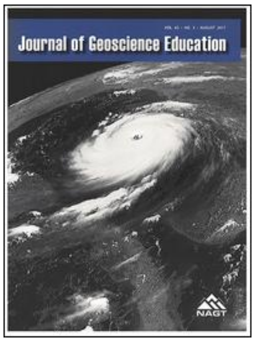

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Increasing Diversity in the Geosciences: Recruitment Programs and Student Self-Efficacy

Lorenzo D. Baber[1], Meghan J. Pifer[2], Carol Colbeck[3], Tanya Furman[4]

ABSTRACT

Using a conceptual framework constructed around self-efficacy, this study explores specific recruitment programs that may contribute to the development of self-efficacy for students of color in the geosciences. This mixed methods study of geoscience education includes quantitative analysis of the Summer Experience in Earth and Mineral Science Program and qualitative analysis of the Summer Research Opportunity Program. Findings identify programmatic components that fostered self-efficacy, thus contributing to students' continued interest in careers in geoscience. This study has potential implications for higher education institutions interested in cultivating programs that attract, support, and retain students of color through various stages of the geoscience education pipeline.

INTRODUCTION

The under-representation of African American, Hispanic, and Native American students in science, technology, engineering, and mathematics (STEM) disciplines has been well-documented in recent years (Anderson & Kim, 2006; Commission on Professionals in Science and Technology, 2004; National Science Foundation, 2004; Riggs & Alexander, 2007). In 2006, while 17% of all bachelor's degree recipients, 16% of all master's degree recipients, and 9% of all doctoral degree recipients were from underrepresented minority groups, these students received just 13% of bachelor's degrees, 8% of master's degrees, and 4% of doctoral degrees in STEM fields (United States Department of Education, 2007). In the geosciences, participation of underrepresented minority groups is even lower, with only 7% of bachelor's degrees, 5% of master's degrees and 2% of doctoral degrees in geoscience awarded to African American, Hispanic, or Native American students (National Science Foundation, 2007). Due in part to such low enrollment in degree-granting programs, racial minorities comprise just 4.4 % of the professional population in the geosciences (American Geological Institute, 2007). Increasing racial diversity in the United States, the approaching retirement of a large percentage of the workforce, emerging climate issues, the rising importance of developing alternative energy sources, and a renewed commitment to economic development and a globally competitive workforce compel the geoscience community to address concerns related to the recruitment and retention of students of color.

Barriers to participation in geoscience for many students of color include under-preparation in math and science, uninviting learning environments, and lack of encouragement and support (Maton, Hrabowki, & Schmitt, 2006; Scholz, Steiner, & Hansmann, 2004; Water & Russell, 2005). Many African American, Hispanic, and Native American students enter postsecondary education less prepared in science and math than their White peers. For example, in 1998, 63% of White high school graduates completed at least one chemistry course, while only 54% of African American students, 46% of Hispanic students, and 47% of Native American students enrolled in at least one high school chemistry course. Differences in math preparation, important in geoscience, are more striking. Nearly twice as many White high school students (12.1%) enrolled in a calculus course as African American (6.6%), Hispanic (6.2%) or Native American students (6.2%) (Barlow & Villarejo, 2004).

When students are able to 'find themselves' in the curriculum or academic projects, they are more likely to be open to new learning experiences and modify previously held beliefs and attitudes about geoscience. Studies have shown that students from groups underrepresented in STEM fields who take a traditional geoscience course have a decreased interest in geoscience at the end of the course (Keilson, 1997; Riggs & Semken, 2001). One of the chief obstacles in diversifying geoscience education is the ineffective way the subject matter is presented, particularly in undergraduate introductory courses (Huntoon, Peach, & Hopkins, 2005).

The purpose of this paper is to describe students' experiences in two projects developed at The Pennsylvania State University designed to increase recruitment, retention, and graduation rates of students of color in geoscience. This paper focuses on students' perceptions of what contributed to their persistence or their reduced interest in science, particularly the geosciences, as well as potential strategies for increasing students' self-efficacy. Specifically, the research question we sought to answer was: How do the SEEMS and SROP programs contribute to the development of students' perceived and observed self-efficacy?

CONCEPTUAL FRAMEWORK

The conceptual framework for this study focuses on self-efficacy. Self-efficacy is defined as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (Bandura, 1997, p. 171). A strong sense of efficacy boosts personal well-being and allows individuals to approach difficult tasks as challenges to be mastered. Conversely, a weak sense of efficacy may cause an individual to underestimate his or her skills and abilities, resulting in perceptions of difficult tasks as challenges to

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be avoided. Bandura (1997) outlined four main sources of self-efficacy:

1) *Enactive mastery experiences* – Success builds a robust belief in one's personal efficacy. Success in new experiences fosters a sense of confidence and ability, increasing the likelihood of engaging in similar experiences in the future.

2) *Modeling influences* – Seeing people similar to oneself succeed by sustained efforts raises observers' belief that they, too, possess the capabilities to succeed.

3) *Social persuasion* – People who are persuaded verbally that they possess the capabilities to master given activities are likely to give greater and more sustained effort than those who do not receive such encouragement.

4) *Altered misinterpretations of stress indicators* – People who have a high sense of efficacy are likely to view challenges as energizing facilitators that heighten attentiveness, rather than as debilitating disruptions of performance.

The development of self-efficacy may be one proactive way of reducing negative attitudes towards geoscience among students from populations underrepresented in the field. While research has shown that subject-specific self-efficacy is associated with academic achievement (Colbeck, Cabrera, & Terenzini, 2001; Drew, 1996), few studies have explored the development of self-efficacy among students, particularly for students of color pursuing majors in STEM fields. The goal of this study was to identify specific experiences in two recruitment programs that may have contributed to the development of self-efficacy for students in the geosciences.

STUDY POPULATION AND SETTING

This study focused on students' perceptions of their experiences in two summer programs at Penn State designed for different stages in the education pipeline along the way to careers in geoscience. Summer Experience in Earth and Mineral Science (SEEMS) is a six-week program targeting high school students (rising sophomore, juniors, and seniors) from low-income families throughout Pennsylvania. SEEMS was developed and is implemented in conjunction with Upward Bound Math-Science, which runs a residential academic enrichment program that requires longitudinal participation by parents and students. Working with each other and faculty members from the College of Earth and Mineral Sciences, students conduct research projects and present their findings to the Penn State community. Data were collected from the cohort of 62 students who participated in the summer 2006 SEEMS program.

The Summer Research Opportunity Program (SROP) is an eight-week intensive research program developed by the Council on Institutional Cooperation (the academic arm of the Big Ten) to prepare undergraduate students from underrepresented groups for academic careers in various fields, including the geosciences. Students from various postsecondary institutions are selected to conduct research with faculty mentors at Penn State and participate in several professional workshops, including a national conference. In 2006, twelve of the students in the SROP program were mentored by faculty members in the College of Earth and Mineral Sciences. Of those twelve, four participants were interviewed for this study.

DATA AND METHODS

In order to assess perceptional changes in students' self-efficacy as a result of participating in these two geoscience programs, a mixed methods approach was employed. The purpose of mixed methods research is to use both qualitative and quantitative measures to investigate multiple questions that are difficult to capture through a single research method (Patton, 2002). Assessing factors that contribute to students' geoscience-related self-efficacy is a complicated inquiry that does not lend itself to single-perspective interpretation. Triangulation of both methods and data sources reveals consistencies across groups that become valuable for their illustrative purposes in explaining students' experiences in the geosciences. The use of quantitative methods addressed the relationships between factors contributing to students' self-efficacy, while qualitative methods were employed to investigate how and why the relationships between these factors and self-efficacy may have formed.

SEEMS Program Data and Methods

Identical pre- and post-experience questionnaires were administered in class to all 62 high school students enrolled in the six-week SEEMS program. Students responded to two categories of questions: student background characteristics and statements about personal and academic activities related to geoscience.

Student background characteristics - Of the 62 students participating in the 2006 SEEMS program, 63% were female and 37% were male students. Over 90% of participants were students of color, including 69% Black and 21% Hispanic. Forty-two percent of the students were entering their sophomore year in high school, 32% their junior year, and 26% their senior year. Fifty-eight percent of students in the sample were returning SEEMS participants, while 42% were first-time participants. Seven percent of the students had never taken a course in high school related to science, 45% had taken one to two courses, and 48% had taken three or more courses. A summary of participant characteristics is provided in Table 1.

Personal and academic activities - Students reported the degree to which they agreed or disagreed with general statements about personal and academic activities related to the field of geoscience. The scale ranged from 1 to 4, where 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. Researchers used a principal component analysis (PCA) of the 42 survey items to explore the possible underlying factor structure among the set of measured variables. When variables are highly correlated,

TABLE 1. CHARACTERISTICS OF SEEMS PARTICIPANTS

Hometown	*(n=62)*
Major U.S. Metropolitan Area	35
Mid-sized U.S. City	16
Small U.S. Town	7
International	4
Gender	
Male	23
Female	39
High School Class	
Rising Sophomore	25
Rising Junior	19
Rising Senior	18
SEEMS Experience	
New	26
Returning	36
Ethnicity	
Black	43
Hispanic	13
Asian	1
White	3
No Data	2

PCA can be used to reduce the number of observed variables to a smaller number of principal components (Suhr, 2005). For this study, only items with factor loadings greater than 0.40 (the minimum value conventionally accepted as meaningful in factor analysis) were considered in deciding the factor structure of each scale, reducing the number of items used in the analysis to 29. PCA produced eight factors with an internal consistency ranging from .61 to .83 (See Appendix A). Using the conceptual framework of self-efficacy, the eight factors related to perceptions of the geoscience field were identified as follows:

1) *Geoscience Faculty as Role Models* – perception of a sense of community among faculty and students and experience communicating with faculty

2) *Self-Efficacy* – perception about academic ability and potential to secure a professional career related to Geoscience

3) *Career Knowledge about Geoscience Field* – awareness of responsibilities in professional positions related to geoscience

4) *Affective Observing Behavior* – positive experiences related to geoscience

5) *Social Persuasion* – links with family and peer networks that support students' interest in geoscience

6) *Interest in Geoscience Field* – heightened curiosity about the field of geoscience

7) *Income Knowledge about Geoscience Field* – accurate information about the financial benefits associated with professional positions in fields related to geoscience

8) *Knowledge about College Application* – accurate information about the process of entering higher education

To determine whether there were statistically significant changes in geoscience-related perceptions among student participants during the SEEMS program, a paired t-test was used to compare pre-test scores and post-test scores. Based on initial results from the paired t-test, we conducted an independent t-test to determine statistically significant differences in new and returning SEEMS participants' changes in perceptions.

SROP Program Data and Methods

We conducted interviews with advanced undergraduate students in geoscience, who are further along in the education pipeline than the SEEMS students, to explore how students' experiences in the Summer Research Opportunities Program (SROP) at Penn State's College of Earth and Mineral Sciences may have increased students' self-efficacy and interest in careers in geoscience. We used purposeful sampling to identify the twelve students of color enrolled in SROP during the summer of 2006. Our invitation to these students to participate in the study yielded four participants, including three men and one woman. The students represented diverse ethnic, geographic, and educational backgrounds, providing multiple perspectives on previous and current experiences in geoscience (see Table 2). All four students were entering their third year of undergraduate study in the fall, pursuing degrees in fields related to the geosciences. Pseudonyms were assigned to each student.

Each student participated in a semi-structured interview at the conclusion of his or her SROP experience at Penn State. They responded to general questions on topics such as pre-college experiences with science, experiences in introductory college courses in science, personal and academic influences on career direction, and future plans related to geoscience. The interview protocol

TABLE 2. CHARACTERISTICS OF SROP PARTICIPANTS

Student names[1]	**Gender**	**Ethnicity**	**Major**	**Institution**
Chino	Male	African	Health & Industrial Safety	Large, Public University Northeast U.S.
David	Male	African American	Geology	Small, Public University Southeast U.S.
Maria	Female	Hispanic/ Non-White	Meteorology	Large Public University Caribbean
Mark	Male	African American	Meteorology	Large, Public University Northeast U.S.

prompted students to discuss significant events or interactions in their educations and lives as they related to their interest in the geosciences. Researchers then followed up on particularly insightful observations and discussions of critical incidents offered by students about their experiences. This method is similar to the critical incident-based method of ascertaining key information about participants' experiences used by Levine et al. (2007). Appendix B provides a sample of questions from the interview protocol.

Themes emerged from each of the interviews with SROP participants through initial coding analysis. These themes were then compared across interviews to ascertain similarities and differences among the students' experiences. Based on these classifications, further within-case and cross-case analysis resulted in the development of themes that reflected participants' experiences coherently and consistently (Patton, 2002). These themes were developed and explored for their usefulness in deepening our understanding of how their experiences affected their self-efficacy.

RESULTS

Effects of the SEEMS Program on Students' Self-Efficacy

Results from the SEEMS survey included information about the overall influence of students' SEEMS experiences on their self-efficacy, as well as significant differences between returning students who had participated in the program at least once before and students entering their first year in the program. Participants' pre-test and post-test survey responses provided information on a variety of topics including academic and personal interest in geoscience, perspectives on faculty in the geosciences program, motivation towards geoscience-related careers, and general knowledge about postsecondary education.

Interest in Geosciences - Interest in geoscience increased significantly among students during their SEEMS experiences (p-value< .01). The factor is represented by questions about interest in, as well as perceived importance and usefulness of, geoscience. The factor had the highest mean value on the final survey (3.55) and recorded the largest change between the initial survey and the final survey (mean change .59). This suggests that, in part, students participating in the SEEMS program develop a considerable interest in the geosciences. Presumably, an increased interest among students would enhance the possibility of the student continuing in the geoscience pipeline beyond the summer program.

Geoscience faculty members as role models - Students' assessment of geoscience faculty members as role models increased significantly during the SEEMS experience (p-value<.05). The faculty-as-role-model factor was measured by questions about perceptions of relationships between students and faculty and openness of faculty. On the initial survey, geoscience faculty members as role models had the lowest mean value of any factor (2.47), compared to a mean value of 2.83 on the post-test. The opportunity for students to interact directly with faculty members on research projects appears to have made an impact during the six week program.

Affective observing behavior - SEEMS students gained significant interest (p-value< .01) in activities related to the geoscience field, reflected by the factor representing affective observing behavior. Geoscience-related activities mentioned on the survey include observation of nature and watching television programs related to nature and scientific phenomena. In addition to being exposed to issues related to earth sciences, the physical landscape and rural setting of Penn State's University Park campus is much different than the urban communities that most

TABLE 3: COMPARISON OF ATTITUDES RELATED TO GEOSCIENCE FIELDS BEFORE AND AFTER SEEMS EXPERIENCE

Variables	Mean[1] (N = 56)	Sig. (2-tailed)
Interest in Geoscience Fields	Pre-test 2.9583 Post-test 3.5536	.000**
Knowledge about College Application Process	Pre-test 2.5170 Post-test 2.6906	.016*
Knowledge about Career in Geoscience Field	Pre-test 2.5273 Post-test 2.7589	.001**
Knowledge about Pay in Geoscience Field	Pre-test 3.0864 Post-test 3.1955	.122
Affective Observing	Pre-test 2.6713 Post-test 2.8889	.001**
Social Persuasion	Pre-test 3.4732 Post-test 3.3661	.362
Geoscience Faculty as Role Models	Pre-test 2.4702 Post-test 2.8274	.012*
Self-Efficacy	Pre-test 2.9643 Post-test 2.8750	.560

[1] 1 represents strongly disagreement and 5 strong agreement
* significant at the 0.05 level (2-tailed)
**significant at the 0.01 level (2-tailed)

participants came from, perhaps influencing differences in affective observing behavior

.

Social persuasion - The social persuasion factor represents SEEMS participants' perceptions of support from friends and family. The factor had the highest mean value in both the initial survey (3.47) and the final survey (3.37). While the mean declined from the pre-test to the post-test, the difference was not statistically significant. Observing high levels of social persuasion among participants is not surprising, given that students had taken the opportunity to spend a part of their summer away from home to explore an area of interest.

Knowledge about careers in geosciences - During the SEEMS experience, knowledge about careers in geoscience also increased significantly among student participants (p-value<.01). This factor included inquiry about understanding of various professional positions related to geoscience. The mean value for the factor increased from 2.53 on the survey taken at the beginning of the program to 2.76 on the survey taken at the end of the program. This change may be the result of the SEEMS program's intentionality in presenting the various domestic and international professional opportunities in geoscience.

Knowledge about pay in geoscience fields - The knowledge about pay factor measured perceptions about salary for geoscience-related positions. While knowledge about pay in geoscience among SEEMS participants increased during the summer program, only a small and statistically insignificant improvement was observed. Students reported high levels of awareness about pay in geoscience prior to their 2006 SEEMS experience (mean value 3.08) indicating awareness among students that careers in geoscience would provide an opportunity for upward socioeconomic mobility. In order to introduce underrepresented students into the geoscience education and career pipeline, knowledge of geoscience careers may be important by high school, if not sooner. This may be particularly true for students from disadvantaged socioeconomic backgrounds, who may factor career salary into their choice of major.

Knowledge about college application process - During the SEEMS experience, knowledge about the college application process increased significantly among student participants (p-value< .05). The factor included questions about familiarity with standardized testing, awareness of financial aid and scholarship options. Prior to the SEEMS experience, a mean value of 2.52 was observed among participants, while the mean value at the end of the program was 2.69. Given that over 40% of the participants were rising high school sophomores, the SEEMS experience may have provided younger students with an introduction to specific information regarding admissions standards, state and federal financial aid options, and scholarship opportunities, leading to the observed increases.

Self-efficacy - The self-efficacy factor was represented by questions about confidence in knowledge of science and math and ability to become a scientist. The mean value for self-efficacy declined during the SEEMS experience, although not significantly. The decline in self-efficacy measures was surprising, leading the researchers to consider possible differences between new students and returning students on this factor and the other factors as well.

Differences Between New and Returning SEEMS Students

Because 52% of the students had participated in SEEMS before, their survey results were compared with

TABLE 4. CHANGES IN NEW AND RETURNING STUDENT ATTITUDES RELATED TO GEOSCIENCES AFTER SEEMS

Variables	Mean[1] (N = 56)	Sig. (2-tailed)
Change in Interest in Geoscience Fields	Returning .1014 New .9394	.002**
Change in Knowledge about College Application Process	Returning .1364 New .2000	.657
Change in Knowledge about Career in Geoscience Fields	Returning .1848 New .2813	.485
Change in Knowledge About Pay in Geoscience Fields	Returning .0978 New .1720	.892
Change in Affective Observing	Returning .1413 New .2742	.304
Change in Social Persuasion	Returning .0000 New -.1818	.395
Change in Geoscience Faculty as Role Models	Returning -.0362 New .6313	.007**
Change in Self-Efficacy	Returning .1739 New -.2188	.036*

[1] 1 represents strongly disagreement and 5 strong agreement
* Significant at the 0.05 level (2-tailed)
** Significant at the 0.01 level (2-tailed)

those who were participating in the program for the first time in order to determine whether there were significant differences in experiences between the two groups. New students reported greater gains during the SEEMS experience than returning students for the following variables: knowledge about careers in geoscience, knowledge about pay in geoscience, knowledge about the college application process, and affective observing behavior. However, new student gains were not statistically significant from gains reported by returning students in any of these areas. Significant differences were reported for the following variables: interest in geoscience, geoscience faculty as role models, social persuasion, and self-efficacy.

Interest in Geosciences - Experience in the SEEMS program played a significant role in change of perception towards geoscience. When compared to returning students, new students reported a significant increase in interest (p-value<.01). For the new students, the mean value for change in interest in geoscience was .94, compared to .10 for returning students. It appears that for first-time participants, the slight decline in personal confidence is overshadowed by the increasing appeal of the field. This observation highlights the importance of persistence for students in programs such as SEEMS.

Geoscience faculty members as role models - First-time SEEMS participants reported considerable gains, significantly greater than changes for returning students, in positive perceptions of geoscience faculty members as role models. The mean value for change among new students was .63, while returning students actually reported a slight decline at -.04. Along with increasing interest in geoscience, the establishment of relationships with faculty members is considered to be a key component of the SEEMS program.

Social persuasion - On the social persuasion factor, a decline was observed among new SEEMS participants (mean value -.18 change), and no change was observed for returning students during the six-week program. While the difference between new and returning students was statistically insignificant, the decline for first-time participants is an important observation. For new students, the SEEMS experience may prompt consideration of potential sacrifices they may be forced to make in finding a place in the community they have just experienced, particularly if it is vastly different than the community to which they are returning.

Self-efficacy - On the factor representing self-efficacy, statistically significant differences were observed between new and returning students (p-value<.05). The mean value for items relating to self-efficacy increased for returning students (.17), but decreased for new students (-.22). While the SEEMS program seemed to increase confidence among returning students, exposure to the scientific rigors of the field may have left students feeling overwhelmed at the conclusion of the six-week program. This finding may indicate the value of multiple experiences in the field of geoscience, as opposed to one-time participation in a program or event.

Effects of the SROP Program on Students' Self-Efficacy

Analysis of interview data revealed themes within and across SROP participants' experiences. The emergent themes from the SROP participants' interviews indicated the possibility of increasing students' self-efficacy through each of the four main sources of self-efficacy as articulated by Bandura (1997). These include 1) enactive mastery experiences; 2) modeling influences; 3) social persuasion; and 4) altered misinterpretation of stress indicators.

Enactive mastery experiences - Interviewees demonstrated changes in perceptions toward geoscience-related career goals after participating in SROP. While each of the interviewees indicated interest in geoscience before participating in SROP, they also indicated that their summer research experiences had provided opportunities for achievement, which then increased and refined their interests. Mark, for example, originally intended to earn his bachelor's degree and enter the workforce as a television meteorologist. After talking with his SROP professors, Mark began to consider earning a master's degree. Some of the professors he met at SROP told him it would be a useful degree for his career plans because meteorological consulting is becoming increasingly important for companies. This advice led him to seek out more research experience to prepare for graduate school.

Maria identified a tension between her professional goals and what she thought was expected of her in terms of caring for her family one day. Maria's experience at SROP helped her begin to reconcile these thoughts and perceptions. She explained that despite her parents' expectations that she would teach, teaching was not her first choice professionally. Through her research experiences, the professional contacts she made, and the knowledge of careers in geoscience that she acquired by participating in SROP, she came to understand the career options available to her. She said, "Right now if you go to any country, they need you. If you go, 'I'm a geographer,' they say, 'Ok, what do you want us to pay you?' because that's how badly they need us." Learning more about geoscience seemed to provide her with validation that her interests were worth pursuing and the confidence that she had the ability to find options beyond teaching.

SROP students reported changed understanding of the next steps in the education pipeline as a result of participating in the program. They discussed learning more about the application process as well as learning how to prepare for graduate school. This knowledge included how to complete an application, request references, conduct research, discuss prior research, and present findings through papers and presentations. After talking with students who had completed the graduate school application process, David made the commitment to earn his Ph.D., declaring that he was "100% sure" that he will attend graduate school. As he stated, "Before I came here, I didn't know about [graduate school], the way it all works. I think just getting an insider's look at what actually goes on is important." Chino said, "I had thought about [graduate school], but SROP really pushed it to the top level as one of the things I need to do." The knowledge that students gained about graduate school and how to pursue admission into a graduate program was a key outcome of their SROP experiences.

Modeling Influences - Discussion of faculty members as role models for students of color interested in geoscience was one of the most prevalent themes in the SROP interviews. Students noted that faculty members introduced them to academic programs, gave them opportunities to conduct research and present findings with them, gave them advice about their academic and professional interests, provided support regarding their personal lives, demonstrated what a scholar and a researcher does, and discussed what the students should do in order to achieve success in their careers. Additionally, the opportunity to work closely with professors gave students a sense of accomplishment and pride that motivated them to continue with their studies. Students benefited from having access to knowledgeable professionals and opportunities to observe them as they conducted their work. Chino said,

> I've learned over time that you learn by getting more information from people who are knowledgeable….[my advisor] introduced me to the program, and everything about SROP kind of matched exactly what she told me it was going to be. In a sense, she gave me all the inside information because she had a direct connection. I was able to call on her.

He went on to describe the effect of these experiences:

> You learn to work with great people who are really very bright in their field, and you kind of feel, 'Wow, I'm working with Dr. So-and-so' and that just gives you pride. When you feel proud of something you become more confident and therefore you take on more challenges and adventures in your academic life.

David described his conversations with his mentor in the following way:

> Our conversations went beyond our research into what is expected in the field and professionally and what sort of things I would have to do in order to succeed in that respect. So, yeah, definitely. I understand it more now.

Comments such as Chino's and David's illustrate the students' awareness that their contact with faculty members had been important for their success in geoscience to that point, as well as their continued interest in the field.

Like their SEEMS counterparts, SROP students became more interested in activities related to geoscience after affective observing behavior, or opportunities to observe others as they engaged in geoscience-related activities. This can include formal mentoring relationships as well as opportunities to observe professionals informally as they engage in their work. While faculty members certainly served as role models during students' SROP experiences, individuals not affiliated with the university or the program also provided relevant examples of careers in the sciences. For example, David had an aunt whom he considered to be his mentor throughout his high school years. An electrical engineer for Georgia Power, she spent time taking David to her alma mater, talking to him about her work, and introducing him to different types of professional opportunities.

Spending the day observing a meteorologist at a local television station was an influential experience for Mark that he discussed in depth during his interview. While participating in SROP, Mark also observed geoscientists working on projects related to ozone, air quality, environments, and meteorology. Mark noted that since then, learning that meteorologists do much more than forecast weather was "just another thing [he] realized with the help of SROP." Not only are mentors in and of themselves an important factor, but they provide direct links to other factors, such as graduate school preparation activities, knowledge of geoscience careers, experience with geoscience culture, extracurricular experiences related to geoscience, and so on. The students' accounts of these kinds of opportunities indicated that observing such activities contributed to their abilities to envision themselves in similar careers, and thus encouraged them to remain in the education pipeline and pursue their interests in geoscience.

Social Persuasion - SROP students reported receiving strong support from friends, family, and fellow program participants. Although key individuals in students' support networks may not be knowledgeable about science or have experience in similar careers, they provide an important source of support and validation of students' educational interests and life goals. For example, Chino's family lives in Kenya. While he has not seen them since he moved to the United States several years ago, he talks to his family often. He said,

> My family is supportive. Whenever we get a chance, we call each other. They just tell me to work hard and continue to work on things and they would like me to come and visit as often as I can.

Chino lives with a host family in Philadelphia, which he also identified as a strong source of support. As he described his relationship with the members of his host family,

> They have encouraged me to work hard and pursue what I'm good at or what I want to do and so they have been supportive as any parent, I think, in making sure my education is continuing on, that I have a place to stay, that I work, and they encourage me on what I

need to do to excel.

Peers who have had similar experiences are uniquely qualified to support students. Students were able to collaborate with peers on their projects, and enjoyed getting to know each other socially as friends and housemates. For example, David's parents had always demonstrated strong interest in and support of his goals, yet they were not "science people." He acknowledged his SROP housemates as an additional and important source of support, noting that they helped him acclimate and meet people and that the experience would have been difficult without them. At one point, Maria was frustrated by an assignment that her advisor gave her and worried that she was the only one who felt that way. She then met a former SROP participant from her hometown. As she recalled, "When I mentioned to him one day that I thought I would never finish, he told me, 'Yeah, sometimes you feel like that.' He taught me, 'ok, I'm not going to think like that'." Identifying roommates, family, friends, and even surrogate family members, the SROP participants were quick to recognize the role of their social networks in providing invaluable support throughout their educational experiences. Their statements demonstrate that family and friends play an important role in developing students' senses of self-efficacy as they progress through the education pipeline.

Altered Misinterpretation of Stress Indicators - Just as the SROP participants demonstrated the development of self-efficacy in other ways, they also revealed the ability to interpret stress indicators as challenges to overcome as opposed to setbacks. For example, Maria reflected on her experiences in the following way,

> Right now, I have a hard situation with my mentor and you have a lot of situations with professors but if you have a goal, you just make it. That's all. So, no matter what could happen, if I have [my family's] support and I feel that they are proud, I'm going to be proud and I'm going to do it in the end. And the first thing that I know is that if I have to move, I don't know, to the moon, I will do it just to meet my goal.

Despite the overwhelmingly positive accounts students gave of their experiences with SROP, students did experience challenges in their academic and professional pursuits both before and during SROP. Maria was discouraged by her advisor's harsh criticism and insistence that she study a topic of interest to him instead of the topic she intended to study. What was most concerning to her was the possibility that because she was less familiar with his topic, she would not represent him or herself well when conducting her research and presenting her findings at the SROP research symposium. However, this fear led Maria to become more motivated. She was proud of herself not only for succeeding in her work, but also for overcoming the challenges that she encountered. Maria said that she, in fact, had gained more confidence by learning that she will always do the best she is capable of, and that she had represented herself well despite the complications that she faced. Maria responded to the challenge of having a discouraging advisor by talking with peers who had also participated in SROP, relying on her family for emotional support, and recognizing her own motivation to succeed. Maria's case is just one example of how students engage in stress management as a type of efficacy-building that allows them to achieve success.

DISCUSSION

This study has shown that programs such as the Summer Experience in Earth and Mineral Sciences and the Summer Research Opportunity Program provide important experiences for underrepresented students interested in pursuing careers in the geosciences. These programs have the potential to cultivate students' self-efficacy by introducing students to similar peers and role models, informing them about careers in the geosciences, and perhaps most importantly, allowing them to achieve academic success and cultivate feelings of pride and accomplishment with geoscience-related tasks. The programs provide valuable information about careers in geoscience, as well as prepare students for future opportunities along the pipeline such as college choice and scholarship information. The programs are also beneficial in altering perspectives about college faculty and life as a professional in the geosciences.

The results from this study suggest that collaborative learning opportunities, including direct participation in research projects, should be a central component of programs developed to increase diversity in geoscience. In particular, students in the SROP program highlighted the value of working on projects, as they were exposed to the research process. For SEEMS students, the collaborative nature of the program appears to have contributed to the significant increase of interest in geoscience. Such opportunities serve as enactive mastery experiences, allowing students to see themselves as capable of succeeding in geoscience-related careers and thus increasing their self-efficacy.

Interactions with professors are another valuable component of programs such as SEEMS and SROP, and appeared to play an important role in increasing students' self-efficacy. Faculty members of color are not overrepresented at Penn State, and the positive perceptions about faculty members among students demonstrate that commitment to diversity is just as important as visual representation of diversity. This commitment from institutions could alleviate concerns among students that certain stereotypes are commonly held in the academic community. Further, it appears that mentors do not necessarily have to be faculty/staff of color to have an impact on students of color.

The high degree of social persuasion among students attending SEEMS and SROP appeared to reflect how important support from family and friends is for young people exploring their interests. For underrepresented students in the sciences, this support is especially important as aspirations are often tempered by a demoralizing focus on perceived personal deficiencies. Building upon verbal encouragement from home, programs such as SEEMS and SROP provide another level of social capital that may reduce moments of self-doubt.

Regardless of the structure of their families or the level of their parents' education, support from their families, friends, fellow participants, and broader social networks seemed to be important for participants in both programs. Several of the students indicated that one of the main benefits of SROP was the opportunity to meet students like them as well as those who came from backgrounds different from their own, and that they formed friendships around the commonalities in their lives and experiences, which influenced students' perceptions of their own fit within these programs. This finding supports the inclusion of factors such as parental support and peer support as strategies for increasing student self-efficacy.

It appeared that as students persist along the pipeline, they began to understand how to use stress indicators as opportunities to intensify their efforts rather than impede their progress. By itself, the path from high school to college triggers many moments of anxiety as students develop socially, culturally, and intellectually. Since stress is impossible to avoid, the ability to handle stress becomes an indispensable skill, particularly for students of color attending Predominantly White Institutions. Engaging with challenges throughout their participation in SEEMS and SROP, and overcoming those challenges, allowed students to interpret stress indicators in a way that elevated their self-efficacy and contributed to their persistence in the geoscience education pipeline.

CONCLUSION

Levine et al. (2007) propose a pipeline model that includes student, pedagogical, and institutional factors related to persistence in geoscience from secondary school through graduate school. Findings from this study add detail to this geoscience pipeline model through highlighting perceptions and experiences of high school students and undergraduate students, the development of students' self-efficacy, and their subsequent intentions to pursue careers in geoscience. The convergence of data from these two sources suggests that the geoscience pipeline may be better understood through a conceptual framework that includes the development of self-efficacy, specifically, providing extended enactive mastery experiences, exposure to role models, social support, and opportunities to alter perceptions of stress indicators.

As demonstrated by the initial decline of self-efficacy variables among first-time participants during SEEMS, building student confidence is a complicated task. It is likely that at some point during their SEEMS experiences, the adversity experienced by students was even greater than what was reported at the end of the program. We may be observing the SEEMS program as a springboard effect – a brief dip in self-efficacy precipitates an eventual higher level of self-efficacy than what was initially observed. Students may reflect on their experiences over the course of the year and, as memories of challenges fade, the acquisition of skills and experiences is recognized, triumphs are recalled, and participants confidently return for a second year. On the contrary, one may argue that there is a degree of self-selection among the returning SEEMS students, that only those who develop and maintain positive reflections return for a second year in the program. As a result, students who experience initial struggles in a program without experiencing positive follow up, may "leak" out of the pipeline. Future research should explore the causes and outcomes of this initial decrease in self-efficacy among program participants.

Future research should include longitudinal studies of students of color as they engage in various stages along the geoscience education pipeline, building on the model proposed by Levine and colleagues. This model should be tested in environments similar to those investigated in this study, as well as those that may provide different types of support and challenges to students in order to strengthen awareness of factors that contribute to the success, as well as the failure, of educators and other stakeholders engaged in all stages of the geoscience education pipeline.

Finally, the development of self-efficacy as resistance to pressure caused by stereotype threat is, potentially, an important connection. Stereotype threat refers to the vulnerability of being judged by a widely-held negative assumption about a group that one belongs to, or the fear of performing in a way that would inadvertently confirm that stereotype (Steele & Aronson, 1995; Steele, 1997). The negative effects of stereotype threat on student performance, for racial minorities and women in particular, has been examined in a variety of academic subjects, including teacher education (Milner & Hoy, 2003), math education (Quinn & Spencer, 2001), and engineering education (Bell, Spencer, Iserman, & Logel, 2003). Given that many geoscience programs are homogenous racial communities, the development of stereotype threat among traditionally underrepresented students (through observation and perceptions, not necessarily direct experiences with racism) is a strong possibility. Therefore, the value of programs such as SEEMS and SROP is they provide students of color high levels of self-efficacy to counteract their own or peers' negative perceptions of science or concern of stereotype threat. Future research should explore the relationship between self-efficacy and stereotype threat and strategies for increasing the former and reducing the latter in order to recruit, support, and retain diverse students throughout the geoscience education pipeline.

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REFERENCES

American Geological Institute (2008). *Guide to geoscience careers and employers*. Retrieved online September 1, 2008 at http://www.agiweb.org/workforce Anderson, E.K., &Kim, D. (2006). *Increasing the success of minority students in science and technology.* Washington, DC: American Council on Education.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of Human Behavior* (Vol. 4, pp. 71-81). New York: Academic Press.

Barlow, A.E., & Villarejo, M.R. (2004). Making a difference for minorities: Evaluation of an educational enrichment program. *Journal of Research in Science Teaching*, *41(9)*, 861-881.

Bell, A. E., Spencer, S. J., Iserman, E., & Logel, C. E. R. (2003). Stereotype threat and women's performance in engineering. *Journal of Engineering Education, 92(4)*, 307-312.

Colbeck, C. L., Cabrera, A. F., & Terenzini, P. T. (2001). Learning professional confidence: Linking teaching practices, students' self-perception, and gender. *Review of Higher Education, 24(2),* 173–191.

Commission on Professionals in Science and Technology. (2004). *Professional women and minorities: A total human resource data compendium*. Washington, DC.

Drew, D. W. (1996). *Aptitude revisited: Rethinking math and science education for America's next century.* Baltimore, MD: Johns Hopkins University Press.

Huntoon, J., Peach, C., & Hopkins, J. (2005). *Geoscience education and diversity: Vision for the future and strategies for success.* Washington, DC: Directorate for Geosciences, National Science Foundation.

Johnson, R.B., & Onwuegbuzie, A.J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33(7),* 14-26.

Keilson, S. (1997). *Infusing a multicultural approach to education in the engineering and science curriculum.* ASEE Conference: National Conference on Outcomes Assessment for Engineering Education, Washington, D.C.

Levine, R., Gonzales, R., Cole, S., Fuhman, M., &Carlson Le Floch, K. (2007). The geoscience pipeline: A conceptual framework. *Journal of Geoscience Education, 55(6),* 458-468.

Maton, K.I., Hrabowski, F.A., & Schmitt, C.L. (2006). Increasing the success of minority students in science and technology. *Journal of Research in Science Teaching, 37(7),* 629-654.

McEneaney, E.H., & Radeloff, C.L. (2000). Geoscience in social context: An assessment of course impact on attitudes of female undergraduates. *Journal of Women and Minorities in Science and Engineering, 6(2),* 131-153.

Milner, H., & Hoy, A. (2003) A case study of an African American teacher's self-efficacy, stereotype threat and persistence *Teaching and Teacher Education, 19,* 263 - 276.

National Science Foundation. (2007). Integrated Science and Engineering Resources Data System.

Patton, M.Q. (2002). *Qualitative research and evaluation methods.* Thousand Oaks, CA: Sage Publications.

Powell, L. (1990). Factors associated with the underrepresentation of African Americans in mathematics and science. *Journal of Negro Education, 59(3),* 292-298.

Quinn, D. M., & Spencer, S. J. (2001). The interference of stereotype threat with women's generation of mathematical problem-solving strategies. *Journal of Social Issues, 57*, 55-71.

Riggs, E., & Semken, S. (2001). Culture and science: Earth science education for Native Americans. *Geotimes, 46(9)*, 14-17.

Riggs, E., & Alexander, C. (Eds.) (2007). Special Issues: Broadening participation in the Earth Sciences. *Journal of Geoscience Education, 55(6).*

Russell, M.L., & Atwater, M.M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African American students at a predominately white institution. *Journal of Research in Science Teaching, 42(6),* 691-715.

Scholz, R. W, Steiner, R., & Hansmann, R. (2004). Role of internships in higher education in environmental sciences, Journal *of Research in Science Teaching, 41,* 24-46.

Steele, C.M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African-Americans. *Journal of Personality and Social Psychology, 69,* 797-811.

Steele, C.M. (1997). A threat in the air: How stereotypes shape the intellectual identities and performance of women and African Americans. *American Psychologist, 52,* 613-629.

Suhr, D. (2005). Principal component analysis vs. exploratory factor analysis. SUGI 30 Proceedings. Retrieved May 18, 2009 from http://www2.sas.com/proceedings/sugi30/Leadrs30.pdf

United States Department of Education (2007). National Center for Education Statistics: Digest of Education Statistics 2007. Tables 275, 278, and 281. Available online at http://nces.ed.gov/programs/digest/d07/tables_1.asp

Wilson, R. (2000). Barriers to minority success in college, science, mathematics, and engineering programs. In G. Campbell, R. Denes, & C. Morrison (Eds.), *Access Denied: Race, Ethnicity, and the Scientific Enterprise* (pp. 193-206). Oxford: Oxford University Press.

Zappo, L. E. (1998). A demographic survey relevant to Earth-science teachers as mentors and role models for minority students. *Journal of Geoscience Education, 46,* 368 – 373.

APPENDIX A

Description of items comprising analyzed factors; Factor loading for survey items

1. Geoscience faculty role models (Cronbach's Alpha = .73)
   - There is a real sense of community among geoscience students and faculty
   - Geoscience faculty members are easy to talk with
   - Geoscience faculty members are willing to answer questions outside of class
   - Geoscience faculty members make their subjects interesting

2. Self-Efficacy (Cronbach's Alpha = .61)
   - If I want to, I can become a scientist, mathematician, or an engineer
   - I know enough English, Science, and Math to do well in college
   - I have the study skills to do well in college

3. Career Knowledge (Cronbach's Alpha = .71)
   - I know what biologist do at work
   - I know what geologist and geoscientist do at work
   - I know what engineers do at work
   - I know what computer scientist do at work

4. Affective Observing (Cronbach's Alpha = .74)
   - I enjoy observing nature
   - I enjoy nature books and magazines
   - I enjoy watching television shows about nature and scientific phenomena
   - I find earth science interesting

5. Social Persuasion (Cronbach's alpha = .61)
   - My family would be very supportive if I decided to major in a geoscience field
   - My friends would be supportive if I decided to major in a geoscience field

6. Geoscience Interest (Cronbach's Alpha = .68)
   - Geoscience is interesting
   - Geoscience is important
   - Geoscience is useful

7. Pay knowledge (Cronbach's Alpha = .83)
   - Biologist are paid well
   - Geoscientist are paid well
   - Engineers are paid well
   - Computer scientist are paid well

8. College application knowledge (Cronbach's Alpha = .83)
   - How much do you know about the college application process
   - How much do you know about the SAT
   - How much do you know about scholarships that are available to help pay for college
   - How much do you know about others ways to help pay for college
   - How much do you know about government programs to help pay for college

APPENDIX B

Selected questions from SROP interview protocol

1.) What were your experiences with science classes in elementary school and high school? What did you like or dislike about science?

2) What was the highest level of science that you completed in high school?

3) Before coming to Penn State, can you identify role models (teachers, family, or friends) who were influential in shaping your interest in science?

4) Did you attend any pre-college programs that helped you prepare for college, such as overnight visit programs or summer experience programs?

5) Were you satisfied with the way you had prepared for a science-related major through your coursework and other experiences?

6) Why did you choose to participate in SROP at Penn State?

7) How would you compare your academic experience this summer with the rest of your college experiences?

8) What is your understanding of geoscience as a career? Has SROP altered your perspective on professional opportunities in geoscience?

9) Have you been encouraged or discouraged to pursue a career or graduate study in geoscience? If so, who were the main influencers of your encouragement/discouragement?

10) How would you describe SROP at Penn State to students who may be considering participating in the program?