

Research Opportunities for Science Educators (ROSE)

Pilot Project Report

Part A. Activities

July, 2021

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Executive Summary

The Research Opportunities for Science Educators (ROSE) pilot program was a collaboration between the University of New Mexico (UNM) and the New Mexico Public Education Department (PED). The idea was originally conceived by researchers in the Department of Chemistry and Chemical Biology at UNM and the final version of the pilot program was developed through discussions among these researchers and PED officials over a period of several weeks in Spring 2021. The goal of the program is to help improve the quality of science education in New Mexico by enabling educators to refresh their knowledge and develop new skills, while gaining appreciation for and inspiration from current scientific research. Another long-term goal is to substantively change perception of the research enterprise, as high school science teachers experience the excitement and satisfaction of cutting-edge research first-hand and convey this to their students.

Applications were solicited from New Mexico high school chemistry/science teachers across the state, and finalists were invited to join principal investigator (PI)-led research laboratories at UNM for one month as resident researcher-Scholars. Demand for the program far outstripped available positions in hosting labs, with 39 official applications and 3 additional inquiries for 5 positions. Additional funding from the UNM research office allowed a total of 8 Scholars to be funded, 2 from Albuquerque and 6 from smaller communities throughout NM. All selected Scholars teach at schools with high percentages of under-represented minorities in the student bodies. The Scholars' projects in five research groups included molecular modeling, chemical synthesis and chemical biology.

Assessment of the program is ongoing, through personal interviews with the ROSE Scholars and PI lab directors. An independent third party is conducting the personal interviews and anonymizing the results. Initial results indicate that the pilot program was an extraordinary success. Participants were enthusiastic about their experiences and willing to recommend the program to colleagues. A second round of follow-up interviews will be held in the fall to gain insight into how the 2021 cohort of Scholars have incorporated their experiences within their classroom lessons, and a final assessment report will be issued in late 2021.

Based on the success of the 2021 summer pilot, we are excited about the possibility of improving and expanding the ROSE Program in the future, and we look forward to future collaborations with NM PED and hope to include other partners as well.

Motivation

New Mexico typically ranks in the bottom decile of US states in quantitative educational outcomes like high school graduation rates and standardized test scores¹. In spite of the presence of three national laboratories (two DoE, one DoD) and a relatively high percentage of STEM Ph.D. recipients in the state, New Mexico ranks in the bottom quartile of all states for eighth grade science proficiency². The NM Public Education Department (PED) considered only 1/3 of high school juniors (11th grade) to be proficient in science in 2019³. This problem is particularly severe for underrepresented minority (URM) students and students from rural areas, as detailed in the Yazzie-Martinez lawsuit decision⁴.

Chemistry is a notable weak spot in high school science instruction for New Mexico. Openings for “chemistry teacher” positions consistently attract far fewer applicants than those for “biology teacher” or “science teacher”⁵. This may be related to the New Mexico teacher licensure system, which does not require a chemistry background for secondary science teachers. New Mexico HS students had a consistently lower passing percentage for the AP Chemistry exam than for the AP Biology and Physics exams over the period 2015-2019⁶.

The University of New Mexico (UNM) is a high-research activity (R1) university with over 800 sponsored research projects in FY 2019⁷. STEM research is conducted in new or recently renovated state-of-the art laboratories, including several interdisciplinary facilities like the Center for High Technology Materials (CHTM), Center for Alcohol and Substance Abuse (CASA), Center for Advanced Research Computing (CARC), Center for Quantum Information and Control (CQuIC), and new PAÍS (Physics and Interdisciplinary Science) building. Over 200 faculty and 1000 graduate students are engaged in STEM research ranging from fundamental quantum mechanics and particle physics to applications-oriented engineering and field ecology projects working on Mars rovers and the evolution of the human species.

UNM and the Department of Chemistry and Chemical Biology (CCB) have a vested interest in supporting and improving science education generally and chemistry education specifically in NM public schools. Reaching out to individual students has real benefits, but does not scale to the large numbers of NM high school students we would like to reach. By working with high school science teachers, we can leverage the research resources of an R1 university to benefit many more students, albeit indirectly. As noted in the initial program summary (Appendix A): “ROSE will improve the quality of science education by allowing educators to refresh their knowledge and develop new skills while gaining appreciation for and inspiration from current scientific research.”

1. <https://nces.ed.gov/programs/coe/indicator/coi>
<https://www.nationsreportcard.gov/profiles/stateprofile/overview/NM>
2. <https://nces.nsf.gov/indicators/states/indicator/eighth-grade-science-proficiency>
3. <https://webnew.ped.state.nm.us/bureaus/accountability/achievement-data/>
4. <http://nmpovertylaw.org/wp-content/uploads/2018/09/Graphic-Yazzie-Martinez-Decision.pdf>
<https://webnew.ped.state.nm.us/bureaus/yazzie-martinez-updates/>
5. Personal experience from SE Cabaniss school board service.

6. New Mexico Math and Science Advisory Council Public Elementary and Secondary Mathematics and Science Achievement for School Year 2019-2020, available at <https://webnew.ped.state.nm.us/bureaus/math-science/msac-math-and-science-advisory-council/>
7. <https://viewbook.unm.edu/research-brochure/8-9/>

Planning and Preparation Timeline

The ROSE pilot project emerged from discussions among three CCB faculty. Prof. Jeff Rack noted during an NSF review panel that CCB community outreach to high schools and underrepresented minorities has been piecemeal relative to many other departments and lacks documentation of long-term effectiveness. In discussions with Prof. Steve Cabaniss and Prof. Susan Atlas in March 2021, the idea emerged to invite teachers from high schools and primarily undergraduate institutions (PUIs) to participate in ongoing research at UNM as a way of establishing connections to schools across the state and enhancing the chemistry expertise of their faculty.

The organizers (Rack, Cabaniss, Atlas) created a short proposal for this idea under the program name Research Opportunities for Science Educators (ROSE), included here as Appendix A. The original intent was to obtain support to implement some version of the program in Summer 2022, after pandemic restrictions were relaxed and the Clark Hall (UNM Chemistry building) renovations were completed.

On April 12, 2021, the organizers and CCB department chair Jeremy Edwards met with NM PED deputy secretary Gwen Warniment and Jacqueline Costales to discuss the ROSE proposal outlined in Appendix A. Dr. Warniment proposed a small pilot project for summer 2021 to be supported financially and logistically by PED.

On April 30, the organizers met with Yanira Vazquez and Shafiq Chaudhary, to determine the number of people who could participate, and discuss organizational and operational details of the Program. All other correspondence prior to, during, and after the Summer 2021 Program was through email.

Organizer Biographical Sketches

Steve Cabaniss has taught analytical and environmental chemistry for over 30 years at Kent State University (1989-2002) and UNM (2002-present). His research examines the behavior of metals in natural waters and soils, including uranium contamination on the Colorado Plateau. He served as department chair for CCB (2012-2018) and on the governing board for the Albuquerque Institute of Mathematics and Science (AIMS) from 2006 to 2014 including 4 years as board president.

Jeffrey Rack began his professorial career at Ohio University in 2001 and moved to UNM in 2016, where he continues to teach general chemistry, inorganic chemistry and photochemistry. His research interests center around photochemistry and photophysics of materials and transition metal complexes. He presently serves as Secretary for the Division of Inorganic Chemistry (DIC) of the American Chemical Society (ACS), DIC Councilor for ACS, and is Vice-President for the Inter-American Photochemical Society.

Susan Atlas has been a faculty member at UNM since 1994, following a postdoctoral fellowship at Los Alamos National Laboratory. She teaches courses in introductory physical chemistry, statistical mechanics, parallel computing, electronic structure, and computational genomics. Her research is focused on the theoretical chemical physics of biophysical, biochemical, and materials systems. She has served as Director of the UNM Center for Advanced Research Computing and as Program Director in the Division of Chemistry at NSF.

Scholar Recruitment and Selection

The pilot program was announced May 5, 2021 in the PED's NM STEM Connect Newsletter, which is sent to science teachers across the state. Between May 5 and May 15 (the closing date), we received 39 total applications and three independent email requests about applying. The applicants were independently evaluated and ranked (by Cabaniss, Rack, and Atlas) based on the following criteria: whether or not the applicant will teach high school chemistry next academic year, will teach high school science next academic year, total number of years teaching experience, and self-identified area of research interest. This selection yielded a group of 15 prospective ROSE Scholars. Final selection from this group was based on matching individual high school science teacher interests with PI interests, applicant availability, personnel capacity in host (PI) laboratories, and geographic location of the applicant and their school. Preference was given to those educators who teach in rural areas or who teach large numbers of underrepresented minority students and/or had specific interests or background relevant to a particular research project. Declination letters were sent to all applicants who were not selected.

June Activities/Timeline

Program activities began with the arrival of scholars and orientation the morning of June 1. Scholars met with faculty organizers and PIs, completed paperwork required to give them access to UNM facilities (keys, card access, etc.), and participated in a chemical safety program. ROSE scholars began their respective research programs on June 2. Each Friday (June 4, June 11, June 18, and June 25), ROSE Scholars, host PI's, and other special guests were provided lunch, where we met to informally discuss aspects of the experience. On June 25, ROSE Scholars participated in the ROSE Symposium, where each Scholar presented a brief lecture on their experience. The ROSE pilot program was completed on June 25.

Research Descriptions

Prospective ROSE Scholars were provided a menu of research projects to select areas of interest. This selection was used to pair the science educators with a PI host. Those areas were:

Chemical Synthesis	Molecular Modeling	Nanochemistry
Biochemistry	Chemical Education	Solar Energy
Materials Chemistry	Photochemistry	Polymers
Proteins & peptides	Catalysis	Genomics
Drug discovery	Electrochemistry	

A more detailed description of each research project as provided by the host PIs can be found in Appendix G.

Assessment Procedures and Outcomes

Evaluation of the pilot program is in progress, and an assessment report will be prepared for distribution late in the Fall 2021 semester. The report will include information collected from the Scholars on their expectations for the program during the orientation session (form in Appendix E) and more extensive interviews of scholars and PIs conducted shortly after the pilot project ended (completed for Scholars, in progress for PIs), and during the Fall 2021 semester (planned for Scholars in late September/early October).

Interviews are being conducted and summarized by Dr. Abigail Stewart, who is the Sandra Schwartz Tangri Distinguished University Professor of Psychology and Women's and Gender Studies at the University of Michigan (UMich) (lsa.umich.edu/psych/people/faculty/abbystew.html). Prof. Stewart directed the UMich ADVANCE program for women and minority STEM faculty from 2001 to 2016, and more recently co-authored (with Virginia Valian) “An Inclusive Academy: Achieving Diversity and Excellence” (2018, MIT Press). She consults for the UNM ADVANCE program (<https://advance.unm.edu/about-us/>).

The primary purpose of these interviews is to help improve the program in subsequent summers, from advertising and selection of Scholars through on-campus activities and responses to how the experience “carries through” to the classroom in the fall. PIs are being asked to comment on program workload and disruption, as well as interactions with Scholars. The initial interviews with Scholars focused on program logistics and activities and their responses, while the later interviews will emphasize changes (if any) in the classroom.

The pilot program exceeded our expectations on several levels, including the enthusiastic responses of the teachers (ROSE Scholars). A few excerpts from Prof. Stewart’s report on the first round of scholar interviews follow in italics; quotes from individual teachers are also in quotation marks.

The program was, as is evidenced below, enormously and universally successful, in the eyes of the ROSE Scholars. Participants came with high hopes, and those hopes were met and exceeded. They greatly valued, in particular, the opportunity to do hands-on research with mentors they perceived as both patient and supportive, and brilliant. They felt this experience provided them with many resources to bring to their teaching.

All 8 of the 2021 participants would like to participate again.

All of the participants expect to maintain ties with people in the program.

Would you recommend this program to others? All of the participants said, yes, though two qualified their responses by saying: “I think it has to be a teacher that is willing to come in and know that, you know, they need to ask questions.”

The participants outlined the program’s powerful impact on them in every case. For that reason I have left in their verbatim quotations about it. Some focused on the impact of learning and experiencing new things; others on the way in which past and current knowledge integrated and created a more meaningful whole. In every case, though, participants reported that the impact was positive and substantial.

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

"I'm just jazzed to tell them about the research, you know like, to be able to get involved in something that you don't get to experience as a teacher... and it was just such a great experience to see how the applied lab techniques, the instrumentation they used, what kind of things we should probably think about covering more, that ties into this... I think that's what I'm really want to bring back to my peers is: just what did we work on [in the ROSE Program], and how does this tie to what we're working on [in high school]."

Since the pilot emphasized individual research projects, each Scholar answered differently about how they might incorporate skills from ROSE into their pedagogy:

"...in biology, we talk about enzymes, the binding of enzymes, and the protein. And so this is a very good example because we can, I can even teach my students to actually do the simulation using a free program just using our laptops"

"I learned how to let the student visualize the data. For example, I modeled interactively with our Python plot package... And that could be very good to teach biology students and chemistry students, or the physics and say: You see this is our atoms and molecules, this is how they enter to connect to the cell membrane, so it could be a very authentic project for the teaching."

Several of the Scholars noted the diversity within the research groups and wanted to take that observation back to their students:

"...now when I develop a lesson plan I can rely on my experience about how these things are studied. And I also learned new concepts that I can embed throughout my lessons. What does the research look like? Bringing that perspective to them, maybe let them do projects, and really recruit them not just to UNM—it's not boring, it's not oriented just to males, the group I participated in was very diverse!"

"...in the lab, the people that I work with: there is diversity, and I want to emphasize that the research is not [only] for men. Researchers are doing experiments doing work in the lab are not only men. This is this work is also for women, different background. Right. So I want to highlight that. And I really wanted to invite my, my students to pursue college, and want them to experience research. My goal is to motivate them. My goal is to inspire them to pursue their dreams to do to pursue STEM career."

We also asked whether the experience had changed their impression of UNM. Note that five of the eight scholars live outside the Albuquerque metropolitan area, while two teach in APS and one teaches in Cuba but lives in Rio Rancho.

Five of the participants outlined particular ways in which their view of UNM had changed.

One commented that it is a very nice campus; and another that they learned about it from the administrators who came to lunch. One pointed out that “Now I think I’m very confident that I have a connection to UNM.” Another pointed out that “I never thought that they have these interdisciplinary department here. I didn’t realize that they have an interdisciplinary department wherein, you know, they actually apply all these different principles to zero in on the common ground. I’m very surprised and lucky to know that, because I can share it more to my kids with the students.” Finally, one said that, to their surprise, they “saw some really cool things at UNM that made her know it’s friendly, has rethought use of space outdoors, to study, to sit, not just one concrete slab.” They now think it’s an “Excellent place to go.”

Based on the overwhelming response to the initial advertisement and the enthusiastic positive responses of the ROSE scholars in the initial interviews, the organizers want to offer an expanded version of this program in Summer 2022.

Acknowledgements

The ROSE pilot project was supported by the New Mexico Public Education Department and the University of New Mexico, Office of the Vice President for Research, and the Department of Chemistry and Chemical Biology (CCB). NM PED provided stipends, travel allowances, and housing for five of the Scholars. The UNM Office of the Vice President for Research provided stipends for three ROSE Scholars. CCB provided administrative support for the program as well as funding for the weekly lunch meetings.

Special thanks to Gwen Warniment, Jacqueline Costales, Shafiq Chaudry and Yanira Vasquez (NM PED), Mary Jo Daniel and Ellen Fisher (UNM OVPR), Dan Garcia, Tim Schroeder and Arash Mafi (UNM Administration) and to Teri Anderson, Sharon Boyd, Bobby Ortiz and Felicia Rider (UNM CCB), who all provided crucial support to the program in many different ways. We are especially indebted to the graduate students and postdoctoral researchers helped make the inaugural ROSE program an extraordinary success. They are Glorianne Dorce, Mark Aldren Feliciano, Tongtong Li, Shenghan Song, Amy O. Stevens, Rajani Thapa Magar, Emigdio Turner, and Pavel Yamanushkin.