BEST Practices for Broadening Participation in the Geosciences: Strategies from the UCAR Significant Opportunities in Atmospheric Research and Science (SOARS®) Program

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ABSTRACT

This article offers a set of design principles distilled from the Building Engineering and Science Talent (BEST) examination of over 100 programs with documented success in recruiting and retaining minority students in sciences, technology, engineering and mathematics. By illustrating these principles in the context of the Significant Opportunities in Atmospheric Research and Science (SOARS®) program, we provide examples for applying them in the realm of the geosciences.

The SOARS Program combines multiple summer research experiences with intensive, multidimensional mentoring and a robust learning community to help undergraduate students complete college and make successful transitions into graduate school in the Atmospheric and related sciences. SOARS has been widely recognized through formal and informal assessments as a highly successful program.

INTRODUCTION

In the coming decades, we will face pressing challenges as human activities increasingly impact the Earth system. Responding to these challenges will require broader participation in the geosciences. Given the profound demographic changes underway in the US (by 2050, for example, white and Euro Americans will make up less than 50% of the US population [US Census Bureau, 2003]), we will be much more successful in meeting future workforce needs if we can include more participants from currently underrepresented groups. Broadening participation will also make the geosciences more robust, more creative, and more relevant. Like all research, atmospheric science increasingly involves collaborative teams, and research shows that diverse groups design more innovative solutions to problems and bring a higher level of critical analysis to decisions (McLeod et al., 1996). Greater diversity will make the science more relevant: in a country where scientific priorities are set by the competition of ideas in a peer-reviewed arena, one way to encourage consideration of all communities' scientific priorities is to make certain that each community has qualified participants in the peer-review process. Finally, diversity will improve the quality of geoscience education. Educational research has also shown that the most effective learning environments are ones that are diverse, and that the benefits of a diverse classroom extend to all students who participate, not just students from minority groups (Gurin, 2001).

The University Corporation for Atmospheric Research (UCAR) Significant Opportunities in Atmospheric Research and Science (SOARS®) program is dedicated to broadening participation in the geosciences, specifically the atmospheric and related sciences. SOARS has been widely recognized through formal and informal assessments as a highly successful program.

SOARS, however, is but one of many programs designed to increase minority participation in the fields of science and engineering. We should also examine successful practices in these other programs and disciplines, and adopt and adapt proven practices. This paper is an attempt to do that, using two specific reference points to anchor the discussion. The first reference point is a recent report that surveyed over 124 programs with demonstrated success in recruiting and retaining minorities in the sciences; the Bridging Engineering and Science Talent (BEST) report (BEST, 2004) (see Table 1). From this, we pull a list of BEST practices to guide the design of any effort to broaden participation. The second reference point is the SOARS program, which we will use to provide specific examples of these best practices. Our approach is aimed at the practitioner; we seek to provide concrete suggestions for the design of programs anchored in real-world experience and informed by relevant research. To provide context, we begin with a brief overview of the

UCAR SOARS PROGRAM.

SOARS Overview - The mission of SOARS is to broaden participation in the atmospheric and related sciences by engaging students from groups historically underrepresented in science and preparing them to succeed in graduate school. These groups include Black or African-American, American Indian or Alaska Native, Hispanic or Latino, female, first-generation college students, and students with disabilities. SOARS welcomes lesbian, gay, bisexual, and transgender students. SOARS also encourages students who have experienced, and worked to overcome, educational or economic disadvantage and/or have personal or family circumstances that may complicate their continued progress in research careers. This mission contributes to national goals of developing a diverse, internationally competitive, and globally engaged workforce of scientists and engineers.

Eight Design Principles

1. Institutional leadership
2. Targeted recruitment
3. Engaged faculty
4. Personal attention
5. Peer support
6. Enriched research experience
7. Bridging to the next level
8. Continuous evaluation

One Pervasive Need

Comprehensive Financial Support

Table 1. The BEST Report. In 2004, BEST published A Bridge for a All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics. This document reviewed 124 exemplary higher education-based programs and distilled eight design principles and one pervasive need.

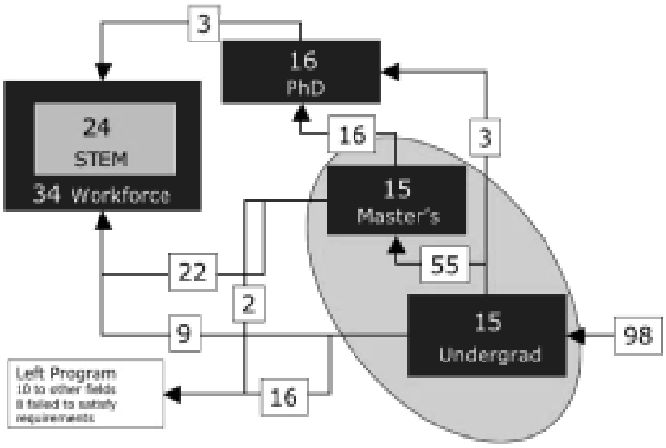

Figure 1. Protégé pathways through the SOARS Program, as of January 2006. The numbers in dark boxes indicate the number of protégés in that stage of their academic career (e.g. 15 protégés are currently undergraduates). The solid lines indicate pathways, labeled by number of protégés who have completed that pathway. For example, 55 protégés have completed their undergraduate degree and enrolled in masters' program. The light oval highlights the SOARS program focus on the transition from undergraduate to graduate school.

At the heart of SOARS is a ten-week summer program in which protégés conduct research at the National Center for Atmospheric Science in Boulder, CO or laboratories of other SOARS sponsors, such as NOAA Boulder Labs and the Cooperative Institute for Research in Environmental Sciences (CIRES). A strong learning community, multidimensional mentoring program, writing workshop, and leadership training augment the research internship. In addition, SOARS offers opportunities for up to four summers of research, funding for graduate school, and funding for conference travel for protégés to present their research.

Results, 1996-2006 - Since the 1996 inaugural summer, 98 protégés have participated in SOARS. Participants' ethnicity and gender are outlined in Table 2, with the national (US Census Bureau, 2003) and atmospheric science graduate school demographics (NSF, 2003a) included for comparison.

The academic and professional pathways of SOARS protégés is shown in Figure 1. As of January 2006, 37 protégés have completed their masters' degrees and three have successfully defended their PhD (in Computational and Applied Mathematics, Environmental Engineering, and Atmospheric Science). Of the 37 students to complete masters, 13 are in atmospheric sciences or meteorology, the rest are in related STEM fields. Sixty-five protégés have completed bachelor's degrees in an atmospheric or related science. Thirty-one protégés are currently enrolled in graduate school, 15 in masters' programs and 16 pursuing PhDs. Of the 34 protégés who have entered the workforce, 24 are currently in the scientific or engineering workforce. In total, 55 protégés have completed or are currently enrolled in graduate school in atmospheric or related sciences. This number is smaller than the sum of the number of PhDs and masters' earned (40) plus the number currently enrolled in graduate school (31) because 16 of the protégés who earned a masters' degree went on to pursue a PhD.

The success of SOARS is also apparent in the quality of the protégés scientific contributions. During the past ten years, SOARS protégés have presented more than 113 posters and 65 oral papers at regional, national, and international scientific conferences, with several receiving awards. Protégés have been accepted into and excelled in top-rated graduate programs in atmospheric science. Twelve summer research projects have resulted directly in protégé-coauthored papers published in peer-reviewed journals. Three protégés have earned NSF-graduate fellowships, three have earned graduate fellowships from the American Meteorological Society (AMS), and four have received NASA pre-doctoral fellowships. SOARS also received a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring in 2001, and underwent a comprehensive external evaluation in 2006. The evaluation was overwhelmingly positive, and concluded "SOARS is beloved by its participants, who see it as a highly successful and well-run program. Based upon engaging protégés in an authentic research experience and providing a structure that supports protégés' success, SOARS successfully promotes retention of undergraduate and graduate protégés from underrepresented groups within the atmospheric and related sciences. Just as importantly, SOARS inspires participants' loyalty and generosity, directly affecting the quality of the program, and its continued success."

The SOARS model is being adopted by other programs interested in broadening participation. In 2005, SOARS partnered with the Research Experience for Students in Solid Earth Science (RESESS) to adapt the SOARS model and apply the BEST design principles for the solid Earth community. The three-year, NSF-funded project uses a "mentor the mentoring program" model, and RESESS protégés will participate in SOARS along with traditional SOARS protégés. In addition, this partnership contributes funds to the program infrastructure that supports all protégés. At the end of three years, RESESS will have the experience and a sufficiently large cadre of RESESS protégés to become an independent program.

Ethnicity and Gender	Number of Protégés	Percentage of Protégé Population	18-24 Year Olds in 2004 Census	In Atmospheric Science Graduate Programs 1994-2000
African American or Black	39	40%	14%	1.8%
Hispanic or Latino	34	35%	17%	1.6%
American Indian, Alaskan Native, or Native Hawaiian	13	13%	0.9%	0.4%
Asian American	6	6%	4.3%	7.1%
White	6	6%	62%	85%
Female	59	60%	48.8%	33.6%
Male	39	40%	51.2%	66.4%

Table 2. Ethnicity and gender of SOARS protégés, 1996-2005

This comprehensive view of SOARS over the last 10 years underscores the sustained effort required to make an impact on the diversity of the atmospheric science workforce. SOARS protégés begin as undergraduates, and the typical time to a PhD in the geosciences is among the longest in any science. Thus, it is only now, after 10 years of investment, that we are seeing members of the earliest SOARS classes earning their PhDs.

Applying BEST Design Principles - The BEST report recommends eight design principles and one pervasive need. One thing not addressed by the BEST report, and yet fundamental to the successful management of any program that seeks to broaden diversity, is the design of a mission and processes that are legally viable in the face of recent Supreme Court decisions (e.g. Grutter v. Bollinger and Gratz v. Bollinger). An invaluable handbook for these efforts is the AAAS publication Standing Our Ground (Malcom et al., 2004). SOARS has taken the guidelines offered in this document into consideration in the design of our application and selection process and our program mission statement. In addition to encouraging students from historically underrepresented groups, SOARS also encourages applications from individuals who have experienced, and worked to overcome, educational or economic disadvantage and/or have personal or family circumstances that may complicate their continued progress in research careers. Applicants are invited to describe how they could contribute to building a more diverse future workforce. This means that SOARS is open to an applicant from a majority group who is committed to the goal of diversity.

Design Principle One: Institutional Leadership -

> *I think there's a much greater recognition of the value of these contributions, and in the national sense of we just have to do this. Well it's an intrinsic part of our mission. [In] my role as a division director here at NCAR, I certainly try to encourage my staff to participate in the SOARS program, because I do think it's been a very successful and useful program. And I myself have participated.*
>
> *NCAR Division Director*

The BEST report found that extensive and sustained institutional commitment, starting at the top, plays a key role in the success of minority recruitment and retention programs. SOARS enjoys strong institutional support from UCAR. This commitment is most apparent in the visible commitment of UCAR senior management to the program. UCAR leaders regularly attend SOARS events, actively encourage their staff to participate as mentors, and even volunteer to serve as mentors. The mentors' time is significant; surveys of former mentors indicate that UCAR mentors spend over 2000 hours a summer supporting the 24 protégés.

SOARS also enjoys institutional leadership from its sponsors. The National Science Foundation (NSF) is SOARS principal sponsor, and NSF has a deep commitment to broadening participation in STEM, devoting approximately 10% of its FY06 budget to such efforts. Within NSF, SOARS enjoys leadership from within the directorate for geoscience and the division of atmospheric science; their 10-years of support for broadening participation is unusual in a research-focused directorate.

NOAA's Climate Program Office (formerly the Office of Global Programs) and the CIRES also sponsor SOARS protégés. In the past, the Department of Energy Global Change Education Program and NASA's Living with a STAR program and Goddard Laboratory have supported protégés as well. Colorado State University's Center for Multi-Scale Modeling of Atmospheric Processes and NCAR's Earth Observing Laboratory are more recent sponsors. These multiple funding sources are an important aspect of the broad institutional support that is the foundation of SOARS' sustainability.

Design Principle Two: Targeted Recruitment -

> *If you're talking to another student who's in the program now, and who can basically give you the low down on what it's like-at the apartments, what it's like in the town, what it's going to be like at NCAR-I mean they're not going to lie to you, and I think that brings in a lot of students.*
>
> *SOARS Protégé*

The BEST report recommends that programs build a feeder network that identifies and attracts the best students from underrepresented groups. As the quote indicates, word-of-mouth is a key part of a successful feeder network, and many applicants to SOARS indicate they have already discussed the program with another protégé before applying.

Our experience in SOARS suggests that the most efficient way to develop this feeder network is through institutional partnerships. An especially effective SOARS recruitment strategy takes advantage of the 69 UCAR member institutions. Of the 98 protégés to participate in the program, 35 have entered SOARS from UCAR members or academic affiliates. Other, multi-institutional SOARS recruiting partners include the Model Institutions for Excellence at Universidad Metropolitana in San Juan, Puerto Rico, the City University of New York Louis Stokes Alliance for Minority Participation (CUNY LS-AMP), and the Leadership Alliance, a consortium of 31 research and teaching academic institutions. SOARS also work closely with the Summer Multicultural Access to Research Training (SMART) at the University of Colorado. This collaboration has been particularly effective, both as a pool from which to recruit and also as a partner in providing research opportunities to students who don't yet qualify for SOARS but likely will with additional experience.

SOARS also recruits from throughout the US and Puerto Rico through direct communication, conference presentations and booths, web presence, advertisements, and campus visits. The biannual newsletter and SOARS recruitment materials are sent to over 1000 sponsors, college faculty, student organizations, and professional societies related to atmospheric science. SOARS operates a booth regularly at national and regional conferences, including American Indian Science and Engineering Society (AISES) and Society for the Advancement of Chicanos and Native Americans in Science (SACNAS). More importantly, SOARS protégés present their research at these national and regional conferences. These presentations contribute to faculty awareness of the SOARS program and provide a chance for SOARS protégés to encourage other undergraduate students to apply for the program. The SOARS director regularly visits college campuses, both to recruit students for SOARS and to describe other opportunities in atmospheric and related sciences. In our experience, the campus visits are essential to developing an effective recruiting network.

Design Principle Three: Engaged Faculty -

> *I've always wanted to work with students and I found this was a good outlet to do that. When I became a tenure track scientist I was actually trying to decide between going to a university or staying here and one of the reasons I would want to go to a university would be to teach and work with students. So I felt that if I decide to stay here there are opportunities to work with students or to work with universities and teaching. So I might as well take advantage of the opportunities that there are here. I think it's part of my personality that I enjoy working with other people and it's fun to teach someone and see them learn something new in their life....*
>
> *NCAR Scientist and SOARS Mentor*

The BEST reports suggests that most successful programs include people who "view student outcomes as critical measures of their performance and … are rewarded accordingly."

In SOARS, basing mentor participation on volunteerism helps ensure mentors' commitment to student success. All SOARS mentors are volunteers. According to the independent evaluation, using volunteers attracts "employees who are more 'people oriented' and care most about education, outreach, and diversity … without unduly coercing others to participate, which could result in lower quality mentoring experiences." Using volunteers, however, requires a large pool of potential mentors.

The most frequent motivations cited by mentors were:

- Valuing education and outreach
- Enjoying collaborating with and teaching students
- Feeling a sense of social responsibility, specifically toward underrepresented groups
- Wanting to share the science

At UCAR, scientists and staff are formally rewarded for their participation in SOARS. Participation in SOARS contributes positively to the annual evaluation of scientists and non-scientists, and is included in the tenure process for scientists. SOARS itself sends thank you letters to mentors with copies to their immediate supervisors, outlining the significant time required to mentor. This helps ensure that mentoring is included in their annual appraisal.

Design Principle Four: Personal Attention -

> *[Mentor relationships are] not like, "okay this is the research, this is what it's all about, go figure it out yourself." It's not been like that. We've been working together like, "Okay, I have a problem here," or "what do you suggest?," "Okay, I think this will work good," or "your suggestion is okay." It's been back and forth…We do come with our different ideas and we work together.*
>
> *SOARS Protégé*

A unique and important aspect of SOARS is its strong, multidimensional mentoring structure, which was established by the first SOARS Director, Thomas Windham. Strong mentoring helps protégés succeed academically and professionally (Kardash, 2000; Seymour et al., 2004), and the formal structure ensures equal access to mentoring (Riggs, 2004). Good mentors model professional success, transfer necessary skills, provide relevant resources, advise about career options, introduce protégés professionally, assist in career placement, and provide inspiration and personal support (NRC, 2003).

All SOARS protégés are supported by up to four mentors: a science mentor to guide research practice; a writing mentor to improve scientific communication skills; a community mentor to help navigate scientific and local culture; and a peer mentor, a protégé who has participated in the program in previous summers. All four mentors model effective scientific and professional practices. According to the external evaluation of SOARS, "the multiple-mentor structure and interactions with protégés as young scientists and colleagues are critical factors in promoting student achievement and SOARS' success."

The mentoring relationships are intense and committed. Surveys of past SOARS mentors indicate that science mentors spend an average of 8 hours a week with their protégé. Writing mentors typically spend 2-3 hours a week with their protégé, and even more in the weeks before the protégés final presentation. Community and peer mentors' time commitment varies the most, from a minimum interaction of once a week to more extensive

and ongoing interactions. In sum, protégés receive up to 10 hours per week of personal support from four mentors, in addition to the sustained attention of the SOARS director, administrative staff, and writing workshop coordinator.

Design Principle Five: Peer Support -

> *It's just that sense of, I think, family. You know, when I first went, I was kind of worried: you know we're just going to be individuals going there and doing our own thing, but we soon became our own group, our own family-a family of friends and that makes a big difference as well…When you know there's people that you can fall back on to ask questions about or talk about issues or problems that you're having.*
>
> *SOARS Protégé*

According to the BEST report, "model programs enable students of diverse backgrounds and interest to interact routinely and intensively." In SOARS, this interaction is precipitated by the program's emphasis on developing a strong learning community. The learning community, in turn, is based on the principle that learning is a social activity and learning is enhanced in settings, called communities of practice, that are based on common learning goals (Wenger, 1998). Learning communities on college campuses represent one type of community of practice that has been shown to enhance academic engagement (Zhao and Kuh, 2004). These communities may be especially important for students from underrepresented groups as they can provide a welcome exception to the ubiquitous experiences of isolation that discourage academic and professional success (Kozoli and Osborne, 2004; Seymour and Hewitt, 1997).

The SOARS learning community is designed around a critical mass of 20-25 diverse students living together, working on related scientific projects, and collaborating to develop and refine their leadership, professional, and communication skills. All protégés in Boulder reside in the same apartment building, with new protégés sharing housing with older, more experienced protégés. Through informal interactions over meals, during protégé-led weekend activities, and on the bus to and from their labs, protégés have the opportunity to develop a strong and supportive community. SOARS encourages and nurtures this community through its peer mentoring program and team-building activities, and through ongoing advice about a wide range of professional skills. SOARS also supports protégés as they move into the larger national and international atmospheric science community. SOARS encourages and funds protégé participation in national and regional conferences; provides protégé-led skill building seminars on topics including proposal writing, graduate school admission, and effective communication; and offers ongoing career and academic guidance. In addition, the SOARS learning community has proven to be an important source of comfort and information by bringing together protégés and alumni.

Design Principle Six: Enriched Research Opportunities -

> *To…actually do real research-I think that's the best thing about SOARS. It's not just, "Oh, I already know the answer to this," but you finding it out, it's like, "We don't know the answer, we're waiting on you to figure this out."...SOARS gives you that chance to realize you're going to go into situations not knowing anything, and it's your job to go and just do it…until something comes out of it.*
>
> *SOARS Protégé*

As recommended in the BEST report, the foundation for the SOARS program is a ten-week summer immersion program in which protégés conduct scientific research at UCAR or at laboratories of other SOARS sponsors. Studies suggests that undergraduate research experiences contribute to success in graduate school (Kardash, 2000; Kremmer and Bringle, 1990; Seymour et al., 2004) and that these experiences offer other benefits as well, including gains in personal/professional skills, ability to "think and work like a scientist," (Figure3) clarification or confirmation of career plans, and shifts in attitudes towards learning and working as a researcher (Seymour et al., 2004). It is also consistent with current pedagogical recommendations for student-centered, hands-on, authentic, relevant educational practice (Bransford et al., 2000; Somerville and Bishop, 1997).

Design Principle Seven: Bridging to the Next Level -

> *I also saw other protégés that after SOARS were willing to go to grad school, and they were getting accepted into these very recognized schools. Of course that motivated me to believe that I could be accepted...Seeing the others going into grad school, I said, "Well, I have to do it myself!"*
>
> *SOARS Protégé*

The BEST report found that the most effective programs see themselves as part of an education and workforce continuum, and build the institutional relationships and provide personal skills that enable students to succeed at the next academic level (BEST, 2004). In SOARS, we help our students transition from undergraduate-to-graduate through three principle strategies: leveraging institutional partnerships with UCAR universities, preparing our protégés with skills that complement their research and academic experiences, and providing up to four years of support for all protégés.

The majority of SOARS institutional relationships are with UCAR's 69 member institutions; of the 55 protégés to go to graduate school, 43 have entered graduate school at UCAR member institutions. We also work closely with many of the NSF-funded Alliances for Graduate Education and the Professoriate (AGEP) institutions. For these programs and institutions, SOARS has become a trusted source for well-prepared students. The institutional relationships provide an avenue for protégés to interact with potential advisors before graduate school, and SOARS mentors regularly introduce protégés to their university collaborators, and often serve as undergraduate and graduate thesis committee members.

The BEST report also recommends attention to skills that complement students' academic skills and prepare them for continued professional success. SOARS nurtures the leadership and communication skills that will leverage protégés scientific expertise and better prepare them to be future leaders. All protégés participate in a weekly writing and communication workshop. The workshop is guided by a pedagogy of learning science by writing (Carle and Krest, 1998) and

an emphasis on peer review (Henderson and Buising, 2000). The content is organized around the sections of a scientific paper (Koprowski,1997). SOARS protégés also attend a three-day leadership training that emphasizes practical work skills including time management, having difficult conversations, setting expectations, working across differences, managing group dynamics, and scientific ethics.

Consistent with pedagogical recommendations (Bransford et al., 2000), SOARS provides all training in a format that incorporates both direct instruction and hands-on practice. The direct instruction occurs primarily in the orientation and workshops throughout the summer. The real learning, however, occurs in the application of these skills. SOARS offers multiple opportunities for protégés, especially returning ones, to demonstrate leadership during the summer by serving as peer mentors to new protégés, developing and arranging seminars, leading elements of the orientation for new protégés, and consulting with the SOARS program office in ongoing efforts to improve the program.

To develop the necessary skills and allow ample time to leverage these institutional relationships, a protégé may participate in SOARS for up to four years, pending satisfactory academic progress. Typically, protégés begin SOARS in the summer after their junior year, and so these four summers and year-round support span the critical transition to graduate school, a point at which a number of students leave the field (CEOSE, 2002). This allows protégés to explore the breadth of geoscience over multiple summers, improves their application to graduate school, and eases the transition into graduate school, once admitted. For the undergraduate protégés considering graduate school, interacting with new graduate students provides an important and unusual opportunity to hear frankly about the challenges of graduate school from a "been there-done that" perspective.

In summary, SOARS is built as a bridge program, and provides focused activities, over multiple summers, designed to help protégés successfully transition to graduate school.

Design Principle Eight: Continuous Evaluation -

> *This philosophical framework drives SOARS' flexibility as a living organism, evolving according to who protégés are at any given time and what they feel the program needs to be. While protégés are encouraged to shape SOARS to meet their needs, the SOARS director and staff insist upon the existence of the program's core elements and philosophies.*
>
> *From the external evaluation of SOARS*

Consistent with the BEST report, a key value of the SOARS program is responsiveness to participant suggestions. According to the external evaluation, "Feedback is continuously solicited from program participants, and their input is duly considered and incorporated into SOARS over time, resulting in a dynamic program that has successfully responded to changing circumstances and insights generated by participants' experiences."

Much feedback is given informally, through direct interaction with the program staff. There are three formal means of feedback as well: the All Hands Review, the Mentor Survey, and the Protégé Survey.

All Hands Review: Near the end of the summer, SOARS invites protégés to provide feedback on every aspect of their summer experience. First, all protégés are invited to submit anonymous comments on every aspect of the program. Second, teams of protégés summarize and organize these comments. Third, new teams brainstorm strategies for program improvement.

Mentor Survey: A week after the end of the summer program, mentors are given a survey, customized by mentor type. It includes open-ended questions and Likert-scale questions covering the program and their experience with their protégé.

Protégé Survey: These are mailed out a week after the end of the program to invite protégé feedback on their experience with their mentors and the program. This instrument includes both Likert-scale questions and open-ended queries.

All of these modes of feedback as well as additional, targeted conversations are used in preparing the next summer program. The SOARS program office uses the advice to guide appropriate changes, with additional direction from the steering committee. Some program elements that have been revised in response to feedback include the writing workshop, mentor training and the role of the peer mentors.

One Pervasive Need: Comprehensive Financial Support -

> *The first reason I wanted to come to SOARS was for the research. The chance to do actual research. But a big second reason was that we would get paid and that we would live in Boulder. And that SOARS would help graduate school funding.*
>
> *SOARS Protégé*

Although not a design principle, the BEST report notes that successful programs combine need and merit based support to allow students to make academics, not part-time work, the focus of their educational experience. SOARS accomplishes this by providing comprehensive summer support and supplementary support during the academic year.

During the summer, SOARS protégés receive a competitive stipend of between $14 and $22 an hour for a 40-hour workweek during the summer. In addition, SOARS provides housing (one bedroom in a two bedroom town home) and round-trip travel to Boulder. These funds and housing are provided to make SOARS competitive with other internships and, more importantly, so that protégés are not forced to take non-STEM summer jobs to finance their undergraduate education. SOARS protégés often participate in field projects related to their research, when these projects occur during the summer, and SOARS maintains funds to cover the additional costs associated with these kinds of opportunities.

Because conference attendance and presentations are key parts of the life of a scientist, SOARS also funds student participation in national and regional conferences. SOARS protégés usually present first at student-centered conferences like the AMS Student Conference, the AISES annual meeting, and the SACNAS National Conference. These conferences, which emphasize strong mentoring and encourage student research, introduce protégés to the broader scientific community. More experienced protégés attend

conferences such as the Fall Meeting of the AGU or disciplinary AMS conferences.

SOARS also provides partial funding for undergraduate and graduate education. Graduate funding is available for the first two years of graduate school, and undergraduate funding available after the first summer. In both cases, funding is meant to complement other forms of funding the protégés receive in order to bring their total package to parity with other students in their department. SOARS graduate funding is offered and is limited to $11,000 a year. Starting in 2006, SOARS will add an undergraduate academic-year scholarship of up to $4000 a year for SOARS protégés who have successfully completed their first year of summer. In both cases, funding is awarded based on need and limited to the difference between funding the protégé is already receiving and the university-documented cost of living, tuition, and fees.

SUMMARY

Our nation and the world face rapidly escalating challenges arising from our large-scale impacts on the Earth system and our growing vulnerability to sudden and gradual changes in the Earth system. To manage these challenges, we need a capable, diverse scientific workforce to generate new understandings and work with a scientifically literate and informed citizenry to implement those new understandings. In the atmospheric sciences, these needs are particularly acute; one need only think about the implications of climate change and the impact of the recent hurricanes.

To meet these challenges, we must enrich our workforce in the geosciences by encouraging and increasing students from historically under-represented groups to pursue careers in these fields. The recommendations of the BEST report, based on a survey of over 124 programs with demonstrated success in recruiting and retaining minorities in the atmospheric and related sciences, provide a blueprint for these efforts. The SOARS program has, over its 10-year history, successfully applied this blueprint to the atmospheric and related sciences.

SOARS' goal is to prepare the next generation of leaders in atmospheric science; we want to nurture scientists and educators with strong foundations in research and complementary skills that make them effective advocates and ambassadors for the science. Toward this end, SOARS is equal parts research internship, learning community, and mentoring program and offers comprehensive, multi-year, holistic support as protégés make the transition to graduate school.

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REFERENCES

BEST, 2004, A Bridge for All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics, 48 p.

Bransford, J. D., Brown, A. L. and Cocking, R. R., editors, 2000, How People Learn: Brain, Mind, Experience, and School, National Research Council, 374 p.

Carle, D. A. and Krest, M., 1998, Facilitating research between the library and the science writing classroom, Journal of College Science Teaching, v. 27, p. 339.

CEOSE, 2002, CEOSE 2002 Biennial Report to Congress, National Science Foundation, Committee on Equal Opportunities in Science and Engineering.

Gurin, P., 2001, Expert report of Pat Gurin, Gratz, et al. v. Bollinger, et al., No. 9775321 (E.D. Mich.) and Grutter, et al. v. Bollinger, et al., No. 97-75928 (E.D. Mich.).

Henderson, L. and Buising, C., 2000, A peer-reviewed research assignment for large classes, Journal of College Science Teaching, v. 30, p. 109-113.

Kardash, C. M., 2000, Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors, Journal of Educational Psychology, v. 92, p. 191-201.

Koprowski, J. L., 1997, Sharpening the craft of scientific writing, Journal of College Science Teaching, v. 27, p. 133. Kozoli, R. H. and Osborne, M. D., 2004, Finding meaning in science: Life, world, identify, and self, Science Education, v. 2, p. 157-181.

Kremmer, J. F. and Bringle, R. G., 1990, The effects of an intensive research experience on the careers of talented undergraduates, Journal of Research and Development in Education, v. 24, p. 1-5.

Malcom, S. M., Chubin, D. E., and Jesse, J. K., 2004, Standing our ground: A guidebook for STEM educators in the post-Michigan era, American Association for the Advancement of Science, 99 p.

McLeod, P. L., Lobel, S., and Cox, T., 1996, Ethnic diversity and creativity in small groups, Small Group Research, v. 27, p. 827-847.

NRC, 2003, Minorities in the chemical workforce: diversity models that work - A workshop report to the Chemical Sciences Roundtable, 174 p.

NSF, 2003, Survey of graduate students and postdoctorates in Science and Engineering, 1994-2001, TABLE D-1: S&E graduate students, by field, citizenship, and race/ethnicity.

Riggs, E. M., 2004, Field-based education and indigenous knowledge: Essential components of geoscience education for Native American communities, Science Education, v. 89, p. 296-313.

Seymour, E. and Hewitt, N. M., 1997, Talking about leaving: Why undergraduates leave the sciences, Westview, 448 p.

Seymour, E., Hunter, A.B., Laursen, S. L., and DeAntoni, T., 2004, Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study, Science Education, v. 88, p. 493-534.

Somerville, R. and Bishop, W., 1997, Geoscience Education: A Recommended Strategy, National Science Foundation, NSF 97-171.

US Census Bureau, 2003: Table US-EST 2001=ASTP-03, National Populations Estimates - Characteristics.

Wenger, E., 1998, Communities of Practice: Learning, Meaning, and Identity, Cambridge University Press, 308 p.

Zhao, C.-M. and Kuh, G. D., 2004, Adding value: learning communities and student engagement, Research in Higher Education, v. 45, p. 115-138.