Science in the Mountains: A Unique Research Experience to Enhance Diversity in the Geosciences

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ABSTRACT

Ethnic and racial minorities constitute an important part of the geosciences community because of their diverse perspectives and backgrounds. However, the geosciences have the poorest diversity record of all the science and engineering fields. Recruitment of minorities is important and numerous programs are focusing on engaging students in geosciences during their undergraduate schooling. The Geoscience Research at Storm Peak (GRASP) program provides a model for retaining students in the geosciences pipeline and encouraging students' interest in geoscience careers. GRASP offers college age students research experiences in urban and rural environments, introduces students to a wide range of geosciences career options, and connects students to mentors and role models. The main challenge associated with the GRASP program in its first year was recruitment. This paper uses the Geoscience Pipeline Model as a framework for evaluating the program's success. GRASP not only exposed the students to a variety of geosciences careers, but it also taught them skills used by geosciences professionals. Overall, GRASP participants demonstrated a positive change in knowledge, attitudes, and behaviors related to the pipeline indicators.

INTRODUCTION

In the United States, ethnic and cultural minorities and persons with disabilities are a valuable pool of candidates for recruitment of geoscientists. Despite this, the field of geosciences has the poorest diversity record of all science and engineering disciplines. Of the scientific fields of study pursued by African Americans and Hispanics, the geosciences rank last (Czujko, 2002). Only 1.3% of geoscience bachelor's degrees were awarded to African Americans and 3.1% to Hispanic Americans in the year 2000 (Drummond, 2004). As stated by the American Geophysical Union Diversity Plan [2002], "racial and ethnic minorities and persons with disabilities are under-represented as scientists … thus valuable human resources, that can bring insights, perspectives, and talents into our programs, are not being given the opportunity to add to the knowledge base of science." Ethnic and racial minorities represent approximately 40% of elementary school students [U.S. Census Bureau, 2000], and thus must be a strong influence on the future talent pool of scientists to ensure the success of research in the U.S. Furthermore, as shown by the research of Johnson and Johnson [1998] and Butler and Kirwan [2002], science is improved through diversity. These studies demonstrate that cooperative groups composed of diverse populations are able to perform more effectively in resolving and understanding issues from different perspectives. To reach ethnic and racial minorities, the geosciences must recruit effectively via specific educational pathways, including minority institutions [American Geophysical Union (AGU) Diversity Plan, 2002]. Programs successful in the recruitment of minorities in the geosciences have

FIGURE 1: Storm Peak Laboratory at 10,500 feet.

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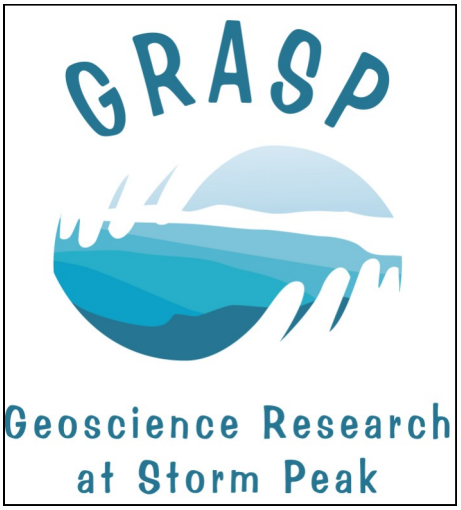

FIGURE 2: GRASP logo created by Lisa Wable

combined a network of minority and majority institutions with supportive, challenging, hands-on research opportunity for students (e.g., Significant Opportunities for Atmospheric Research and Science [SOARS] program). These programs have employed specific educational pathways—including academic and social integration, knowledge and skill development, support and motivation, and monitoring and advising—which have been shown to be best practices for student engagement and retainment (Maton et al., 2000; Summers and Harbowski, 2006). With these factors in mind, the Geoscience Research at Storm Peak (GRASP) was initiated.

COURSE

GRASP is a program providing exceptional field research experiences for a diverse group of undergraduate students and is funded by the National Science Foundation's (NSF) Opportunity for Enhancing Diversity in GeoScience Program (OEDG). This was the inaugural year of the program directed by Dr. A. Gannet Hallar of Storm Peak Laboratory (SPL) in Steamboat Springs, Colorado.

SPL (http://stormpeak.dri.edu/) is a unique facility located on the summit of Mt. Werner near Steamboat Springs, Colorado (see figure 1). SPL provides an ideal location for hands-on experiences in atmospheric science with a high-elevation location, exceptional instrumentation, and a staff of knowledgeable scientists and educators. SPL allows the students and mentors to work and live within its facilities providing an opportunity for scientific exchange.

Recruitment methodologies for GRASP included marketing material, (i.e., brochures and posters), which were distributed to partnering institutions. The GRASP logo (figure 2) was used in all marketing material. The logo was designed to represent the mentoring aspect of the program as symbolized with clasping hands. The background is an artist's rendition of the view from SPL. GRASP partnered with faculty at Tennessee State University, Howard University, Colorado State University at Pueblo, and the University of Nevada, Reno. To increase participation, GRASP was not limited to students from these institutions. GRASP was also advertised via the Earth Science Women's Network (ESWN) list server. ESWN is a peer-mentoring network of women and most are in the early stages of their careers. Currently ESWN includes nearly 1000 members spanning most universities, government agencies, and research organizations in the U.S. This was a very effective means for recruitment, as approximately half the applicants learned about GRASP indirectly (i.e., forwarded email) via this mechanism. Dr. Hallar and Ian McCubbin also advertised GRASP with fliers at professional meetings and numerous emails to colleagues throughout the country.

FIGURE 3: GRASP Team in front of NCAR C-130 research aircraft.

GRASP participants must have completed the equivalent of at least one year of college, have a cumulative GPA of 3.0 or higher, and be pursuing a major in the geosciences or related fields (e.g., chemistry, atmospheric science, computer science, Earth science, engineering, environmental science, mathematics, meteorology, oceanography, or physics) at the time of their applications. The application was available via an online submission process. Applicants were reviewed by a committee of GRASP mentors, and selected based on their academic performance and enthusiasm for science. The application form required short essays to gather information pertaining to students' goals and aspirations as well as enthusiasm for science. Sample essay questions include: What are your academic and career goals? What do you hope to gain from participating in GRASP? How will participating in the program help you achieve your academic and career goals? Describe your academic plans, career interests and objectives, community involvement, and significant events/experiences that have influenced your life. Overall, the GRASP PIs strived for a participant pool that was diverse in their level of education (i.e., freshman and seniors) and experiences (urban and rural students). Four GRASP participants were selected. Although this program was open to both males and females, the most qualified candidates were females, representing African-Americans, Hispanic, and Caucasian. The GRASP participants included undergraduates: one freshman, two juniors, and one senior. Although these students were majoring in a scientific field with geoscience applications, two students had not previously considered a career in the Earth Sciences. Two students were from partnering institutions.

The program was developed to introduce the GRASP participants to potential careers in the geosciences, provide them with an authentic research experience at SPL, and expose them to dynamic scenery. The four GRASP participants and mentors assembled initially in Boulder, Colorado in late June 2008 and were introduced to the program by Dr. Hallar, the director of SPL. They were given lectures that evening and the following morning by a variety of scientists representing a diverse demographic and wide range of areas in atmospheric science research. The following day students took a guided tour of the National Center for Atmospheric Research (NCAR) including a demonstration of the capabilities of the Visualization Laboratory, which allows

scientists to represent data three dimensionally. Also at NCAR, GRASP students were able to have lunch with students from the Significant Opportunities in SOARS program, which provides undergraduate students with four years of research experience. This program piqued the interest of several GRASP participants and we hope this will offer them further research opportunities. After the tour of NCAR, GRASP participants traveled to the NSF's Research Aviation Facility (RAF) where they participated in a science team meeting for an on-going research aircraft mission and toured a research aircraft (see figure 3). The participants were able to communicate with a scientist aboard the aircraft in real-time using a messaging system. The GRASP team was in Boulder for two days and every night they assembled with atmospheric scientists in order for the participants to have further exposure to professionals in the field. The GRASP team then traveled to SPL and spent a total of five days there. The participants were able to learn about the SPL facility, instruments, and data collection. After GRASP participants received lectures in atmospheric science both in Boulder and subsequently at SPL, where they began their research projects. Each project focused on identifying sources of pollution observed at SPL. The four participants formed two research teams and investigated the problem via data analysis of different pollution sources, using satellite data, and models. Specifically, one team investigated increase levels of atmospheric gaseous elemental mercury at SPL associated with wildfires in Siberia. The other team researched organic carbon aerosol levels at SPL, during the winter of 2008, in comparison to other sites. In addition to working on their research projects, the GRASP team also took field trips to several local sites of natural beauty, including waterfalls, hot springs, and mountain vistas.

After leaving SPL, the GRASP participants worked with Dr. Hallar on their research projects for the next four months primarily via email and conference calls. In November of 2008, all GRASP participants met at Howard University for a reunion workshop. While at Howard University, the students presented the results of their research project to faculty members and graduate students within the Program of Atmospheric Sciences. Additionally, they were given a tour of the Howard University's campus and Research Site in Beltsville Maryland, which was established to observed surface fluxes, the boundary layer, cloud optical properties, aerosols, gas concentrations, and precipitation. The students then visited NASA Goddard Space Flight Center and received several lectures from leading earth scientists including a presentation on stratospheric ozone studies. They also received a tour of the NASA facility. Finally, GRASP mentor, Dr. Ann Fridland of NASA Goddard Institute for Space Studies, presented a workshop to the participants focusing on crucial advice for a successful transition into graduate school and beyond. Guest scientists were invited each night to dine with the GRASP participants, allowing them the opportunity to meet a diversity of people working in the geosciences. Overall, GRASP PIs worked to ensure that mentors represented diverse research interests and diverse ethnic communities.

RESULTS

To determine if GRASP achieved its principal goal of encouraging underrepresented student's interest in geoscience careers, we used the Geoscience Pipeline Model (Levine et al., 2007) as a framework for evaluating this goal. This model was developed in light of the OEDG program, funded by NSF. Again, OEDG is the primary funding source for GRASP and "awards grants to projects that are intended to increase participation in geoscience careers by members of groups that have been traditionally underrepresented in geoscience disciplines" (NSF, 2009). The pipeline model is a synthesis of different approaches used by diversity projects to increase the likelihood of participants becoming employed in the field of geosciences. Because long-term studies on eventual geoscience employment choices are difficult to ascertain, the study focuses on short-term factors that indicate a student will join or remain in the pipeline during school. The study makes the assumption that students in the pipeline are likely to pursue geosciences careers. We used the portion of the model that targets college age participants for our evaluation. This portion contains twenty-one different indicators ranging from fiscal abilities to engaging geosciences courses.

The presence of a pipeline factor alone (e.g., participation in a field trip) was not enough to determine whether or not the event had a positive or negative effect on a student's decision to pursue a career in geosciences. Rather, these indicators needed to be evaluated through a demonstrated change in knowledge, attitudes, and behaviors reflective of these factors (Levine et al., 2007). GRASP used seventeen of the twenty-one indicators for college age participants. To determine pipeline factors most important to the GRASP experience, an evaluation was completed to further explore participants' experience during the GRASP program. Two sets of interviews were conducted. The first was a focus group session after the students' week at Storm Peak Laboratory and the second was an individual interview with each of the four participants upon completing the six-month program. In addition, a pre and post survey was given to better understand the impact of GRASP on the four participants. The instrument was developed and tested by staff at the American Institutes for Research (AIR). Given there were only four respondents for the pre and post survey, the survey results were only used to complement findings from the focus group and individual interviews. Four themes emerged from the data that were central to the participants' experience in GRASP. They were: extracurricular activities and effective instruction, fiscal abilities, geoscience awareness and knowledge of geoscience careers, and role models and mentors. Each of these themes and how they connect to the pipeline model are discussed below.

Extracurricular Activities & Effective Instruction

Participation in an intervention program that includes research in the geosciences is one of the most influential factors for why minority students remain in STEM disciplines (Levine et al., 2007; Bembry et al., 1998; Office of Technology Assessment, 1988). Three of the four

participants stated that the extracurricular research experience and exposure provided by GRASP positively impacted their experience in geosciences. Likewise, all four participants said that GRASP provided them engaging and effective instruction that placed high expectations on them and provided them diverse hands-on experiences.

> [T]here's two things that I like about research programs – the hands on experience and the mentorship… For me, what [GRASP] does… is it confirms that I am in the right place, I'm doing what I should be doing, it was a new challenge, I felt very comfortable with it, I completed it.

> [K]nowing that I was coming to DC and would be able to present my research in DC, it gave me something to look forward to and work hard for.

For science and math instruction to be effective, instructors must place high expectations on students and use cooperative learning techniques while making "provisions for as much individualization as possible." (Clark, 1999). Low teacher expectations persistently deter success in geosciences among African-American geoscientists and students (Fields, 1998). GRASP engaged the students in a collaborative research project that challenged them to develop and conduct their own experiments and synthesize their results into individual presentations.

Likewise, the place-based teaching practices used in GRASP helped make the research project more relevant to the students. Minority students often encounter incongruence between their knowledge and ways of understanding science (Levine et al., 2007). As acknowledged in a recent article by Steward Birnbaum (2004), ethnic minorities commonly populate urban areas, where mountain vistas and dynamic scenery are absent. Dr. Birnbaum concludes that minority under-representation in the geosciences may be linked to life experiences dominated by urban settings. With regard to undergraduate education, scientific interest can be developed through the interaction with fascinating phenomena, such as the SPL alpine environment (figure 4) and once interest is developed students make an effort to seek out additional scientific experiences and information (Jarrett and Barnley, 2003).

FIGURE 4: GRASP participant before Lake Dillon.

Fiscal Abilities

Possessing adequate financial resources and knowing about financing post-secondary education are cited as important factors associated with pipeline retention (Levine et al., 2007). While the pipeline model addresses fiscal ability in terms of affording traditional higher education, we found that finances were a limiting factor for some students in GRASP. Providing students participation costs (e.g., airfare, meals, lodging) was not enough; students also earned a $350 stipend during their week at SPL. The stipend was commensurate to earnings from a typical summer job and was necessary to offset the students' lost income while in Colorado. Two of the four participants directly stated that GRASP provided the fiscal support that allowed them to participate.

Fiscal abilities made recruiting students to GRASP challenging. Minority students have a variety of summer intervention programs available to them, and larger, more established summer programs were able to pay students more money for a greater duration of time. Because most students independently finance part or all of their college educations, they need to earn money during the summer. Limited funds during GRASP's inaugural year may have contributed to our inability to attract students. Although fiscal resources presented challenges in recruiting GRASP participants, the four participants' indicated they had a better understanding of other ways to pay for graduate school besides loans and personal funds.

Geoscience Awareness & Knowledge of Geoscience Careers

The pipeline model includes two factors relating to an increased knowledge of geosciences opportunities: geosciences awareness and obtaining information about geosciences majors. All four participants said that GRASP increased their knowledge of geosciences careers, while three of the four participants stated that GRASP taught them more about majoring in geosciences. As well, the pre and post survey results indicated that participants had a better understand of what atmospheric scientists do at work and had increased their consideration of pursuing a career in the geosciences after their GRASP experience.

> [GRASP] opened my eyes to a lot of things, careers in atmospheric science, graduate opportunities, and just the people that who are in the field and have had the similar struggles that I have had.

> I never really thought about geosciences up until this program. Now that I see that there is a different path I can take, by that I mean that I have options of things that I can do with my major or schools that I can attend to further my education.

Many students never get exposed to the geosciences, especially in their early academic training (Fields, 1998). Because the four GRASP participants had only partially completed their undergraduate educations, they learned important knowledge about geosciences relatively early. This early knowledge can play a critical role in a student's career choice (Levine et al., 2007).

GRASP not only exposed the students to a variety of geosciences careers, but it also taught them skills used by geosciences professionals. GRASP gave students the opportunity to work hands-on with instruments and resulting data sets (see figure 5). The opportunity to participate in such research helped the GRASP students to see how their classroom learning translates into actual research and determine if the geosciences field is a career option.

Role Models & Mentors

One of GRASP's greatest strengths for encouraging pipeline retention is providing role models and mentors. Role models and mentors in the geosciences are cited separately in the pipeline model and both can profoundly influence a student's career choice decisions (Levine et al, 2007; Alfred et al., 2005; Armstrong and Thompson, 2003; Bembry et al., 1998) All four participants said they gained at least one mentor from GRASP and were connected with role models—notably women—in the geosciences.

> I think that GRASP has definitely gave me a broader view of what women could do in science and atmospheric science.
>
> [GRASP] has really opened my eyes because all the women that we have been introduced to are doing huge, huge things.

GRASP recruited geosciences professionals from underrepresented groups to support students during their research. Students also met participants from SOARS, an intervention program whose mission is to broaden participation in the atmospheric and related sciences by involving more students from historically underrepresented groups.

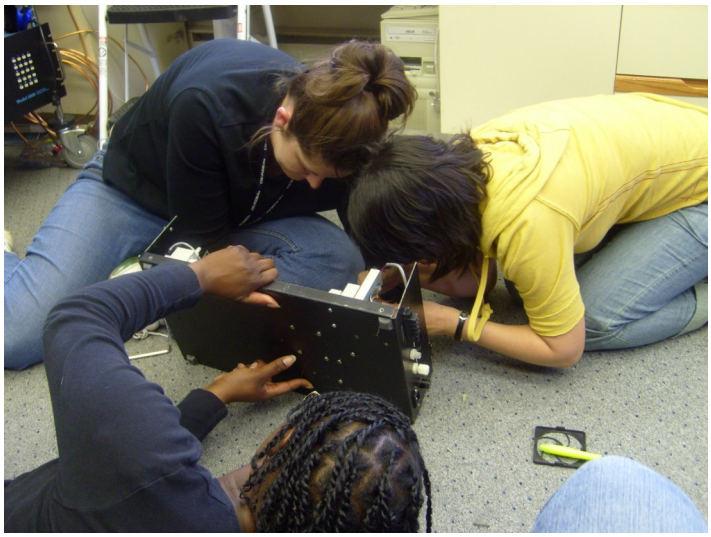

FIGURE 5: Students disassembling an ozone instrument.

While the geosciences professionals who mentored the students during GRASP are committed to maintaining those relationships, one student expressed a need for more faculty contact at her college. Upon returning to school, she wanted to establish a positive relationship with a professor who would encourage her interest in geosciences but did not know who to contact. Recognizing the importance of ongoing support, we have developed a mentoring program that will allow GRASP participants to work on a research project with a pre-selected professor upon returning to school. GRASP will provide each student an hourly stipend for completing this work.

Challenges

The main challenge associated with the GRASP program in its first year was recruitment. Although our partnership institutions greatly assisted in recruiting students, our pool of applicants was limited. The GRASP program received a total of 12 applications. Two selected students declined the opportunity due to other summer internship programs. New recruitment methodology for this upcoming year includes a short "You Tube" video using material from our previous GRASP program (available at: www.youtube.com/adhocprod). This was a suggestion from a GRASP mentor as a method he successfully implemented to quickly reach out to students. The addition of several partnership organizations since our pilot program will also provide a stronger network for recruitment. Finally, GRASP participants have suggested the use of a social networking site (Facebook) for the recruitment of their peers. The most useful recruiting tool is the current GRASP participants: These students serve as ambassadors for the program.

CONCLUSION

Overall, GRASP participants demonstrated a positive change in knowledge, attitudes, and behaviors related to the pipeline indicators. We believe GRASP helps retain students in the geosciences pipeline and encourages students' interest in the geosciences careers. When asked directly if they would consider a career in geosciences, all four students responded "yes." Despite the impact GRASP has had on students during this inaugural year, an intervention program is only one piece of the pipeline. Ongoing positive experiences, including support from professors upon returning to school, positive internship experiences in subsequent summers, and guidance navigating graduate school options, are a few important factors that will support a geosciences career choice.

GRASP strives to provide more than an isolated experience for its participants. Dr. Hallar and other participating mentors have established an ongoing dialog and network of support for these four women, which has included emailing them frequently with new opportunities and funding them to attend professional conferences. GRASP mentors have also provided reference letters for other geoscience opportunities such as graduate school, summer programs and jobs, and work-study. We think GRASP can serve as a

model for engaging a diversity of students and encouraging their interests in geoscience careers.

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