SOARS: A RESEARCH-WITH-EVALUATION STUDY OF A MULTI-YEAR RESEARCH AND MENTORING PROGRAM FOR UNDERREPRESENTED STUDENTS IN SCIENCE

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EXECUTIVE SUMMARY

Introduction

This report is an evaluation-with-research study of the Significant Opportunities in Atmospheric Research and Science (SOARS) program. The goal of SOARS is to promote careers in atmospheric science research among students from underrepresented groups. It is hosted by the University Corporation for Atmospheric Research (UCAR) in Boulder, Colorado.

In early 2003, Dr. Thomas Windham, who was then the SOARS program's director, invited a research/evaluation team from Ethnography & Evaluation Research (E&ER) to conduct an independent, qualitative evaluation of the SOARS program. Periodic quantitative measures collected by SOARS indicated that the program was succeeding in recruiting students from underrepresented groups, encouraging their continued participation in the program, and in encouraging students' persistence in science, mathematics, engineering, and other related majors (Windham, Stevermer, and Anthes, 2004). Data collected by SOARS also indicated that the program was successful in promoting participants' enrollment in graduate programs in science. It was due to these positive outcomes that the SOARS program was recognized by a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring in 2001. Dr. Windham had clear evidence of the success of this program. However, beyond providing quantitative data that proved SOARS' effectiveness, Dr. Windham was interested in documenting *why* SOARS was effective. Because quantitative studies can not answer questions concerning how the social dynamics, structure, or organization of programs may contribute to or limit their success, Dr. Windham chose to evaluate the SOARS program qualitatively and to include a research component that would address these issues. With the objective of helping SOARS not only assess its effectiveness, but also to identify the critical structural elements of the program and how they are articulated to support program objectives and produce positive program outcomes, a research team from E&ER undertook this evaluation-with-research study.

Initial funding from the SOARS program allowed the evaluation team to begin collecting data in summer 2003 as student participants, or protégés as they are called, began to arrive for the SOARS summer program. Independent funding was sought and secured from the National Science Foundation (NSF) to maximize the independence of the evaluation (NSF Proposal Number 0401704, "SOARS: Research-with-Evaluation of a Multi-Year Student Research and Mentoring Program for Students from Groups that are Underrepresented in Science"). The

evaluators wish to thank the NSF and Bernard Grant, Program Officer, in particular, for the support that made this work possible.

This report provides detailed descriptions of:

- SOARS' program objectives and origins of the SOARS program
- SOARS' current program design
- SOARS' leadership, staff and steering committee
- Protégé and mentor recruitment and selection
- Protégé and mentor matching
- Preparation and support for mentors
- Critical program elements, such as the research project, writing and presentation component, multi-mentoring structure, and protégé community
- Protégé gains from participation in SOARS
- Protégés' career aspirations and influences on protégés' academic and career goals
- Mentor gains, costs, challenges, and readiness to mentor again
- Suggestions for program improvements
- SOARS solicitation and responsiveness to formative feedback
- The evolution of SOARS over time and suggestions for expanding SOARS
- Suggestions for replicating the SOARS model

This report also discusses participants' observations identifying how SOARS' structural elements are articulated to support and give rise to positive program outcomes. The authors of this report hope that SOARS, the NSF, and other organizations promoting the full inclusion of people from as-yet underrepresented populations in the sciences will find this report useful in the development and refinement of their initiatives.

Objectives of this Qualitative Evaluation-with-Research Study

This study was guided by the question: "What factors contribute to, or serve to limit, the success of the SOARS program, and what relative importance do they play?" We included in this study analysis of structural, organizational and social components of the SOARS program.

Methods

We used both direct observations of official and informal SOARS events and minimally-structured, open-ended interviews to explore these research questions in detail. Over 100 hours of direct observation were conducted in 2003 and 2004, where the evaluators attended formal meetings of various groups, including the SOARS Steering Committee and SOARS administrative staff, training sessions for various SOARS participants, formal meetings for protégés, and other types of organized and impromptu gatherings of SOARS participants. The observations were documented with field notes, which were transcribed and considered by the research team in constructing and enhancing interview protocols and during data analysis.

In-depth interviews were minimally structured so that we could elicit participants' opinions and explanations, as well as their spontaneously-offered comments, narratives, and illustrations. In the 174 interviews conducted, we explored the experiences of the:

- SOARS student researchers (called "protégés")
- SOARS research, writing, community, and peer mentors to the protégés
- SOARS directors and staff
- SOARS Steering Committee members
- UCAR managers

We asked all interviewees to discuss their views of what contributed to, or limited, SOARS' successes. We also explored protégés' career goals, and factors that influenced their ideas about possible future careers. We invited all interviewees to share their observations about the SOARS program and ideas about how to improve, replicate, and expand the program.

Findings

Overall, we found that SOARS has achieved its primary goal of increasing retention and participation of students from underrepresented groups in the atmospheric and related sciences. Our study revealed that 83% of protégés aspire to, are pursuing, or have already completed a graduate degree in science, technology, engineering, or mathematics (STEM) fields (47% in atmospheric and earth science, 38% in mathematics, engineering, and computer science, 7% in other sciences, 7% in other fields (UCAR, 2005c). Furthermore, 55% or protégés aspire to, or are already working in, research or academic careers in the atmospheric and related sciences (and in some cases, other STEM fields). In addition, another 14% of protégés aspire to shaping the future direction of their fields via careers in policy, administration, or outreach. Thus, two-thirds of protégés are pursuing careers where they are likely to have a "multiplier effect" and help further SOARS' goal. Moreover, 94% of all protégés aspire to, or are already working in, STEM careers.

We conclude that the significant investments of time and money that SOARS makes in its protégés are essential to the program's success. SOARS' positive outcomes are due to multiple highly-articulated program features rather than any individual, specific feature. We found that a cohesive network of interconnected program elements function effectively to promote the goals of SOARS and to produce positive student outcomes. We list below structural elements identified as critical to SOARS' success:

- ***Sustained Engagement***

SOARS offers a multi-year program to protégés, and encourages their involvement for a period of up to four years. Sustained engagement facilitates significant improvements in protégé understanding of and skills in performing authentic research as well as protégé professional and personal development.

- ***The Research Project***

Similar to the goal of other undergraduate research programs, SOARS seeks to engage undergraduates in authentic research with the objective of increasing protégés' understanding of how real science research is accomplished.

- ***Multiple Mentors and Establishing Collegiality***

In the SOARS program, UCAR scientists volunteer to mentor an undergraduate or graduate student in an original research project for 10 weeks during the summer. The scientists ("research

mentors") design the project and guide protégés in their research activities. Protégés are also assigned a "writing mentor." Writing mentors support and coach protégés in formal writing assignments, including a report of their research project that is presented at the end of the summer. In addition to research and writing mentors, first-year protégés are assigned a "community mentor," who helps new protégés adjust to Boulder and to SOARS. "Peer mentors" (returning protégés who have received mentor and leadership training) are also assigned to first-year protégés. Peer mentors serve to orient new protégés to the program and to Boulder and also support new protégés over the course of the summer. Thus, in tandem with research, SOARS' program structure incorporates multiple mentors to facilitate protégés' progress and success in the program. The multiple-mentor structure and interaction with protégés as young scientists and colleagues are critical factors in promoting student achievement and SOARS' success.

- ***Focus On and Support of Protégés' Professional Development***

Ongoing writing workshops, seminars on various topics, and organized protégé activities are other key components of the SOARS program designed to support protégés' success.

- ***Peer Collegiality and Belonging to a Community***

Protégés live near one another in one apartment complex. This program feature encourages and supports the development of a tight-knit community and friendships that provide meaningful help and support to one another.

- ***Financial Support of Protégés***

Multi-year summer involvement, along with strong financial support communicate commitments that SOARS makes to protégés, and elicits protégés' best efforts to live up to the high expectations placed on, and investments made in, them. As well, significant financial support is extended to protégés beyond the SOARS summers, including costs to attend conferences and graduate school.

- ***Holistic Support of the Protégé***

The original SOARS director, Dr. Windham, drew upon his expertise as a psychologist to design and implement program elements that address specific protégé needs and challenge protégés beyond their intellectual comfort zones. Dr. Windham believed that it was important to support protégés holistically to ensure that they would succeed and develop confidence rather than be overwhelmed and discouraged. Holistic support is achieved through multiple mentors, a collaborative and collegial learning community, and the SOARS community as a whole.

- ***Protégé Integration into Positions of Leadership within SOARS***

Dr. Windham also believed that it was important to empower protégés within the structure of the program so that they take on roles of leadership within SOARS, develop their leadership skills, and increasingly take "ownership" of it.

- ***Effective Signposting for Participants***

SOARS' objectives, and the objectives specific to individual program elements, were carefully, clearly conveyed to all participants. Effective "signposting"—the systematic explanation to participants at each stage of an activity, what the goals, methods, and outcomes anticipated are in order to facilitate their optimization—was noted throughout the program.

- ***Institutional Support and Prestige***

UCAR, the hosting organization, has provided steady, visible and significant support to the SOARS program. This support from UCAR's upper-management has facilitated the prestige that this program has gained at UCAR and garnered high rates of participation of UCAR scientists and other employees. It is important to note that mentors volunteer their time and energy; UCAR does not "reward" mentors (through financial compensation or career promotion) for their participation.

- ***Encouragement of and Responsiveness to Feedback***

Formative feedback is continuously solicited from all program participants, and their input is duly considered and incorporated, as appropriate, into the overall SOARS program. Constant assessment of the effectiveness of program elements results in a dynamic program that is able to successfully adapt to changing circumstances and insights generated by participants' experiences. One outcome of valuing formative feedback is that it promotes participants' positive morale, as they better tolerate inherent "bumps" in their experiences knowing that, in the not too distant future, things can be "worked out."

Mentor and Protégé Observations on Gains to Protégés

Mentors and protégés alike identified many gains that protégés made as a result of their involvement with SOARS. Some gains that protégés' described are over-arching, while others refer to specific types of gains.

Over-arching gains to protégés include:

- Learning how science research is done
- Increased confidence as a result of engaging in hands-on research
- Insight into science careers, particularly in atmospheric science
- "Thinking like a scientist": developing patience and critical thinking skills
- Increased understanding of how scientists practice their profession
- Understanding science in political and global perspective

Particular types of gains from the SOARS experience are:

- Increased appreciation of relevancy of, and preparation to undertake, coursework
- Increased interest in and likelihood of going to graduate school
- Strengthened graduate school applications
- Enhanced presentation, writing, leadership, time management, computer, collaborative, and social skills
- Professional development
- Personal growth in confidence and responsibility
- "Becoming a scientist"
- Ongoing support from the protégé community and SOARS' director, staff, and mentors

Many of the student gains identified by this study are commonly reported in the literature. More unique to this program, however, are the stronger gains in peer and community collegiality

engendered by peer mentoring, protégés' living arrangements in an apartment complex, protégé leadership in training and seminars, and formal SOARS social events for protégés. Establishing a working, collegial relationship with the research mentor was also an important student gain found in this study. Gains in collegiality (with mentors and peers) and feelings of "belonging to a community of learners" are particularly important findings and were so prevalent as to be embedded in almost every aspect of the data. These gains, which coincide with other studies, are a significant factor in the retention and persistence of protégés from underrepresented groups in college.

Gains in collegiality are also important because they foster other types of student gains, especially increased confidence to do science research. Establishing a collegial relationship with a research mentor contributed not only to protégés' understanding of how science research is done, but also to their understanding of *what* scientists do and *how* they do it. Protégés experienced first-hand what it is to do real research. They learned that setbacks are a normal part of "real" research; that research can be slow, boring and tedious, and required temperamental attributes such as patience and perseverance. Some protégés learned that knowledge is constantly constructed, "facts" are subject to revision, and that "black and white answers" are rather rare. Learning instrumentation and laboratory techniques or how to write a formal, academic article and present one's research provided protégés with direct knowledge of how scientists actually work. Importantly, working side-by-side with a research mentor also gave protégés the opportunity to assess how well the daily work of research fit their own conceptions of future careers and whether research would be "right for me."

Protégés emphasized that gains in skills and increased understanding of science research as daily work led to strong gains in confidence to successfully take on the challenges of graduate school. They described the SOARS research experience and culture of inquiry as enhancing their preparation for subsequent undergraduate coursework, graduate school and careers in science (and contributed considerably to a graduate school application or résumé). The SOARS experience engendered in protégés the confidence to make choices about "next steps," informing their decision-making processes regarding graduate school and possible careers. Thus gains from the research experience played an important role in protégés' confidence and professional socialization and positively influenced their education and career goals.

Protégés' also emphasized the personal growth they experienced as a result of SOARS. They talked about gains in leadership skills and how they wanted to "pass on" or "pay back" the benefits that they had received from SOARS by becoming mentors for others upon returning to their communities. Some protégés had already done so, or had otherwise assumed leadership roles back home—roles they had learned as SOARS protégés. In a few cases, protégés reported advocating for mentoring programs and/or SOARS-inspired program features in their universities' academic programs. In all of these cases, protégés were promoting goals of SOARS by encouraging others to pursue science, to aspire higher than they otherwise would have, and to develop more supportive learning environments.

Suggestions for Replicating the SOARS Model
Several suggestions were made by SOARS program participants and UCAR managers to other organizations seeking to replicate the SOARS model. The structural elements of SOARS identified by participants as crucial to its success include the following:

- Deeply committed leader and staff
- High-quality, sincerely motivated protégés
- System of multiple mentors who value the program goals and have ample time to devote
- Multiyear program
- Good protégé-mentor matches
- Significant but achievable challenges for protégés
- Authentic, meaningful, and achievable research projects
- Professional development opportunities, including scientific writing and presenting
- Funding for protégés to present their research at professional conferences
- "Community" living arrangements
- Strong financial and institutional support
- Solicitation and incorporation of feedback

Recommendations
The evaluators have made several suggestions for the optimal success of SOARS. The evaluators' suggestions are minor in nature, as the program works very well overall. Suggestions offered are generally encouragement to extend signposting within certain aspects of the program, including:

- Increased clarification of the role of the community mentor
- Increased attention to the role played by informal mentors
- Clearer signposting for the leadership training given to peer mentors
- Clearer signposting for protégés as to work expectations
- Clarification of norms for ongoing communication between mentors and protégés beyond the summer session
- Increased clarification of UCAR's appreciation for employees that volunteer as mentors

In addition, we recommend continuing attention to aspects of the following program components:

- Refinement of the writing workshop
- Discussion of race issues protégés may face in their academic and professional careers
- Challenges of mentoring new versus returning protégés
- Recruitment and selection of protégés to boost SOARS' success rates
- Diversity of the SOARS Steering Committee and staff
- Aspects of mentor training

Conclusions
SOARS is a highly successful program as measured by a number of different metrics. Qualitative measures indicate high rates of protégé retention in the program, protégé educational

aspirations and progress in atmospheric and related sciences and mathematics, engineering and computer science fields. Quantitative measures (both those SOARS has been tracking over the years and those we contribute in this report) indicate successes in protégé confidence and comfort interacting with scientists and other professionals, enhanced research, writing, and presentation skills, and sense of belonging among a community of peers. We also see indicators of a "multiplier effect," in which protégés actively use leadership skills developed through SOARS to promote the aspirations and successes of individuals in their home communities and universities.

SOARS has also achieved unintended successes. Mentors cite numerous personal and professional gains from their involvement in SOARS. In addition, even protégés who have discontinued their participation in the program credit SOARS with increasing their career aspirations and skills.

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.