
| Autocratic      | Decides the direction of the field and laboratory research and expects students to complete the research based on clear and firm communications as would be expected by research assistants |
| Democratic      | Consults with the undergraduate students, listens and considers their research ideas, and accepts the majority viewpoint in the planning of the field and laboratory research               |
| Laissez-faire   | Provides little direction to participating students and expects that students are able to identify, develop and execute research independently  |

## METHODS

Pre- and post-trip focus groups were conducted in both 2011 and 2012 to observe and record the differences from pre- to post-trip in students' attitude, relationship, and overall evaluation of their respective REU programs. All focus groups were audio recorded, and a full transcription was made of the first (2011) REU group. The full transcription was analyzed with latent content analysis to establish themes presented within the focus groups. An abridged transcription was made of the second (2012) REU group, based on the established themes from the first REU group. The moderator of the focus groups was purposefully chosen as someone independent from the REU program, so that students would not feel the necessity to filter their answers according to the moderator's position within the program. Precautions were taken according to institutional review board protocol, and students were made aware that their identity would not be revealed. An independent moderator and confidentiality helped the students to feel more comfortable in giving candid and unbiased answers. The purpose of the moderator was to elicit information from the students to provide insight to improve subsequent REU programs.

For the pre-trip focus groups, the REU students were broken up into several smaller groups composed of three to six students, depending on the group and scheduling availability. Focus groups were conducted in such a way that each student was able and did respond to every question asked. For the 2011 program, pre-trip focus groups were conducted within the first 2 days of arrival to Costa Rica. REU 2011 pre-trip focus groups were moderated by the practitioner and the students were asked to discuss three initial questions: (1) "What made you decide to participate in an REU program in general?", (2) "Why did you choose this specific REU program?", and (3) "What are your expected outcomes?" After the data were collected and analyzed from the 2011 program, certain themes (i.e., the role of the faculty mentor) became apparent, and questions for subsequent REU focus groups were changed accordingly. Specifically, the REU 2012 pre-trip focus groups were asked the same three questions as the 2011 cohort, with the addition of a fourth question: (4) "What do you expect from your mentors?" The pre-trip focus groups for the 2012 cohort were held the week before departure to Costa Rica, since the practitioner was not joining the 2012 group to Costa Rica as he did in 2011.

The 2011 post-trip focus groups were held during the last week in Costa Rica and the 2012 post-trip focus groups were held within the first week of arrival back from Costa Rica. Post-trip focus groups were conducted in the same

manner as described above. The REU 2011 post-trip focus group discussion was moderated around two main instructions/themes, (1) "Give a critical evaluation of your respective REU program," and (2) "Give a positive evaluation of your respective REU program." In the first instruction, students were prompted to give a critical evaluation of the program. The students, through this instruction, were encouraged to discuss the negative aspects of the REU. This was done in order to understand the areas in which the REU program could improve on in subsequent years. After certain themes (i.e., the role of the faculty mentor) presented themselves as being the determinant factor of student evaluation of the program, the 2012 focus group discussion was focused on the role of the faculty mentor and centered on two slightly different instructions/themes, (1) "Give a critical evaluation of your mentor," and (2) "Give a positive evaluation of your mentor." The first instruction prompted the students to consider the negative aspects of their relationships with their respective mentors, while the second instruction prompted the students to consider what they perceived as the positive aspects of that relationship. It is important to note that while these instructions were specifically given to the 2012 group, the positive and negative aspects of the faculty mentors were focused points of discussion with the 2011 students.

Through these questions/instructions, the investigators defined the mentoring style of the faculty as "laissez-faire," "democratic," or "autocratic," based on the Lewin et al. (1939) definition of management styles. To our knowledge, this is the first time that the Lewin management styles have been used to define academic mentoring styles. Specifically, the classification was based on whether the responses focused on a lack of independence (autocratic mentoring), lack of oversight and mentoring (laissez-faire), or a collegial (democratic) relationship with the student's mentor (Table I). The classification is then used to determine if the style of mentoring within each research group affects the decision of the student to pursue a graduate degree, evaluation of the research experience, and research productivity in the form of national conference presentations and/or a referred publication. Although these relatively simple descriptions of management styles were heavily criticized through the 1980s and 1990s (see Pettigrew, 1985; Kanter et al., 1992; Hatch, 1997), there has been increased recognition and acceptance of Lewin's management views, with the majority of recent studies attempting to identify how these management styles generates favorable outcomes for different organizations (e.g. Burnes, 2004; Burnes, 2007; Castle and Decker, 2012; Hackman, 2012; Peus et al., 2012).

TABLE II: Demographic data for applicants and participants of the REU program in both years.

| Parameter                    | 2011         |            | 2012         |            |
|------------------------------|--------------|------------|--------------|------------|
|                              | Participants | Applicants | Participants | Applicants |
| Total                        | 13           | 136        | 12           | 129        |
| Gender                       |              |            |              |            |
| Male                         | 5            | 47         | 2            | 47         |
| Female                       | 8            | 89         | 10           | 82         |
| Race                         |              |            |              |            |
| White                        | 12           | 114        | 10           | 103        |
| Black                        | 0            | 7          | 0            | 3          |
| Hispanic                     | 1            | 12         | 1            | 15         |
| Other                        | 0            | 3          | 1            | 8          |
| Travel                       |              |            |              |            |
| Previous                     | 10           | 115        | 11           | 101        |
| None                         | 3            | 21         | 1            | 28         |
| Previous research experience |              |            |              |            |
| Another REU                  | 0            | 3          | 2            | 10         |
| Assistantship                | 1            | 26         | 1            | 22         |
| Internship                   | 2            | 14         | 2            | 24         |
| Research course              | 1            | 21         | 1            | 18         |
| None                         | 9            | 72         | 6            | 55         |
| GPA                          |              |            |              |            |
| Overall                      | 3.7          | 3.5        | 3.8          | 3.8        |
| Earth sciences               | 3.8          | 3.6        | 3.7          | 3.5        |

## RESULTS

Data were collected from 22 students enrolled in the 2011 and 2012 REU programs, using pre- and post-trip focus groups. All of the students in the 2011 program participated in both pre- and post-trip focus groups, while 11 of the 12 students participated in the pre- and post-trip focus groups in the 2012 cohort. Demographic data of the 2011 and 2012 participants are presented in Table II.

### Pre-trip Survey and Focus Group

Prior to the start of the research experience, the majority of students saw the REU as an opportunity to learn essential skills in research and to determine whether they wanted to attend graduate school. As noted by some of the participants:

- “If I like conducting scientific research, I will likely have greater motivation to go to graduate school.”
- “...being a good scientist involves both emotional and intellectual strength; emotionally, I need patience, because science experiments don’t always work out, and intellectually, I need persistence, because the right answer is not always the easy answer.”
- “I believe that participating in this REU will allow me to take charge of my education, discover what motivates me and makes me happy, and teach me skills in ways that few classroom lectures can.”

- “...participating in this REU will allow me to become more comfortable with research processes in general and the technologies used during them.”
- “...REU programs are well known to encourage intellectual growth in participating students.”

The students also saw the REU as an opportunity to determine whether they wanted to continue in a graduate program:

- “...from participating in the program, I would hope my summer research experience would help further solidify my aspirations of earning a PhD.”
- “By participating in the REU program in Costa Rica, I hope to give focus to what I would like to study in graduate school...critical step in determining the type of research and career I would like to pursue after graduation.”

The students also noted that the REU would allow them to “...work with faculty mentors who will help me grow professionally and intellectually.”

In general, the REU participants saw the program as an opportunity to work with and learn from the faculty mentors:

- “I hope to gain insight into how other kinds of labs are run and how other mentors work.”



- "...[the] REU experience will allow me to study and learn from a professional in my field in a one-on-one capacity."
- "By working under the mentorship of a diverse group of faculty, I know I will gain an intimate and deeper knowledge and understanding."
- "...invaluable opportunity to learn firsthand from professional researchers and build my research skills in an international studies environment."
- "Working with professionals in their selected fields will introduce me to the field research work environment and common practices of reputable scientists."
- "I know that the impressive range of fields represented by the faculty mentors can only expand my education."
- "...access to a wealth of practical knowledge accumulated from their experience and hard work."

The majority (61%) of students participating in this REU program had some previous experience conducting research either through an internship, as a research assistant for a professor, at their home institution or through undergraduate theses and coursework. The opportunity to work with faculty mentors was noted by all students and does not appear dependent on previous research experience.

The results of the pre-trip survey were consistent with the results of the original focus group in each year. Specifically, 17 of 23 students said that their main expectation was to find out if attending graduate school is for them and to discover if they like research:

- "Is research really for me?"
- "I see this REU serving as a stepping stone toward grad school"
- "This experience will allow me to figure out what I want to do... Is grad school for me?"

Other students within the 2011 group focused on the international aspect of the REU and saw the program as an opportunity to study abroad:

- "Just wanted to leave where I had been before, never been to Costa Rica before."
- "I consider myself... a global citizen... I want to study other cultures, I want to be there and see how they interact. That's why going abroad is so important to me specifically."
- "Because it was in Costa Rica, I want to spend more time and have a lot more cultural interaction."

None of the students in 2011 cohort mentioned the mentor in the pre-trip focus groups, either directly or indirectly. Only when the 2012 group was prompted in the focus group about the role of the mentor (based on the result of the 2011 post-trip survey) did they consider how the mentor might affect their research experience. Specifically, 2 of the 11 students did not know what to expect and did not have an opinion. Of those that had an opinion, 8 of the 9 students that did respond said that they expected a hands-off approach and that the mentors would not micromanage their research, but be available to help when needed, while 6 of the 9 students also said that they expected to be given time to solve problems on their own. In general, none of the

students voiced a concern or appeared to give any importance to their relationship with the faculty mentor. The majority of the student focus was on the importance of research and how that would affect their decision about graduate school. However, 6 of the 11 students noted that they hoped to make a good connection with their faculty mentors in support of future networking.

### Post-trip Focus Group and Survey

The students of the 2011 focus group directed the post-trip focus group on the role of the mentor. Responses suggested that the students enjoyed the opportunity to work with faculty and saw that as one of the most positive aspects of the REU:

- "Great experience gained by working with legitimate researchers. You know what you are doing, and learning is pertinent, because you are learning it from actual researchers."
- "Liked how [the] mentors in my research cluster were very good, gave freedom to design project, appropriate freedom."
- "Some mentors were really good: they had [a] good schedule [and] were organized."
- "Keep mentors coming down, it was very helpful. Wouldn't have worked without mentors coming down."

However, other students identified the mentors as one of the more difficult aspects of REU program:

- "We felt like research assistants."
- "Feel like it would be better if we were presented options and knowledge of limitations to then be able to choose and build our own project."
- "The graduate students were often the best mentors we had because they related to us."

The first two quotes suggest that students in different research clusters were critical of very different mentoring approaches, which reflects the preference of some students to have more or less direction. As noted, the focus of the 2011 students on the relationship with their faculty mentor prompted the moderator to add a specific instruction about the faculty mentor in the 2012 post-trip focus group. The majority (8 of 11) of students in the 2012 cohort also felt that they were not a priority for the faculty mentor, while 3 of the students felt that their meetings with the mentors were unproductive, and 6 students believed that their mentors were too busy for them. The students in both years noted that the research clusters helped alleviate some of the perceived problems with their faculty mentors:

- "It is good that in this REU there is a community of scholars, because if you didn't get along with your mentor you could find support through other faculty. Whereas in other programs, you might just be stuck with your mentor and that's it."
- "This experience has not changed my plan, I will go onto grad school...[but] if this were my only experience with research and mentors it would dissuade me from grad school."

In this respect, all of the 2012 students believed that one of the most important outcomes of the REU program was a

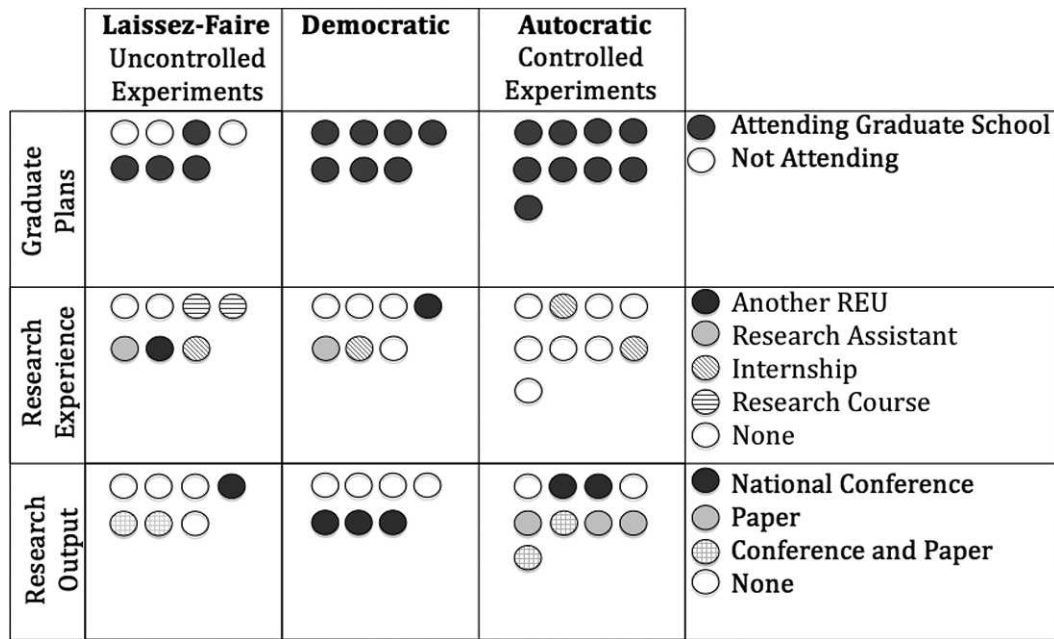


FIGURE 1: Distribution of undergraduate students in their research clusters with respect to the mentoring styles of their faculty mentors. Each circle represents a student, and the position of the student in each cell is consistent down each column.

better understanding of their relationship with a faculty mentor:

- “Grad school seems really determined by your mentors [advisors].”
- “Before this experience, we didn’t put importance of making the graduate school decision on mentors, it was all about the program and project. Now, after the experience, a mentor almost seems like the most important factor in choosing a program.”
- “Now I know how important a mentor is.”
- “...helped me realize the attributes that I need to seek out in a future mentor.”
- “It was nice to get to know what the faculty was all about and what they do.”

Despite the criticism of their mentors, the majority of students said that their decision to pursue a graduate degree was unaffected by the relationship with their mentors. With the exception of three students, all of the students who participated in the REU program have or are planning to pursue a graduate degree. The students who are not planning to pursue a graduate degree in the immediate future reported that their decision was partly based on the relationship with their faculty mentors.

### Mentorship Styles

Based on the student responses, the faculty mentors were classified by the investigators on a sliding scale as laissez-faire, democratic, or autocratic. The distribution of the students is presented in Fig. 1. Results suggest that those students who decided not to pursue a graduate degree (in the immediate future) tended to have experienced a more laissez-faire mentoring and provided the most negative reviews of their mentors and research experience. It was

these students who “...felt it would be better if we were presented options and knowledge of limitations...” and felt like the direction was “...go get all this data and then we’ll figure it out.”

It is important to note, however, that these students tended to conduct exploratory research involving extensive sampling (in time and/or space) with limited experimental control required, which would explain the focus of the responses on the lack of direction. Regardless of the reason for the more critical review, this mentoring style also had the least research productivity, with the exception of the two students with previous research experience in another REU program or as a research assistant.

In contrast, the students with the more autocratic mentors had a mixed review of their mentors, commenting that the research “wouldn’t have worked without mentors coming down,” but they also “felt like research assistants.”

The students working in these groups were conducting research that required greater control and involved relatively sophisticated technology and exact methodologies. The responses of these students tended to be in stark contrast to the students with the relatively laissez-faire mentoring, and while many expressed concerns about their respective faculty mentor, the majority of these students either presented their research at a national conference or were a contributing author.

The students with more democratic mentoring had the most positive reviews of the mentors and the research experience in general and liked the balance of direction and independence, i.e., “...liked the importance of working on my own, but also liked the support in case something went wrong.”

In general, these students developed collegial relationships with their faculty mentors. Their research included intensive sampling within the forest and over the course of

the REU program, but they were required to compare their results with a control station outside the forest canopy. Despite the more positive view of their research, fewer of these students participated in a national conference compared with the students with the relatively autocratic mentors. On average, these mentors stayed in the field for 2 weeks (of 6 weeks total) with their students, while the *laissez-faire* and autocratic mentors stayed in the field for 1 and 3 weeks, respectively.

## DISCUSSION

REUs are designed to recruit students to science and engineering research careers by allowing the students to conduct research with faculty mentors. Post-program reviews tend to focus on the perceived benefits of the research experience by both the student and the faculty mentor, and there is a paucity of studies to critically evaluate the different aspects of the research experience, and in particular, few studies to consider the nature of the relationship between the students and their faculty mentors. A combination of focus groups and pre- and post-program surveys are used in the present study to better understand the relationship between the student and his/her faculty mentor, and to determine how the student's perceptions affect his/her experience and desire to continue with research. Results of the focus groups before and after an international research experience suggest that mentoring styles can be defined with the Lewin et al. (1939) management styles as *laissez-faire*, democratic, or autocratic. These mentoring styles are different with respect to the time of transition from a dependent to independent relationship between the faculty and student, which determines the length of time that the student is provided hands-on experience on how science research is conducted (Hunter et al., 2006). Despite the limited sample size ( $n = 23$ ), student plans to pursue a graduate degree and their research productivity after the research experience appear not only influenced by the mentoring style, but are also found to be dependent on whether the student had previous research experience. Those students who had no previous research experience and either had *laissez-faire* or autocratic mentors tended to not present at a national conference in the year after the program, despite being given the opportunity (Fig. 1). While the opportunity to present their research as journal publications can vary between research clusters, the opportunity for a conference presentation is equal across all students and an appropriate measure of productivity that can be related back to the mentoring style.

The *laissez-faire* mentoring style tended to be used in research clusters that conducted exploratory research involving extensive sampling (in time and/or space), with limited experimental control. While the students were provided with adequate instruction on how and when to conduct the sampling before and at the start of the international experience, the faculty mentors were in the field for the least amount of time with their students. In this respect, the students of the *laissez-faire* mentors had the greatest freedom to develop their research, but were provided with the least guidance on how to alter their field experiments when required by the equipment and conditions of the forest not anticipated at the start of the program. Based on research productivity (papers and/or conference

presentations), this mentoring style was not a significant problem for those students with previous research experience in another REU program or as a research assistant. Those students without previous research experience were the most critical of this mentoring style and are the only students not planning to pursue a graduate degree in the immediate future (Fig. 1). Specifically, the lack of guidance in an REU program, or a research assistantship or honors thesis, does not allow the student to develop a clear understanding of his/her research and contribution to the literature (see Hunter et al., 2006), which reduces interest in pursuing a graduate degree (Zydney et al., 2002a). At the other end of the leadership spectrum, the autocratic mentors spent the most time in the field with their students and provided the greatest level of guidance at the expense of the student's freedom to develop and conduct their own research. While the students were most critical of this mentoring style and expressed their frustration with feeling like "research assistants," these students had the greatest research productivity and all are planning to pursue a graduate degree independent of their previous research experience. The greater guidance of the student research is partly a reflection of the greater experimental control required by the research and the relatively sophisticated technology and exact methodologies. As a consequence, these students also noted how the research experience "wouldn't have worked without mentors coming down," suggesting that the student's desire for greater research freedom was tempered by a recognition of the complex nature of his/her research and the need for continued faculty guidance through the research experience. In contrast, the democratic mentoring style provided less guidance but greater freedom for the student to design and execute his/her research. This mentoring approach reflects the nature of the research involving exploratory sampling within the forest but with a greater need for experimental control (from a station outside the forest canopy) compared with the research directed by the *laissez-faire* mentors. The students liked the balance of direction and independence and provided the most positive reviews of the mentors and the research experience in general, but fewer of these students participated in national conferences or had plans for a research publication, compared with the students with an autocratic mentor.

The observed relationship between mentoring style and research outcomes does not suggest that a particular mentoring style is better than the others. As noted, the appropriate style of mentoring for a student appears to depend on his/her previous research experience. Those who had previous research experience were critical of their *laissez-faire* mentors, but presented at national conferences and have plans for research publications within a year of their research experience (Fig. 1). Those students who were also critical of their *laissez-faire* mentor but did not have previous research experience are the only students of that group who are not planning to pursue a graduate degree and had no research products after their research experience. In general, the appropriate mentoring style also depends on the nature of the research. The *laissez-faire* mentoring is appropriate for exploratory research, while it is reasonable to expect an autocratic approach to research requires a greater level of experimental control. For whatever reasons a particular mentoring style is used, it should be recognized as



a contributing factor to student decisions about whether to pursue research (Zydney et al., 2002a). In other words, mentoring styles and student expectations of his/her mentor should be taken into consideration when developing a research experience and pairing mentors with prospective students. Most undergraduate students have limited to no research experience and might have a limited understanding of the role of the faculty mentor. A student with no previous research experience who is paired up with a laissez-faire mentor might deem that faculty mentor ineffective because the faculty mentor was not available, and the student was required to work independently (Behar-Horenstien et al., 2010). It is reasonable to assume, however, that this mentoring style would be more effective for a student with previous research experience and a developed confidence and independence in research. Students can develop these skills if initially mentored by faculty who provide instruction guidance and direct modeling of how to be a scientist (Baxter-Magolda, 1999).

The research program was structured around research clusters addressing a common research question. Not only were the research clusters important for cohort development, but they also promoted safety in the field and during free time, and also helped make sure that the students did not feel isolated at the relatively remote research station. However, this shared experience and greater familiarity of other students' experiences can highlight differences among the faculty mentors and make the students evaluate their individual experience more critically when evaluating it in the focus groups. As a result, this paper is an overly critical review of the relationship between the faculty mentor and the students. While such introspective analyses can be difficult the results of the study provide a basis through which undergraduate research programs, whether a formal REU, honors thesis, or research assistantship, can be improved through an explicit consideration of how mentoring styles affect the student experience.

It is important to note that the participating students had a generally positive review of the research experience and the structure of the program, and with the exception of the three students with the laissez-faire mentoring, the majority of students said that their decision to pursue a graduate degree was unaffected by the relationship with their mentors, but that the relationship helped the student decide on what style of mentoring they would prefer in the future. Whether they had a positive or a negative view of their relationship with the faculty mentor, the majority of students stated that one of the most important outcomes of the REU program was a better understanding of their relationship with a faculty mentor. When prompted, several students from the 2012 cohort noted that the style of mentoring is just as important in selecting a graduate program as the program and the research project. In this respect, a research experience can prepare students for graduate school by educating them on the mentoring style that is best for them. More importantly, this critical introspection of the mentor/mentee relationship is an important step in making sure that the research experience is effective for both the faculty mentor and the student by highlighting the importance of matching student expectations and previous research experience with faculty mentoring styles. Not only do these results provide guidance to faculty mentors and directors of other undergraduate

research program, but also, the results can be used to evaluate prospective students for a graduate program.

## CONCLUSION

Results of focus groups before and after an international research experience suggest that students do not consider their relationship with the faculty mentor before the research experience, and that they focus strictly on the research to be conducted and the importance of the program in their decisions about graduate school. Post-program focus groups revealed the influence of the faculty mentor to the student's perception of the research experience, and the students were encouraged to be critical of their relationship with the faculty mentors. The mentoring styles were classified as autocratic, democratic, or laissez-faire, and there are differences between these groups with respect to research productivity and intentions of the student to pursue a graduate degree. It is argued that the student-to-mentor relationship created through these authentic experiences is one of the most important aspects of REU programs and affects the research productivity of the students. More importantly, the relationship with the faculty mentor appears to influence the decision of the students to conduct future research and/or attend graduate school. Reflection on that relationship can, however, help students identify the characteristics and mentoring style they perceive as important to their success in a graduate program. Further study is required to both determine the appropriateness of classifying academic mentoring using the Lewin et al. (1939) management styles and to increase confidence in the identified relationship of the mentoring style on student productivity and decisions about graduate research.

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