


National Summer Undergraduate Research Project (NSURP): A Virtual Research Experience to Deliver REAL (Retention, Equity, Access, and Life-Changing) Outcomes for Underrepresented Minorities in STEM

 Michael D. L. Johnson^{a,b,c} and Corey J. Knox^d

^aDepartment of Immunobiology, University of Arizona, Tucson, Arizona, USA

^bBIO5 Institute, University of Arizona, Tucson, Arizona, USA

^cValley Fever Center for Excellence, University of Arizona, Tucson, Arizona, USA

^dCollege of Education, University of Arizona, Tucson, Arizona, USA

Summer undergraduate research experiences (SUREs) provide important onramps to secondary STEM graduate degrees and subsequent careers. Studies demonstrate that these experiences increase the likelihood of students advancing to a graduate-level STEM degree, positively impact STEM identity and confidence, and imbue a sense of professional belonging. In 2020, COVID-19 shutdowns eliminated many in-person SUREs. In response, we launched the National Summer Undergraduate Research Project (NSURP). While NSURP addressed an immediate need for a flexible research experience, we found that this model extends access to underrepresented minorities because it provides authentic research experiences for students who are unable to travel to a research location, and/or who have familial responsibilities that necessitate a flexible work model, and/or students facing financial challenges. What began as an emergency summer research program for undergraduates to address laboratory closures resulted in what we believe is a necessary and normalized addition to the undergraduate STEM training and preparation repertoire.

KEYWORDS microbiology, minority, REU, remote, research, STEM, undergraduate, underrepresented, virtual

INTRODUCTION

As many articles in the “Teaching in Time of Crisis” edition of the *Journal of Microbiology and Biology Education* described, SARS-CoV-2 presented significant challenges to hosting undergraduates in the laboratory (1–3). Because SUREs have been documented to encourage student success and persistence in STEM, it is concerning that even in non-pandemic years, these enriching opportunities are inaccessible for many students—particularly students of color and other underrepresented minorities (URMs). URMs are more likely than majority peers to face systemic barriers such as being place bound (e.g., being unable to travel to a SURE location), having family responsibilities that require schedule flexibility that traditional SUREs rarely accommodate, and facing financial challenges. It’s important to note that these barriers are not isolated to pandemic times—they are long-standing and ongoing considerations when we reflect on URM participation in SUREs.

In response to COVID-19 closures, we created NSURP. Our program provided online summer research opportunities for students barred from in-person research experiences. Led by a URM professor (Dr. Johnson) at The University of Arizona, NSURP specifically targeted URMs to help these budding scientists gain access to research opportunities that would foster their knowledge, build their professional network, and bolster their confidence. Ultimately, in just 1 year (2020), our program provided 250 URM undergraduates in STEM with mentored research opportunities. Although we previously published the logistics of program establishment and mentor/mentee matching for NSURP (4), here, we emphasize the aspects of our program that authentically serve URMs in ways that achieved REAL (retention, equity, access, and life-changing opportunities) outcomes for URM students. We hope that sharing this perspective will encourage others to replicate our model that meets URMs where they are and empowers them to overcome barriers to SURE participation.

NSURP KEY GOALS

The primary goals of the NSURP pilot were to

1. Develop a remote summer research experience with *national-level* reach to pair URM STEM undergraduates with microbiology laboratory mentors;

Address correspondence to Department of Immunobiology, University of Arizona, Tucson, Arizona, USA. E-mail: Mdljohnson@arizona.edu.

The authors declare no conflict of interest.

Received: 13 January 2022, Accepted: 8 March 2022,

Published: 4 April 2022

2. Facilitate a URM science and professional development seminar series;
3. Provide professional development resources for mentors (e.g., anti-racist literature and mentoring URM resources) and mentees (e.g., presentation tools, career building, and scientific society connections); and
4. Host an online platform for our program's students to present their research in an official capacity.
5. Foster community connectedness for mentees through Slack and other virtual events.

As the NSURP team worked toward these five overarching goals, we documented REAL outcomes for URM students, which we review next.

OUTCOME 1: RETENTION (BUILDING THE “R” OF REAL OUTCOMES)

Our mentors were more than professed allies; they did the work of showing up when needed. This attitude was at the core of the retention outcome. More tangible factors that promoted URM student retention were personalized mentoring; flexible opportunities to connect with peers and STEM professionals; professional development resources for mentors; and clear expectations for mentors and mentees.

Personalized mentoring

In most cases, students worked one-on-one with a research mentor; but small groups of students (two to four) were assigned a mentor in several instances. Mentors included faculty, post-doctoral fellows, doctoral students, and staff scientists at collegiate institutions across the United States. In addition, several of our mentors were research scientists in government, hospitals, or private laboratories.

Due to the wide variety of research conducted by NSURP mentors, student research experiences reflected fields and practices within and tangential to microbiology. This diverse array of projects also promoted student retention because we matched students based on their interests. Mentor-driven virtual projects were proposed for the initial mentor-mentee matching process but were revisited based on mentee-mentor discussions and student interests. This flexibility was highly encouraged as it was essential to meet students where they were both in life and in science.

Flexible opportunities to connect with peers and professionals

Beyond receiving *in silico* microbial training and scientific/career mentorship, retention-promoting program elements included flexible opportunities for building peer and professional connections. This was accomplished through (i) a slack workspace with content specific channels designed to foster connectivity (mentee-mentee, mentee-mentor, and mentor-mentor)

and enhance real-time communication (versus email). (ii) Access to our “BIPOC professional development/science seminar series,” a series which reflected the research demographics of NSURP students (e.g., topics ranged from cryo-electron micrographs of the SARS-CoV-2 spike glycoprotein to inclusive scientific communication). To accommodate students who could not attend an original talk or were hearing impaired, all talks were recorded, transcribed, and uploaded to the NSURP website (NSURP.org) (5). (iii) Waived membership fees for the American Society for Microbiology, which allowed access to online content (e.g., ASM website and ASM MICROBE 2021) for the rest of the year. (iv) Participation in an NSURP essay contest with a monetary prize and a contribution to a charity of their choice (students ultimately selected “Black Girls Do STEM!”). The essay contest prompt was based on late Congressman John Lewis’s quote “good trouble,” where we encouraged students to reflect and write on how this saying could relate to sciences (6).

Professional development resources for mentors

Research has shown that training to address biases, including racism, can help build inclusive teaching and learning environments. As such, we provided all mentors with anti-racism and other diversity, equity, and inclusion training resources on our NSURP website (5).

Communicating behavioral expectations

To foster a strong student work ethic and provide a foundation for professional identity, students signed a behavioral expectations agreement. Some of the behaviors the agreement addressed included the importance of being respectful and punctual, understanding that not all matches are perfect, and the nature of the required project presentation at the end of the summer.

As a preemptive measure to reduce conflict and prepare undergraduates to navigate a world where their interpersonal skills are vital to success, we also provided guidance on being assertive. One example was telling students to speak up when they didn’t understand something, as not understanding foundational concepts and/or details specific to the project reduces the experiential benefit. Each mentor also agreed to expectation guidelines, including weekly virtual meetings with their mentee and the importance of involving mentees in the laboratory culture. Finally, we encouraged both mentors and mentees to immediately inform NSURP administrators if there was a loss of contact or other difficulties arose.

OUTCOMES 2 AND 3: EQUITY AND ACCESS (BUILDING THE “E” AND “A” OF REAL OUTCOMES)

During the increasing racial tensions of Spring and Summer of 2020, there were increases in commitments to be allies to Black people specifically but extended to all people of color in STEM. This was apparent in movements such as Black in

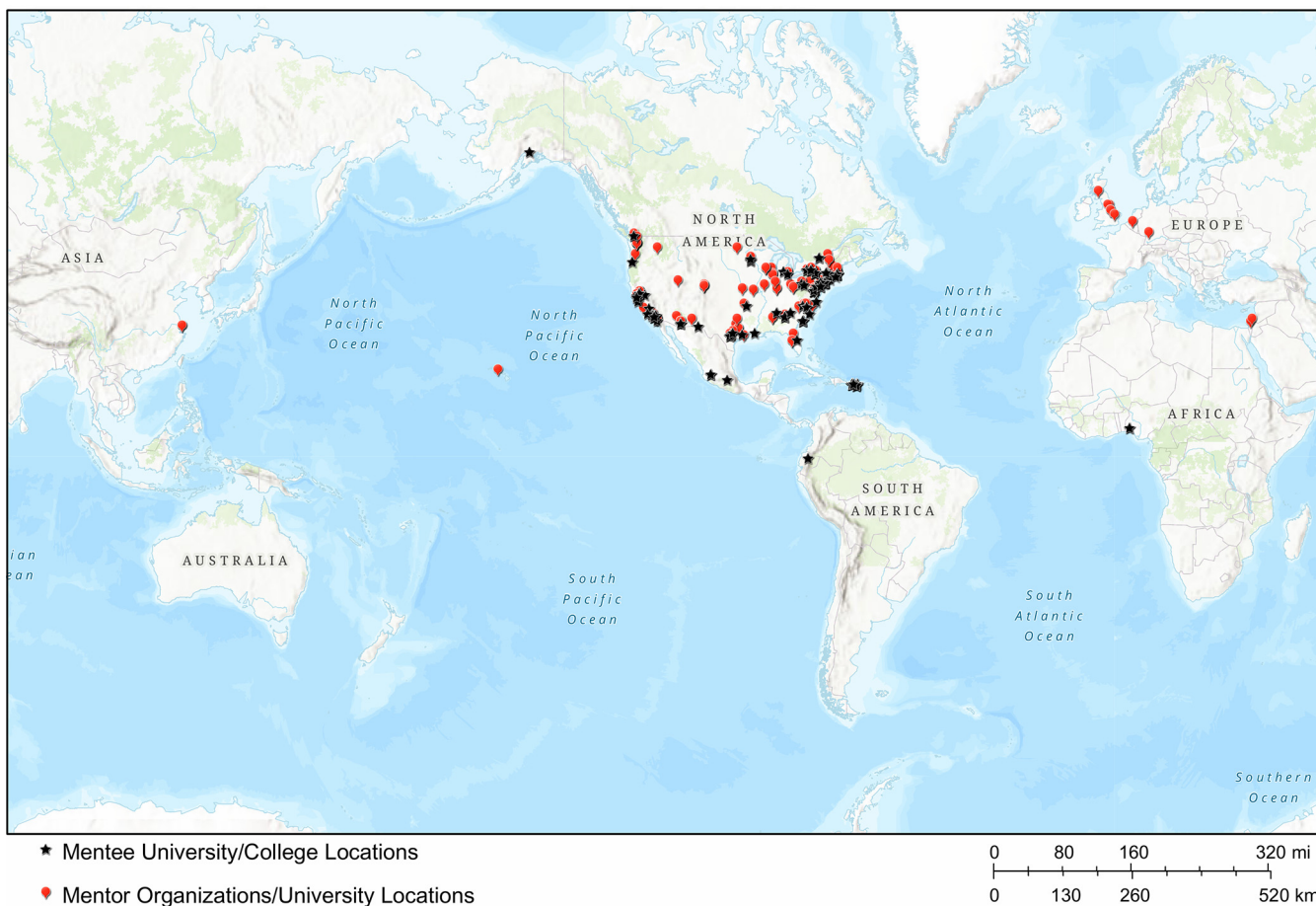


FIG 1. World map of mentor and mentee participant locations. Stars represent the university or college location of the mentee and the red symbols represent mentor university, college, institute, or other organization.

Microbiology and #ShutdownStem (7–10). NSURP provided mentors a platform to focus this support by mentoring URM STEM students who could not participate in in-person programs but were interested in pursuing STEM careers. Accordingly, ~30% of NSURP students stated that their in-person opportunity was canceled in 2020 (4).

The rally cry and answer

Our advertising blitz on Twitter using personal accounts and hashtags such as #nolabnoproblem and emailing program directors of summer REUs resulted in recruiting mentees from 34 states/territories, five countries, and 87 colleges or universities. Mentors represented 30 states, seven countries, and 95 universities, government organizations, or private labs (Fig. 1). An interactive map can be viewed at <https://arcg.is/OruCHP>. This cross-fertilization of research benefits the field, individuals, and future research and work collaborations.

Student demand, access, and participation

In total, NSURP received close to 600 applications from students taking in two cohorts, one starting on June 22nd, 2020 (more than 250 applications) and the other, due to demand and

community support, starting 4 weeks later (20 July 2020). We, Drs. Johnson, Baltrus, and Gardy, handled all applications and matching. While we did not anticipate this many students wanting to participate, we did ask in the matching survey form interest of the students and how many hours they were willing to work per week. We knew this last point represented a burden on the students as we could not pay the students. Therefore, we asked if they could work 0–10, 10–20, 20–30, and 30–40 h per week, and we used this information to match projects that the mentor put in their volunteer form. We also tried to match time zones so that communication during the given workday would be more accessible. As a result, we found that 39% of the students worked 1–8 h, 20% worked 9–15 h, and 41% worked 16–40 h. Surprisingly, but supportive of this program's impact, 36% of post-survey respondents stated that they had no prior research experiences, although these rates varied depending on the year in college.

NSURP's effect on the students

Post-experience program evaluations revealed that mentees had overwhelmingly enjoyable and supportive experiences. They reported self-perceived growth in confidence as scientists,

stronger aspirations toward graduate and medical school, and an. NSURP mentees' post-program self-rating related to confidence, skill, and knowledge increased. Among NSURP post-survey respondents ($n = 100$), 97 (97%) somewhat or strongly agreed that their science abilities increased, 95 (95%) somewhat or strongly agreed that their confidence increased, and 89 (89%) agreed or strongly agreed that the program made them feel more likely to pursue a future career in STEM. We performed *t*-tests to investigate whether student demographics (e.g., gender, race/ethnicity, or year in college) impacted summative experiences of their research experiences. However, self-assessment reports were so consistently positive that experiential differences based on student demographics were not detectable. In essence, NSURP's virtual platform increased the STEM identity of people who had little to no access to a future pool of graduate school applicants.

Breaking accessibility barriers

As the program was conducted virtually, including mentor meetings, program presentations and workshops, and a great deal of asynchronous communication, we questioned the level of perceived support the mentee would experience in this non-person-to-person space. The post-survey responses to questions related to feeling supported, receiving advice related to NSURP projects and beyond, e.g., career advice, were equally positive, with 96% of NSURP participants feeling supported by their mentor and receiving professional development advice. While the goal of the program was to provide research opportunities for URM in STEM who missed research experiences in laboratories due to COVID-19, we found that the number of students who would have been unable to travel to in-person program regardless of a pandemic was 33%, with an additional 25% saying they were unsure. Barriers to participating included but were not limited to caring for a loved one, health issues, financial constraints, being able-bodied, and extra expenses related to travel. These barriers disproportionately impact students from lower-income backgrounds, first-generation, nontraditional students (with families, children, etc.), and Latinx, Black, Indigenous, and other students of color (11). The culmination of these factors impedes many first-generation college students' academic progress (11–14).

While the world will eventually go back to in-person experiences for many research-based programs, URMs will continue to experience barriers to attending in-person summer REUs. Based on feedback and ongoing research, we believe that virtual research opportunities provide an important educational strategy to address systemic and personal barriers to accessing site-based research experiences for undergraduate STEM students, particularly for those groups that have been historically underserved in STEM disciplines. NSURP will continue trying to grow these virtual research opportunities to reach more URM STEM students and conduct research to identify the outcomes and impacts of these experiences.

OUTCOME 4: LIFE-CHANGING EXPERIENCES (BUILDING THE "L" OF REAL OUTCOMES)

Creativity in projects and presentations

As a result of mentees participating in a virtual research experience, over 160 student presentations were uploaded to the NSURP website. The central themes of these projects were analyzing -omics data sets, bioinformatics, or analyzing existing data. Some projects involved writing or editing Wikipedia articles on URM scientists and writing a literature review or reports on the mentors' field of expertise. Due to the wide range of projects, we did not limit our presentations to posters or PowerPoint. Instead, we encouraged our students to use creative formats, in essence trying to meet the student where they were while still trying to maintain the "spirit" of scientific presentations. Although this led to the traditional posters, slide-based presentations with or without video, and reports, students also created poems, musical slide presentations, infographics, science-themed music videos posted to social media platforms, such as TikTok. One mentor noted that allowing students to be creative was a welcome change to the traditional formats, enhanced learning outcomes, and challenged mentors to reflect on their training and laboratory supervision methods. Students can also use the NSURP website as a record of their work, and monetary awards were given to exceptional research (5).

Community support leading to excellence in presentations

There was overlap across projects that supported the development of a strong community of mentees and mentors and, in some cases, led to the creation of dedicated thematic Slack channels where extended conversations occurred. In addition, some of these subgroups conducted symposiums for student presentations, such as ecology and evolutionary biology and genetics and microbiome-focused subgroups. Mentees also gave NSURP presentations at national conferences such as the Annual Biomedical Conference for Minority Students, where several received conference awards.

NSURP CONCLUSIONS

REUs that are flexible, meaningful, and supportive of aspiring URM scientists can enhance the recruitment, retention, and eventual success URMs in STEM. NSURP is a model for reaching URM STEM students where they are in life and giving them authentic and meaningful research experiences that address barriers that URMs face when participating in SUREs. Given the continuing underrepresentation of scientists, faculty, and graduate students of color in STEM fields, we must continue to better understand and dismantle the barriers URM students face as they pursue research opportunities that promote retention and success in STEM. The consensus was that students enjoyed

NSURP, felt more confident in their ability to pursue STEM fields, and appreciated the mentorship they received. This consensus occurred even without paying students. In the 2021 cohort, mentees were compensated through NSF funding. This cohort will be discussed in future manuscripts.

Hypothesis focused, culturally significant, and virtual flexibility

At their core, REUs give students the early tools and confidence to make and support their hypotheses. While there are unique benefits to in-person scientific training, here, we demonstrated that virtual research experiences could provide many benefits (gains in confidence, skills, and knowledge) that established, in-person undergraduate programs offer (15–17). What began as a response to campus closures due to the pandemic has resulted in a model that can facilitate enhanced collaboration between varying levels of scientists and students. Most importantly, this allows a flexible, accessible mode of broadening participation in STEM fields.

The benefits communicated by both mentors and mentees that manifested through NSURP will prepare students to work in the multidisciplinary, multi-institutional research world. As science becomes more interdisciplinary, with collaborations reaching far beyond the walls of departments, institutions, states, and even international borders, the NSURP model of virtual research collaboration, beginning at the undergraduate level, provides exciting new possibilities in undergraduate training and research possibilities. This far-reaching collaboration was exemplified by a partnership between a Canadian researcher and an undergraduate student in Puerto Rico, leading the mentee to connect their research in a culturally meaningful manner through a citizen science approach that connected to place and culture.

Additional work is under way to investigate how geography influenced the choice of research topics and practices and how mentees' connections to community and place impacted their science identity and growth as researchers. By facilitating mentee-mentor partnerships on an international scale and through virtual participation beyond a singular institution, onsite approach, NSURP offered a more flexible, accessible platform to facilitate geographically dispersed research and training opportunities for students. Through this expanded revisioning of a research experience, NSURP was able to promote individualized mentorship that reflects an emerging need to operate in the global biomedical community with the potential of facilitating connecting research experiences to students' communities and culture.

A PERSONAL EPILOGUE

The sacrifices made to start and run this program for a Black pre-tenure PI at a research-intensive institution with no budget were great, but the need was greater. To this end, students of color seeing someone who looked like them in an aspirational position mattered. It demonstrated to those seeking positions in STEM fields that they were indeed possible to obtain.

The recruitment call was a rallying cry from the heart that fortunately broke through the noise of the period's negativity to transform those emotions of sadness, anger, fear, and disgust into something that gave students back previous and present robbed opportunities. Indeed, as an outlet, this program helped more than just the students. In a time where people like the NSURP director couldn't breathe, NSURP was his deep breath and his exhale. All this, combined with the creation of NSURP being born of a perfect storm of need, circumstances, and desire to help many students that felt isolated due to COVID-19, makes NSURP admittedly challenging to replicate. But not impossible. As it stands, NSURP has the potential and desire for collaborations to expand into other disciplines, but as of the present day, not the bandwidth or personnel. Nevertheless, we will press on to run NSURP to the best of our ability and welcome those interested in joining our efforts.

ACKNOWLEDGMENTS

University of Arizona IRB 2108179924, National Summer Undergraduate Research Project (NSURP): Research and Evaluation on Research Experiences for Underrepresented STEM students.

REFERENCES

1. Wester ER, Walsh LL, Arango-Caro S, Callis-Duehl KL. 2021. Student engagement declines in STEM undergraduates during COVID-19-driven remote learning. *J Microbiol Biol Educ* 22. <https://doi.org/10.1128/jmbe.v22i1.2385>.
2. Cromley J, Kunze A. 2021. Motivational resilience during COVID-19 across at-risk undergraduates. *J Microbiol Biol Educ* 22.
3. Brancaccio-Taras L, Mawn MV, Premo J, Ramachandran R. 2021. The editors' perspectives on adjusting STEM education to the "new normal" during the COVID-19 pandemic. *J Microbiol Biol Educ* 22. <https://doi.org/10.1128/jmbe.v22i1.2679>.
4. Johnson MDL, Baltrus DA, Gardy J. 2020. Crowdsourcing virtual summer research opportunities to support minorities in microbiology. *Nat Microbiol* 5:1311–1313. <https://doi.org/10.1038/s41564-020-00807-6>.
5. Johnson M, Baltrus D, Gardy J. 2020. National Summer Undergraduate Research Project. www.nsurp.org.
6. Bote J. 2020. "Get in good trouble, necessary trouble": Rep. John Lewis in his own words. *USA Today*. <https://www.usatoday.com/story/news/politics/2020/07/18/rep-john-lewis-most-memorable-quotes-get-good-trouble/5464148002/>.
7. Johnson MDL. 2020. mSphere highlights black in microbiology week. *mSphere* 5. <https://doi.org/10.1128/mSphere.00966-20>.
8. Kozik AJ. 2020. mSphere of influence: frameshift—a vision for human microbiome research. *mSphere* 5. <https://doi.org/10.1128/mSphere.00944-20>.
9. Taylor K. 2020. mSphere of influence: that's racist—COVID-19, biological determinism, and the limits of hypotheses. *mSphere* 5. <https://doi.org/10.1128/mSphere.00945-20>.

10. Anonymous. 2020. Nature microbiology after #ShutDownSTEM. *Nat Microbiol* 5:875. <https://doi.org/10.1038/s41564-020-0754-5>.
11. Engle J, Tinto V. 2008. Moving beyond access: college success for low-income, first generation students. Pell Institute for the Study of Opportunity in Higher Education. Retrieved from <http://www.eric.ed.gov/PDFS/ED504448.pdf>.
12. Cutrona CE, Cole V, Colangelo N, Assouline SG, Russell DW. 1994. Perceived parental social support and academic achievement: an attachment theory perspective. *J Pers Soc Psychol* 66:369–378. <https://doi.org/10.1037/0022-3514.66.2.369>.
13. Engle J, Bermeo A, O'Brien C. 2006. Straight from the source: what works for first-generation college students. Pell Institute for the Study of Opportunity in Higher Education. <https://files.eric.ed.gov/fulltext/ED501693.pdf>.
14. Ishitani TT. 2006. Studying attrition and degree completion behavior among first-generation college students in the United States. *The J Higher Education* 77:861–885. <https://doi.org/10.1353/jhe.2006.0042>.
15. Lopatto D. 2007. Undergraduate research experiences support science career decisions and active learning. *CBE Life Sci Educ* 6:297–306. <https://doi.org/10.1187/cbe.07-06-0039>.
16. Seymour E, Hunter A-B, Laursen SL, Deantoni T. 2004. Establishing the benefits of research experiences for undergraduates in the sciences: first findings from a three-year study. *Sci Ed* 88:493–534. <https://doi.org/10.1002/sce.10131>.
17. Russell SH, Hancock MP, McCullough J. 2007. THE PIPELINE: benefits of undergraduate research experiences. *Science* 316:548–549. <https://doi.org/10.1126/science.1140384>.