Research Opportunities for Science Educators (ROSE)

Pilot Program Report

Part B. Assessment

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Executive Summary

The ROSE (Research Opportunities for Science Educators) pilot program at UNM in the summer of 2021 demonstrated the need for and viability of the underlying concept: participating in university research projects is both attractive and beneficial to high school science teachers. In spite of the last-minute organization and recruiting for the project, nearly forty teachers applied for only eight Scholar positions, and all of the Scholars found the experience valuable and expressed interest in returning for another summer. The Scholars and their PI mentors all contributed ideas for improving the program in subsequent years.

Scholars and mentors found the ROSE program "overwhelmingly valuable, worthwhile, and well-organized" (Program assessor A. Stewart). While professional development opportunities typically focus on pedagogy, the research experience provided a unique opportunity for development in subject matter mastery and helped to renew confidence and enthusiasm: One Scholar noted that "*I really like to keep developing my teaching and… reinvigorate the love for that science as well… it's a nice thing to just get that love back, and remember why… I love the chemistry…".* Scholars acquired specific skills and tools to bring back to their classes in the Fall—notably, the use of the UCSF Chimera molecular modelling software and experience with Python—but also new ways of explaining and motivating students: *"…some of the ways that the professor teaches with motion was just really great. And it was really effective and I had never really thought of doing that. And when I did that in class—I actually did something kind of like this in class—and it really was an effective way of doing it and explaining something."* The pilot program also familiarized the Scholars with the Albuquerque campus and facilities and made them more inclined to encourage students to attend UNM.

Based on the suggestions of the participants, including PI mentors and Scholars, the organizers hope to expand and improve the Program in coming years. Expansion to a larger cohort of Scholars would occur in stages, beginning with the current focus on chemistry teachers but including PI mentors from other departments who use chemistry to address research problems in related areas such as engineering, physics, biology, and the biomedical sciences. The recruiting process should begin with publicity in January, teacher applications due in March and completion of the selection process in April. The Program should consider a longer research period of 5-6 weeks, rather than the 4 weeks of the pilot program. More informal cohort-building activities could include housing out-of-town Scholars on the UNM campus and scheduled weekend social activities. More formal activities could include scheduled mentor-Scholar communications before and after the research period, organized presentations and tours on campus, and panels/discussions on science teaching and 'taking it back to the classroom'.

Goals of assessment

The ROSE program aims to improve science education in New Mexico by updating and enhancing the training and background of science teachers through participation in funded research projects. New Mexico schools lag behind those in other states by many educational metrics, including graduation rates and scores on science tests. More specifically, under-represented minority (URM) students were found to be at a significant educational disadvantage in the Yazzie-Martinez decision, while all New Mexico students pass the Chemistry Advanced Placement (AP) test at a much lower rate than the Biology and Physics AP tests. ROSE is based on the concept of helping students by improving the scientific knowledge, self-confidence and enthusiasm of their science teachers. ROSE recruits teachers of chemistry and related science courses from schools with significant URM student populations into university research projects, where they can update their science background, learn new skills and new approaches to science, and rediscover the excitement of scientific research.

The pilot program of Summer 2021 was intended to explore the viability of the ROSE concept and the practical mechanics of an on-campus research experience for teachers from across the state. Support from NM PED and UNM VPR allowed a small cohort of 8 science teachers (ROSE Scholars) to participate in research projects in the Department of Chemistry and Chemical Biology (CCB), as described in Part A of this report.

The pilot program assessment was intended to explore:

a) The viability of the general concept: Are NM science teachers interested in and able to benefit from a research experience? Do the benefits translate into changes in teaching and classroom behavior?

b) Are the logistics of Scholar recruitment, selection, support and introduction to research feasible? What are significant costs and requirements?

c) Does the ROSE experience change teacher attitudes toward their subject? To UNM? To faculty mentors and the Department?

d) How can the program be improved going forward?

Assessment Plans and Timeline

Since the ROSE organizers from CCB are not trained in social science or educational research methods, the Program recruited a professional social scientist and researcher, Prof. Abigail Stewart, to perform assessments. Prof. Stewart is currently consulting for ADVANCE at UNM (an NSF-funded center for women and minority STEM faculty).

Abigail Stewart is the Sandra Schwarz Tangri Distinguished University Professor of Psychology and Women's Studies at the University of Michigan (UM). She has published over 200 academic articles on psychology, gender and academic institutions, including the 2017 book The inclusive academy: Achieving diversity and excellence coauthored by V. Valian and published by MIT press. She has served as Associate Dean and Center Director at UM, and from 2001-2016 directed the UM ADVANCE Program for women and minority STEM faculty.

Given the limited number of Scholars (8) and PIs (5) participating in the pilot program, quantitative surveys would be unlikely to produce useable data. Prof. Stewart and the organizers decided upon a qualitative, interview-based post-Program assessment. The team decided on

three sets of interviews, one with the UNM faculty PI mentors and two with the ROSE Scholars; the first round of Scholar interviews was conducted shortly after the pilot finished (so that the experience would be "fresh" in memory), and the second round was conducted two months later during the Fall semester, so that Scholars had more time to process the experience and let it influence their classroom teaching. The organizers discussed the information desired from the interviews and presented brief documents to Prof. Stewart, who transformed them into interview scripts. Dr. Stewart conducted the interviews, recording and transcribing responses, and wrote a report on each set of interviews, contained in Appendices B, C and D.

Mentor/PI Interviews

A review of the Mentor/PI interviews reveals uniform approval of the Program. All mentors found it valuable to their research programs, and many commented that the experience helped them hone their mentoring skills. To quote Prof. Stewart,

> ***"All of them hope to work with the program in the future, all have continuing contact with their Scholar mentees, and all pointed to gains for them and for the Scholars, as well as for the department and UNM, from the ROSE Scholars Program."*** *From Appendix B*

Many felt that the Program could benefit from being one or two weeks longer. There was unanimous support for the weekly Friday lunches, but many felt the entire experience could be made more valuable by including additional structure such as topics for discussion, as well as creating field trips to local museums for the Scholars on the weekends. It was felt that these activities would allow the ROSE Scholars to form more meaningful connections with their peers, and enable them to learn more about Albuquerque, potentially improving undergraduate recruitment efforts. The mentors felt strongly that future versions of the Program should include financial support for those graduate students that are significantly involved in Scholar training. All mentors have maintained contact with their ROSE Scholars, indicating that the creation of community focused on chemistry education instruction has been successful thus far. Lastly, all PIs felt that the Program helped to reveal to the Scholars the nature of research, but it also unexpectedly uncovered the many challenges the Scholars experience as high school teachers.

Scholar Interviews

The feedback from the Scholar interviews was that the 2021 pilot program was "overwhelmingly valuable, worthwhile, and well-organized," with only minor modifications recommended for the Program in 2022. All eight of the 2021 participants would like to participate again. Many of the consensus suggestions of the Scholars can be implemented with the longer timeline available to a regular, rather than pilot, Program; these are included below in the Considerations and Suggestions section. Examples include advertising and recruiting earlier in the calendar year; considering expanding the length of the Program from 4 to 5-6 weeks; additional mechanisms for advertising the Program; arranging for housing as a cohort, on campus; and providing pre-Program briefings on research projects and the way that the Program will be structured—i.e., a more comprehensive setting of expectations.

The motivations of the Scholars in deciding to apply to the Program highlighted their excitement about the opportunity to do (real) research:

"It was a very unique opportunity that I hadn't seen for 20 years—to be able to go into a research lab and [I] don't have to worry about anything else."

"I really like to keep developing my teaching and… reinvigorate the love for that science as well… it's a nice thing to just get that love back, and remember why… I love the chemistry…"

"I really want to experience firsthand… real research… working with experts in their field… [where] we're not just going to be observing… [but] are actually part of the research process."

There were some unexpected (and thus especially valuable) comments that emerged from the interviews. A common theme related to structure—at both the research group and cohort levels. Some Scholars felt that the group activities could have been more structured, "to ensure full participation and equity" and enable greater intra-cohort communication, relationship-building, and the sharing of newly-gained expertise (notably computational tools and visualization software) to take back to their classrooms and enhance their teaching. One suggestion for facilitating cross-fertilization of ideas, and greater interaction within the cohort, was to establish a shared, dedicated space for members of the cohort, in addition to office space within each individual lab. Group lunches coordinated by the Program, and individual research group lunches, were all highly appreciated.

Several Scholars expressed surprise at encountering the largely unstructured nature of research. Although they had enthusiastically taken the leap to apply to the Program, some Scholars were anxious about whether they had the necessary background ("rusty", "intimidated", "out of comfort zone") to participate effectively. One Scholar suggested that the Program might want to "stress to applicants that it's okay if they have no past experience." There was some culture shock associated with transitioning out of the highly structured environment of high school classes ("bells ringing", "very rigid schedule") to the more fluid lab/research environment where the PI is not present all of the time, and researchers are expected to be strongly self-motivated and able to work independently. On the other hand, Scholars also "appreciated that there was time to reflect, consolidate and relax, particularly because their time was not too structured." These expectations about structure could be addressed by setting more specific goals and expectations in advance of the Scholars' arrivals on campus, providing a fact sheet on logistics and expectations, and by describing the unique environment of a research lab as part of the ROSE Program announcement.

All of the Scholars experienced a "powerful" and "substantial" impact from the Program—new ideas, experiences, renewed passion for science, strategies for teaching complex concepts to their students, integration of knowledge, and new ideas for incorporating that knowledge into their pedagogy:

"I'm just jazzed to tell [my peers]… about the research… it was such a great experience to see how the applied lab techniques, the instrumentation… what kind of things we should probably think about covering more… how does this tie to what we're working on [in high school]."

"The really exciting thing for me was… being part of something bigger and really getting the opportunity to learn… about what's happening in research and in the field of chemistry…"

"Even just being able to get in the labs gives you that confidence back in your content area."

"In general ways I have brought into science class a deeper perspective on how scientists operate, how they use evidence to support their claims."

"Everything seems to connect at the quantum level: biology, physics, and chemistry…"

"The interdisciplinary application of chemistry and physics and statistics…"

"I realized I could pull a lot of these organic terms into my class, and that would probably make [my students]… feel a lot less overwhelmed when they get in college later on… this is what's at the forefront [and].... try to get them excited about that."

"This experience got me to reflect: is what I am doing relevant to what's happening out there? Am I building that connection that's really making an impact on our students… Right now I'm thinking about how to introduce some of the concepts that I learned over the summer… [to] make sure that [my labs are]… relevant to current research and try to actually let [my students]… have life experience to get as passionate as I was…"

"It's like the ultimate professional development training for me… [that I] can share to my colleagues [at]… my school and to the district. Number one is the practice of research itself."

"I didn't know computation was out there… I'm a hands-on kind of person. Talking to [peers doing computation] I saw the importance of that as well."

"The use of different equipment, and the instrumentation will be the highlight of my presentation [to my students]… my students can see that research is fun. And I think that's what's lacking in our school today… and there is diversity… My goal is to inspire [my students] to pursue their dreams to… pursue [a] STEM career."

"The opportunity to be in a research lab that's during [sic] groundbreaking current research. The hands-on opportunity is invaluable… not just to read about it, but to be a part of it. That's amazing!"

The second round of interviews in October reinforced the earlier positive assessments of the Program, with Scholars also able to comment on how their teaching was impacted by the summer experience. Specific changes were noted in lab exercise design, answering questions from students, and new ways to explain chemistry material.

"In general ways I have brought into science class a deeper perspective on how scientists operate, how they use evidence to support their claims. I can talk more about what scientific research is like and how it works."

"…now I have a better way of giving these kids a visualization of a protein or an enzyme which is a protein."

"…some of the ways that the professor teaches with motion was just really great. And it was really effective and I had never really thought of doing that. And when I did that in class--I actually did something kind of like this in class--and it really was an effective way of doing it and explaining something."

The Scholars remain interested in returning to research next summer, and several have recommended the ROSE Program to their teaching colleagues. As noted by Prof. Stewart,

"Overall, it was clear that the ROSE Scholars used their summer experience to deepen, reinvigorate and enrich the way they thought about both their pedagogy and the content they were teaching. They valued it highly, as did their schools and the students they are teaching." *From Appendix D*

Future Considerations and Suggested Improvements

Considerations for 2022

Planning for future summer ROSE Programs has been ongoing, and the assessment results will contribute to decisions about coming years. Key issues which will influence the program budget and logistics include the Scholar and PI recruiting process, the size and duration of the summer research experience, and the composition of the Scholar cohorts.

Recruiting. Scholar and PI recruiting was compressed into May 2021, but the schedule should be expanded in future years, beginning with recruiting announcements in January and application and selection in March and April. The timeline should allow for widespread publicity, planning by potential Scholars and a more considered selection process. The announcements in the PED STEM Connect email newsletter generated a large pool of applicants, but using multiple mechanisms (direct emails from the ROSE Program; website and event announcements) might ensure wider coverage while providing more detailed information on the Program. The application process should provide more time for potential Scholars to apply, and a longer period for the selection itself (2-4 weeks). The application form should be re-designed to provide more useful data about the potential Scholars, both for the selection process and for longer-term assessment. The publicity and the application should emphasize Program accessibility: expectations would include Scholars with minimal preparation and some flexibility in daily schedule to accommodate Scholars with family responsibilities. Recruiting of PI mentors should begin early in the Spring semester and possibly be expanded to include faculty conducting chemically-oriented research in other departments (Chemical and Biological Engineering, Physics, Biology, Toxicology, Environmental Engineering, etc.)

Size and Duration. The 4-week pilot for 8 Scholars met the time (Fiscal Year) and financial constraints of available funding from PED and the UNM OVPR, but subsequent discussions have suggested that a slightly longer summer research period (5-6 weeks) for a larger group of Scholars might be preferable. A longer program would allow for more formal activities and better conclusions to some research experiences, while a larger cohort would allow for more interactions among Scholars and increase the reach of the Program.

Program Organization. The following questions need to be considered for Summer 2022:

- Is 5 or 6 weeks preferable? Added length may complicate scheduling for some Scholars.
- Should the number of Scholars be increased to 15? 20? 25? The optimal number may be somewhat higher in the long term, but both the logistics of the Program and need to assure funding suggest this is a good range for 2022.
- How many PI mentors should be recruited? This will depend on the number of Scholars and the Scholar:mentor ratio, which could be 1:1, 2:1, or some intermediate value.
- Can stipends be provided for graduate students who devote significant time to mentoring Scholars? For administrative assistance? For faculty organizers?
- Can out-of-town Scholars be housed on the UNM main campus? This would minimize commuting and parking issues and facilitate 'cohort building' through proximity for meals, etc.?

Future considerations include:

- Should ROSE expand to cover teachers in other science disciplines? Chemistry is the current focus, but Physics, Biology and Earth Science instructors should also benefit; the interdisciplinary nature of research was an important revelation for many of the Scholars.
- Should ROSE expand to other research universities in NM (notably NMSU)?
- Should ROSE be used to open other formal interactions between UNM and high schools? For example, we could initiate a 'science speaker' program to send UNM faculty to high schools, or schedule Zoom lunch meetings between high school and UNM students.
- Should ROSE expand to include post-secondary science educators at 2- and 4-year colleges without extensive research facilities (e.g. CNM, Navajo Tech, SIPI, New Mexico Highlands)?

Scholar Cohort Composition. ROSE is intended to improve secondary science education, especially for URM students, by engaging teachers in research. While the first cohort of Scholars was selected in only a week based on high school student body URM make-up and geographical considerations, other criteria might also be considered:

- What is the optimal rural:urban school ratio?
- How important is geographic distribution throughout New Mexico?
- How important is the percentage of URM students at a school versus the total number of URM students?
- Should a single school have multiple Scholars in the same year?
- Should Scholars be allowed to repeat the ROSE experience? If so, how often? Is there an optimal 'target' percentage or returning Scholars in a given cohort?
- Should the academic degree(s) of the scholars be considered in selection?
- Should the application require an essay or other significant writing?
- Should non-PED schools (parochial, private) be allowed to send Scholars?

Additional Considerations

PI mentors and scholars had specific suggestions for additions to the ROSE program to improve the selection process, summer experience, and follow-up.

Pre-summer actions. Several Scholars recommended some official contact by the PI mentor after Scholar selection by phone or Zoom. Besides establishing a welcoming personal relationship, this could be used to suggest reading materials (or other research preparation), discuss expectations, learn more about the Scholar and answer questions about the summer. Posting orientation materials on the ROSE website could be a useful supplement, but not a substitute.

Advance notice of professional development credit recognized by NM PED would be helpful to Scholars and serve as a possible recruiting tool.

Summer experience.

Housing. On-campus housing, as mentioned above, was cited as more convenient for Scholars, possibly more cost-effective than hotel housing, and a better way to allow Scholars to get to know the University and each other.

UNM and Albuquerque orientation. Since many of the Scholars will be from out-of-town, some introduction to Albuquerque and the UNM campus could help them adapt to their summer environment. A campus tour and possibly a field trip to a museum or Old Town could be arranged for the first on-campus day or the preceding weekend; other field trips and events could continue throughout the summer program (trips to Sandia Crest, IPCC, Old Town, Natural History and Explora, etc.)

Program orientation. The first day orientation program could include formal introductions to UNM faculty participants and Department staff. Returning Scholars could potentially serve as mentors (or orientation counselors) for new Scholars to facilitate the adjustment to UNM and the research environment.

Program activities. While Scholars appreciated the weekly lunch meetings, some of them felt more structured activities would be useful, including:

- Research presentations by faculty, PI mentors and perhaps others.
- Social activities including UNM students and faculty.
- Meetings and/or panel discussions with UNM instructors to discuss chemistry and science teaching, including laboratories.
- "Brainstorming" sessions: time to talk with each other about how to bring their new knowledge and skills back to the classroom, perhaps supplemented by UNM faculty contributions or resources (websites, software and tools).
- More structure to group lunches (seat assignment, discussion topics) to promote broader connections (so the PIs don't simply talk to each other and/or the Scholars from their own labs).
- Poster presentations on research projects (which Scholars could take back to their schools).
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Follow-up. Scholars appreciated continuing contact, which is currently very informal. Some requested a more formal mechanism which might include school visits (by PIs or others) or Scholar meetings (in person or by Zoom) during the school year. Scholars also requested additional information for their students on how to prepare for and apply to UNM.