PURM
Perspectives on Undergraduate Research & Mentoring

Leveraging COVID-era Practices to Robustly Integrate Inclusivity, Access, and Equity into Summer Research Experiences for Undergraduates (REUs)

Kayla C. Kobak, Ph.D., Purdue University
G. Adam Reeves, Ph.D., Stanford University
Harojuanis T. Wade, Ph.D., Stanford University
Latishya Steele, Ph.D., Stanford University
Miranda St. Fleur, Ph.D., Stanford University (mirandas@stanford.edu)

Introduction

Research experiences for undergraduates (REUs) are commonly used in science, technology, engineering, and mathematics (STEM) fields to offer immersive exposure to a particular research discipline (Urias & Gallagher, 2012), generally occurring every summer at various institutions. For undergraduate students majoring in STEM, REUs are often the first foray into a scientist's daily work, expectations, and responsibilities. Additionally, STEM REUs are integral in building professional networks, demystifying applying to graduate programs, and offering clarity on earning a Ph.D. (Vargas et al., 2023).

Recently, a sense of belonging in STEM research environments has been emphasized due to its impact on academic performance, well-being, and connectedness for scientists, especially for scientists from systematically excluded, historically underrepresented, and/or minoritized social identity groups (Ruedas-Gracia et al., 2022). Belonging in this context goes beyond simple affirmations of being a scientist to encompass the integration of diverse identities so individuals can thrive authentically within STEM. It involves merging and celebrating intersectional social identities, where one's social identities are integrated alongside their scientific identity rather than ignoring them while furthering their scientific training (K. H. Collins, 2018). As the demographics of the STEM workforce and STEM trainees are becoming more diverse (National Center for Science and Engineering Statistics (NCSES), 2023), a sense of belonging in research environments can support the retention of underrepresented scientists in STEM fields when their social identities are valued alongside their scientific identity (Jackson & Tran, 2020). REUs are short-term experiences ranging from 8-10 weeks typically held during the summer, and students from social identities that are underrepresented and/or minoritized in STEM benefit from REUs since REUs can offer an opportunity for students to reinforce their identity as a scientist and cultivate a sense of belonging in STEM while demystifying the ways to navigate “hidden curriculums” that are often left undiscussed within academic institutions to build their academic literacy (Carlton, 2015; Gannon, 2023; Jack & Sathy, 2021; Peña et al., 2022; Vargas et al., 2023). Thus, centering the identities of STEM trainees and cultivating a strong sense of belonging in STEM fields during REUs is essential to creating more equitable and inclusive research environments.

Inequalities and inequities for students within academic institutions, such as housing and food insecurity, lack of technology access, and lack of mental and physical healthcare, have become

increasingly evident in the last few years due to the COVID-19 pandemic and increased awareness of social injustices and tragedies (Casey, 2020; J. Collins et al., 2022). In response to the COVID-19 pandemic and the inequalities and injustices it brought to light, many strategies were swiftly implemented to promote equity in academic environments (Parrington & Giardino, 2021; Pfund et al., 2021). As academic institutions navigate the post-COVID-19 pandemic era, we find accessibility practices developed during the pandemic can make traditional academic environments, including REU programs, more welcoming to students from historically excluded and/or minoritized social identity groups.

In this article, we spotlight how one STEM REU program, the Stanford Summer Research Program - Amgen Scholars Program (SSRP), harnessed core values like justice, equity, diversity, inclusion, social belonging, and wellness to evaluate its programmatic offerings throughout the COVID-19 pandemic. Drawing on over 30 years of program experience and undergraduate research mentoring best practices (Shanahan et al., 2015), we reflect on how the lessons learned during the pandemic can be implemented to promote more inclusive and equitable practices in mentoring and program design. To increase students' sense of belonging in STEM fields, we sought to: 1) intentionally enumerate the program's mission, 2) amend established learning goals to explicitly center growth, belonging, and preparation for graduate pathways, and 3) foster scholar success through focused programming, including backward-designed workshops, scaffolded skills training, and peer mentoring structures. The changes instituted due to the global COVID-19 pandemic and the insight gained in the areas above continue to drive programmatic innovation in remote, hybrid, and on-campus experiences, such as the adoption of backward-designed, competency-based programming and the intentional streamlining of program activities to prioritize scholar well-being and equitable access. Through this values-driven programmatic evaluation and restructuring, SSRP continues to create supportive environments where students can flourish and thrive (Jackson & Tran, 2020).

History of the Stanford Summer Research Program - Amgen Scholars Program (SSRP)

Beginning in 1993, the purpose of SSRP has been to expose highly talented, visiting undergraduates enrolled in four-year colleges and universities across the United States to graduate school experiences in the Stanford Biosciences Ph.D. programs, especially students from historically excluded and/or minoritized social identity groups. Each year, the nine-week program has hosted up to 30 SSRP student participants, known as "scholars," who receive hands-on research mentoring by Stanford Biosciences scientists (i.e., faculty, graduate students, postdoctoral scholars, and/or research staff) on challenging research projects involving various scientific techniques. Additionally, scholars receive weekly peer-to-peer support from one another and near-peer mentoring from current Biosciences Ph.D. students, referred to as Program Leaders, who build scholars' sense of belonging outside their immediate research laboratory in small-group mentoring clusters of up to 4 scholars per Program Leader (Barman, 2024; Rayford et al., 2022). Scholars also participate in professional development workshops led by Program Leaders, craft graduate application materials, and present their research findings at an annual end-of-program symposium with an oral presentation and poster presentation. These best practices have helped reinforce and sustain successful undergraduate research mentoring experiences (Shanahan et al., 2015; Goodman, 2025) while providing a robust network to support the scholar throughout their experience (Vargas et al., 2023).

Funding sources have varied throughout SSRP's history, impacting the final cohort size. In 2007, SSRP became an affiliated Amgen Scholars Program site during the first year of the Amgen Scholars Program (Amgen Foundation, 2007). Additionally, SSRP receives support from the Stanford Biosciences Office of Graduate Education (Stanford Biosciences Office of Graduate Education, n.d.-c) and collaborates with the Stanford Genetics Department's Genomics Diversity Summer Program (GDSP) (Stanford Medicine Department of Genetics, n.d.). These unique funding models and

collaborations have allowed the program to broaden the scholar pool, including offering research opportunities to DACA-eligible undocumented students (Stanford Biosciences Office of Graduate Education, n.d.-a; U.S. Citizenship and Immigration Services, 2022). Throughout the upheaval of the COVID-19 pandemic, SSRP continued its commitment to increasing visibility and representation in the biosciences by transitioning to a remote research program. We aim to utilize the lessons from that experience to make the program even more robustly equitable in the future.

From Crisis to Opportunity: Advancements in Programming from Our COVID-19 Response

While uncertainty was rife throughout 2020 due to the COVID-19 pandemic, we harnessed our knowledge of working with underrepresented and minoritized students to reduce foreseeable challenges when shifting from an in-person to a remote REU program. Recognizing the various socioeconomic statuses and living conditions of SSRP scholars, we proactively worked to provide equitable access to the remote REU program. We creatively and proactively offered solutions to address technology-related needs, such as providing high-speed internet access, webcams, headsets with microphones, and, in rare circumstances, laptops. By ensuring scholars had the necessary tools, we aimed to ensure they would fully engage in the remote research experience.

Furthermore, we recognized that transitioning to a remote REU program would significantly impact the mentoring experience. Before 2020, SSRP research projects primarily involved experimental biology-based, "wet-lab," or fieldwork-based projects. This model allowed for direct and ongoing one-on-one mentoring experiences between scholars and their research mentors while offering exposure to the daily responsibilities of STEM Ph.D. students. When previously offered to scholars, computational research projects were limited to students with prior coding experience. This posed a barrier to entry for scholars without computational research or coding skills; however, it also eased the burden on research mentors to teach their scholars basic coding and computational research concepts. Therefore, the shift to a remote setting posed complex challenges to scholars and mentors. To maintain the quality of mentoring we aim to offer our scholars, we implemented a week-long coding course at the beginning of the program to provide scholars without coding experience the entry skills necessary for their computational research projects while reducing some of the research-related challenges placed on lab mentors.

To support our scholars in acquiring proficiency in computational research while mitigating imposter syndrome, we developed a five-day data learning lab series adapted from Software Carpentry curricula (Software Carpentry, n.d.). To execute this learning lab series, Ph.D. students, postdoctoral fellows, and staff were recruited initially as volunteer instructors based on their experiences and expertise in designing computational courses for a diverse set of learners. Our team of instructors collaboratively designed a robust curriculum that provided instruction on fundamental and intermediate concepts, such as using version control with Git and an introduction to Python or R computer programming languages. Scholars learned Python or R, computer programming languages, based on which language would be primarily used in their research project.

Working directly with the program director and faculty advisors, the instructor team designed a successful curriculum that upskilled scholars so they could apply these newly learned skills immediately to their research projects while remaining aligned to program values. For example, to practice continuous feedback and cultivate students' growth, lessons were adjusted in real time based on scholars' self-reported computational experience levels, ensuring that all scholars could develop skills appropriate to their experience levels. Unlike pre-COVID iterations of the program, in which research training was largely project-specific and conducted in stable, in-person laboratory settings, the remote format introduced in 2020 required scholars to rapidly acquire and apply new computational skills, a novel challenge given that scholars entered the program with varying levels of prior computational research experience. Scholars were also required to adapt to evolving research

expectations as the university changed research requirements daily to maintain compliance with pandemic-related recommendations, which created inconsistencies in their lab mentor's availability. Lastly, scholars, lab mentors, and program staff were also learning in real time how to navigate additional uncertainties inherent to remote scientific collaboration at a time when few successful examples existed. By prioritizing skills development and scientific inquiry while also navigating daily uncertainties, SSRP helped scholars develop the resilience and adaptability to thrive in the rapidly changing world of scientific research. Recognizing how integral the data learning lab instructor team was for the program's success, the instructor team was compensated for their invaluable efforts. Scholar participants were also compensated for their participation, as the week-long series was integrated into the formal programming.

Due to the success of the remote five-day data learning lab series in 2020, the learning lab curriculum was revised and executed in the 2021 remote program with new and returning instructors. To extend access and opportunity to visiting scholars in other research programs, SSRP also partnered with the Stanford Summer Community College Premedical Program (SSCCPP) to offer this week-long series to both SSRP and SSCCPP scholars. Since returning to an in-person REU, the data learning lab series has been transformed into a weekly Computer Science (CS) Basic Skills Workshop to address the growing significance of data and computational research in biological studies. Prospective students are also assessed on their computational proficiencies to better inform matching to research projects. These practices have thus expanded the research project offerings to allow computational research projects to become accessible to those who have little to no prior computational research experience.

While needs around computational research skills and training scholars were anticipated and handled proactively, we also needed to act reflexively to adapt to ever-changing circumstances. We aimed to maintain program integrity throughout any adaptations, necessitating that we first enumerate the program's mission and values to ensure all changes occurred intentionally, keeping our goals in mind. We then evaluated program components to ensure crucial offerings' retention and efficacy. We found many opportunities to improve future program offerings by altering the program's structure, delivery, and support services to build robust and equitable remote program experiences in 2020 and 2021. In the following sections, we will discuss these changes in detail and share our insights and learnings from experience, which have informed our reimagined in-person offering.

Enumerate the Program's Mission and Values

When it became evident that the COVID-19 pandemic would require implementing a remote summer program—and that we would need to complete the reformatting with only 10 weeks until the program start date in 2020—we, as program staff, first turned to our program's values and mission to guide us throughout the program restructuring process. SSRP is dedicated to increasing visibility and representation in the biosciences by actively recruiting scholars from communities that have been excluded and/or underrepresented in STEM and higher education broadly (National Institutes of Health, 2019). As a program sponsored by the Stanford Biosciences Office of Graduate Education, SSRP is committed to "fostering a diverse community in which all individuals are welcomed, respected, and supported to achieve their full potential." This commitment is rooted in the understanding that a "highly qualified and diverse [community] —in gender, race, ethnicity, culture and beliefs, socioeconomic background, physical ability, sexual orientation, and work-life experiences—is essential to a rich educational process" (Stanford Biosciences Office of Graduate Education, n.d.-b).

In line with these values, SSRP also aims to provide research opportunities to scholars who may not traditionally have access to such experiences. We prioritize justice, equity, diversity, and inclusion (JEDI) by developing the potential of talented undergraduate scientists while allowing them to

embrace all of their identities in STEM environments. To achieve this, we offer a robust research experience, prepare scholars for graduate admissions, and foster meaningful professional and personal connections. As part of our commitment to inclusivity, we employ a holistic application evaluation process that goes beyond relying solely on merit-based criteria, including an assessment of applicants' upward potential—defined as evidence of motivation, perseverance, and intellectual curiosity demonstrated within the context of available opportunities. For example, applicants may come from institutions with limited access to research infrastructure or formal research training but show strong initiative through pursuing independent projects, engaging in nontraditional or community-based research experiences, seeking mentorship outside their home institutions, or articulating clear research interests despite structural constraints (Gottelieb et al., 2025; National Academies of Sciences, Engineering, and Medicine, 2023). This approach recognizes that undergraduate students from underrepresented groups often face additional barriers in obtaining and accessing educational opportunities while understanding biases that exist in academic systems.

By centering our program's mission and values, we ensured that any changes and adaptations made during the transition to a remote format remained aligned with the core principles of SSRP. These principles have guided our decision-making process, enabling us to maintain programmatic quality and uphold our commitment to promoting JEDI and belonging in STEM education.

Fostering Scholar Success Through Focused Programming

For over 30 years, SSRP has undergone multiple iterations and evolutions to adapt to changing times and the needs of its diverse scholar cohorts. While the program's goals and mission had previously been an implicit part of executing the program, we adopted a backward design approach informed by our explicit statements of values and goals to implement a social justice pedagogy (Bowen, 2017; Taylor et al., 2019). In this context, social justice pedagogy refers to intentionally designing program goals, learning outcomes, and assessments to center equity, access, belonging, and students' lived experiences, rather than assuming a one-size-fits-all model of preparation or success. Using backward design, we aligned programmatic elements with these values to ensure that learning objectives, mentoring structures, and assessments supported scholars from diverse backgrounds in developing scientific skills, professional readiness, and a sense of belonging in STEM. We then examined what programmatic elements would be retained for the remote REU and which would be exclusively offered in person (Table 1). By first investigating program elements with a backward design framework, we identified three key program objectives that promoted student development and belonging in STEM:

- *Experience* (i.e., facilitating growth in research),
- *Preparation* (i.e., preparing students for graduate admissions), and
- *Connections* (i.e., building professional and personal connections).

To operationalize the objectives above, we created nine core competencies organized into these three dimensions (Table 2) that we believe are important for STEM trainees (Association of American Medical Colleges, n.d.; National Postdoctoral Association, n.d.; Office of the Vice Provost for Graduate Education, n.d.; Verderame et al., 2018). Each competency is associated with specific assessments to support the scholars in acquiring the desired skills. For example, the *Experience* dimension focuses on facilitating growth in research framed around a hypothesis-driven question and effective communication of a research project, which is evaluated during the final program symposium by volunteer Biosciences scientists who serve as symposium judges. The *Preparation* dimension demystifies the graduate admissions process and prepares scholars for competitive Biosciences Ph.D., MD/Ph.D., or post-baccalaureate research programs. It is offered through workshops, coaching, and feedback on application materials. The *Connections* dimension develops networks and

fosters a sense of belonging in STEM through community forums, social events, and workshops on social justice and well-being. It is assessed through surveys of scholars' sense of belonging (Table 2).

Table 1. *Examination of SSRP program elements with adaptations and changes based on program experience.*

Program element	**Offered in-person only, remote only, or both**	**Explanation of program element, including notable changes**
Research project with intentional lab matching	Both	Computational research projects were exclusively offered in 2020 and 2021.
Social outings and field trips	Both	Social events were offered virtually in 2020 and 2021.
Housing and meal plans	Both	Meal gift cards were offered in 2020 and replaced with a meal stipend in 2021. Housing support was offered in 2021 on a case-by-case basis.
Transportation resources - airfare, bicycles, car shuttles and/or parking permits	In-person only	Funds for transportation were discontinued in 2020 and 2021, though offered in past in-person experiences.
Research trainings - data workshop course	Both	Though offered exclusively in the remote programs during 2020 and 2021, the data workshop course may be offered in future in-person experiences.
Additional research trainings (e.g., animal handling courses, biosafety lab trainings, etc.)	In-person	N/A
Programmatic support resources (e.g., laptops, other tech equipment, etc.)	Both	Programmatic support resources were offered to scholars on a case-by-case basis, such as loaner technology equipment. In rare cases, emergency funds to help alleviate the financial burdens of purchasing additional equipment were offered.
Professional development workshops	Both	Workshops are led by peer mentors, Biosciences Ph.D. students known as Program Leaders, along with staff, and Biosciences research community members.
Small group meetings	Both	Small group meetings are offered between 3-4 scholars matched with one peer mentor, a Biosciences Ph.D. student (i.e., Program Leader).
Networking with Biosciences community	Both	Networking events were led by peer mentors, Biosciences Ph.D. students known as Program Leaders. Additional community members, such as faculty, staff, and postdoctoral scholars attend.
Symposium	Both	Scholars demonstrate their scientific growth and development by presenting their research findings to an audience including Biosciences community members (research mentors, faculty, postdoctoral scholars, PhD students). Volunteer Biosciences symposium judges critique scholar presentations, offer feedback, and vote on the best presentations.

Implementing a backward design approach allowed us to focus synchronous program time on activities in these areas and reduce redundant and superfluous programming. For the remote REU, we reduced the required meeting hours by half compared to previous in-person experiences. While in person, scholars and staff met for approximately 10 hours per week in workshops, courses, program events, and the required research hours. However, the high quantity of program commitments negatively impacted the quality of content provided. Being mindful of perpetuating "Zoom fatigue" and burnout (Bailenson, 2021), we reduced required meeting hours to approximately 4 hours per week so that scholars could balance program requirements while dedicating up to 30 hours per week to their research projects. This adjustment allowed us to maintain high-quality program content while prioritizing the well-being of scholars, program staff, and research mentors. Adopting a backward design approach enabled us to refine program content and prioritize the delivery of core

Table 2. *Dimensions of SSRP program offerings. Each dimension is written with a clear objective and competencies mapped to program elements*.

Dimension	Objective	Competencies	Example(s) from program elements
Experience	Facilitate growth in scientific research	Research Project	Lab Placement; Ongoing Lab Work
		Scientific Presentation	Final research symposium, including practice and iterative slide development during small group meetings with program leaders
		Computational Expertise	Data learning lab series; Ongoing research and data analysis
Preparation	Prepare students for graduate admissions, emphasizing Ph.D. admissions processes	Ph.D. Application	Reviewing, coaching, and refining of application materials (e.g., CV, personal statements, diversity statements, seeking letters of recommendations, etc.)
		Ph.D. Interview	Networking opportunities with current faculty; Mock Interviews and Elevator Pitch practice with program staff
		Transition into Ph.D. Programs	Workshops on topics to demystify the Ph.D. experience, such as how to apply for Ph.D. programs, rotations, networking, funding, career explorations, opportunities, etc.
Connections	Build professional and personal connections	Casual Communication	Utilize technological communication tools (e.g., Slack, Zoom, GatherTown) for impromptu and formal connections; Schedule office hours with program staff
		Structured Social Events	Game nights, movie nights, and socials with other university programs and external summer programs
		Current issues forums rooted in Restorative Justice practices	Community circle discussions on current social issues and their personal impacts, such as impacts of the COVID-19 pandemic, George Floyd's murder, to collectively process grief, identify hope, and practice care in STEM

competencies that align with the program's mission and values. The refined program content proved effective in a remote format and ensures students are well-rested in an in-person format, allowing us to center their needs and well-being and create a learning environment where scholars can thrive.

Recognize How Your Students' Identities Impact Them in Academic Environments

One of the unintended consequences of shifting to remote programming during the pandemic was that the virtual format exposed certain aspects of students' lives that may not have been regularly displayed to colleagues and classmates in traditional academic settings, such as living situations or socioeconomic status. However, virtual meetings in students' homes blurred the boundaries between personal and professional lives (Casey, 2020). Thus, it became abundantly clear that students' cultural backgrounds, socioeconomic status, and personal experiences are integral to their success in SSRP. These blurred professional and personal boundaries were also experienced by others involved in supportive roles for SSRP scholars, such as faculty, research mentors, and program staff, resulting in a need to explore creative, intentional solutions to address student needs in an equitable and accessible manner. For example, to address needs, incoming scholars received a pre-program assessment that asked scholars what programmatic support resources they needed for a successful research experience (e.g., access to technology like laptops, webcams, or headphones, a quiet, comfortable working space, etc.). The program staff then followed up with scholars individually to provide accommodations on a case-by-case basis, such as loaner technology equipment, and in rare cases, emergency funds to help alleviate the financial burdens of renting a quiet workspace.

Graduate student program leaders were also coached through culturally aware mentoring practices on how to lead effective remote check-ins with their scholars (Byars-Winston et al., 2018; Womack et al., 2020). From their lessons learned, program leaders guided faculty and research mentors when they struggled to connect with their scholars virtually. Because graduate student program leaders connected with scholars weekly or multiple times per week, they often served as 'first responders', learning about students' concerns, unforeseen needs that unintentionally caused inequities in their remote research experience, or changes to their well-being before program staff and research mentors. For example, scholars could discuss with program leaders if they were experiencing challenges managing research expectations with home responsibilities and how to communicate adjusting their work responsibilities with their research mentors. Since addressing needs can be challenging when students are remote, the program director and other staff built additional communication channels with program leaders so they could effectively elevate their concerns for students in crises. As demonstrated above, we continue to strive to provide support and resources that address the holistic needs of our students, along with SSRP program leaders, faculty, and research mentors, by taking a human-centered approach to acknowledge the whole person while implementing the program structure and redesign (Goodman, 2025).

We believe that acknowledging the whole person is critical to promoting success and retention. Some methods of creating an inclusive environment include openly discussing impostor syndrome and offering holistic mentoring (Peña et al., 2022). We recognize the pervasive impact of imposter syndrome on students from marginalized backgrounds, and we aim to address this issue by openly discussing it in our programming. To address concerns, we offered space for scholars to share their experiences and feelings, and we worked with them to develop strategies to manage their feelings of self-doubt and anxiety.

We also held community gatherings and discussions adapted from restorative justice practices (Office of Student Conflict Resolution, n.d.; Pointer, 2020; The Office of Ethical Development and Restorative Practices, n.d.; University of Michigan - Student Resolution Resources) to center students' needs and well-being, especially when social injustices and tragedies impacted students'

well-being and program engagement. In these community gatherings, we responded to timely current events by hosting one-hour restorative justice-based community circles for scholars and program leaders. These optional participation circles were held at least twice during the remote program as another opportunity to check in holistically on scholars and program leaders. Our process included a planning meeting among program staff to determine emerging needs from scholars and to prepare thoughtful reflection questions, including an open-ended check-in question (Schoolcraft, 2026) and opportunities to engage in collective care ("Facilitator Inquiry: Holding a Healing-Centered Circle"; "Resources - Restorative Justice"). To engage in the circle practice, the facilitator, often the program director, shared why it felt timely to gather and established community norms and guidelines for the conversation (e.g., one person speaking at a time) that all agreed to uphold during the circle. All were invited to share a verbal response to a circle question; however, it was not required of everyone before moving to the next question. We then transitioned to the circle practice, beginning first with a check-in question, followed by additional open-ended questions to process feelings and reactions to current events. The facilitator often shared first to help relieve tension and offer circle participants time to process their thoughts before sharing. Lastly, we often ended the circle with a contemplative practice (e.g., playing music, taking deep breaths together) and a closing question before transitioning back to research. Though these sessions were usually planned for 60 to 75 minutes, we often scheduled the sessions on calendars for 90 minutes, so that participants could engage in self-care practices before returning to research.

When offering SSRP remotely, we utilized technological tools to allow scholars and staff to retain agency and practice boundaries in what they chose to share about themselves through various tech-based engagement methods (Tanner, 2013). Scholars were encouraged to respond to prompts verbally, by writing responses in chats, or by using polls. To proactively engage scholars, we redesigned workshops to offer scholars different ways to respond to questions raised, such as using Zoom reaction emojis, virtual hand raises, anonymous screen annotation, and virtual bulletin boards like Padlet and Google Jamboard (Google, n.d.; Padlet, n.d.). One essential function that improved virtual engagement was assigning small groups to breakout rooms to replicate think-pair-share virtually (Cooper et al., 2021). Scholars were also provided clear instructions on content to cover when digital resources like Google Docs were utilized to include guided questions. When available, each breakout group contained a graduate student Program Leader to help facilitate conversations.

When Navigating Uncertainty, Redefine Student Success to Encourage Growth

SSRP has long emphasized holistic mentoring and an immersive research experience since its inception in 1993. Understanding that holistic mentoring involves shifting scholar and mentor mindsets through open communication, we aim to foster a growth mindset in our students as a critical part of supporting scholars in the academy (Posselt, 2018). To encourage a growth mindset, we work with scholars and mentors to establish community norms and guidelines emphasizing learning from failure. Additionally, we encourage scholars to adopt a growth mindset by identifying core research goals, aligning expectations, and embracing the process of scientific inquiry (Dweck, 2016; Pfund et al., 2021; Street, 2015; Vargas et al., 2023). In this way, we redefine success to not solely focus on prolific data output but rather on acquiring new knowledge, cultivating potential, building skills, and becoming familiar with difficulties in research to normalize struggle (Posselt, 2018). Holistic mentoring has always been a significant component of in-person programming and has served an equally important purpose in remote programming.

To foster a growth mindset, mentors must empathize with scholars' challenges and adjust their expectations accordingly (Estefan, 2021). Mentors expressing empathy and adjusting expectations are critical when scholars encounter new and difficult problems, especially when scholars conduct new research projects for the first time. We work with scholars and lab mentors to construct dynamic research goals and expectations to challenge scholars while reinforcing their existing skills.

In the case of remote programming, we used this approach to support scholars with little to no prior computational research experience to learn coding languages and other skills that are increasingly important in the biosciences (Rodríguez-Becerra & Pernaa, 2023). By embracing these opportunities for skill-building and scientific development, we helped scholars gain competence and confidence in navigating computational research projects. Our remote program offered an excellent opportunity for undergraduate students to expand their computational skill sets and grow outside of the traditional comfort zone of many undergraduate biological research experiences while working toward improving equity in STEM education (National Science Foundation, 2021).

It is important to note that the environments in classrooms and jobs that commonly impart these skills are often dominated by white individuals and males, creating an atmosphere where women and people of color may feel like outsiders. In such cases, the feelings of being an outsider are not solely attributable to "impostor syndrome" but rather arise due to the structure of the environment itself (Clance & Imes, 1978; Love, 2019; McGee et al., 2022; Tulshyan & Burey, 2021). This understanding highlights the need for systemic changes to address these issues and create inclusive spaces where individuals from all backgrounds can thrive and contribute to the scientific community.

Foster Community Within the Cohort

Community building has always been an integral part of SSRP. Some potential losses when moving to a remote format are the development of this robust community and networking opportunities. Community building can occur in multiple ways: scholar-to-scholar bonding opportunities, educational opportunities such as journal clubs, casual connections with program staff or lab mates, and formalized connections like scholar-mentor or scholar-faculty meetings. To ensure these opportunities were still available remotely, we offered a tiered approach to strengthen and build remote communities: 1) whole group engagement through workshops and social events, 2) weekly small group check-ins, and 3) one-on-one meetings.

Social events were engineered to allow for various levels of engagement, fostering the formation of both 1-on-1 and group connections. We hosted casual, impromptu virtual hangouts and structured social activities like virtual game nights and movie watch parties with conversation starter activities. Different activities allowed for passive or active involvement depending on the scholar's interest and energy levels. We frequently extended invitations to other university community members who would interact with in-person cohorts so scholars could build their networks broadly. Remaining mindful of scholars' emotional well-being, we also created opportunities to meet and reflect on current issues in the wake of several national and global movements. Community circles were held on topics to discuss social issues and their impacts on scholars and program leaders, such as holding space to reflect on COVID-19's effects on well-being and a gathering to discuss the personal impacts of George Floyd's murder. These opportunities to collectively process grief and identify hope as a form of community care allowed us to deepen connections and build trust amongst scholars and program staff. These responsive events to social issues offered the opportunity to nurture both scholars and program leaders holistically, emphasizing that they are more than just scientists, and that their other identities are also integral to the science they study. While we have always viewed community building as an imperative to fostering belonging in our students, these gatherings were seen evermore clearly during remote programming as students lost the support of other communities they normally had behind them.

Conclusion

As we move forward in a post-pandemic world, offering opportunities for research experiences, skills enhancement, and connection building remains crucial to preparing undergraduates for STEM Ph.D. programs. Following our programmatic rebuild during the COVID-19 pandemic, we found that best

practices in creating an accessible and equitable space remotely were also effective when reimagining in-person offerings. By relying on the program's mission and values and using backward design to create program outcomes, we were able to streamline programming. In tandem, we also focused on students' identities and needs to re-define success. We emphasized community to create more inclusive and equitable spaces, regardless of remote, in-person, or hybrid research experiences.

These intentional programmatic changes resulted in 95% of scholars self-reporting that the remote research experience met and/or exceeded their expectations in 2020 and 2021, which mirrored the in-person experiences prior to 2020. We also found that the remote programs had positive impacts on future career trajectories. In an end-of-program exit survey, 90% of scholars in 2020 and 100% of scholars in 2021 self-reported that they somewhat agreed and/or strongly agreed that they felt confident in applying to Ph.D. or M.D./Ph.D. programs of their choice after participating in the remote program. Lab mentors were also pleased with their remote research mentoring experiences, where 86% of lab mentors in 2020 and 83% of lab mentors in 2021 self-reported that they were somewhat satisfied and/or extremely satisfied with their remote mentoring experience.

Applying these best practices to the Stanford Summer Research Program - Amgen Scholars Program (SSRP), we facilitated scholars' growth in computational research, prepared them for graduate admissions, and connected them with other scientists through community-building activities. We offer our guide as a method for rigorously yet equitably continuing research opportunities, highlighting the importance of empathy and growth mindsets in creating an inclusive environment for participants and program staff. Our thoughtful approach to intentional programmatic redesign enabled us to effectively transition back to in-person experiences beginning in 2022. For example, we retained programmatic changes, such as assessing applicants' and incoming scholars' computational skills and proficiencies. We have also transformed the data learning lab series into a weekly Computer Science (CS) Basic Skills Workshop. Upon returning to in-person experiences in 2022, 94% of scholars reported that the in-person research experience met and/or exceeded their expectations.

The programmatic changes made during the remote research experiences drew upon existing best practices for undergraduate research mentoring, such as one-on-one, hands-on mentoring, fostering community between undergraduate researchers and near-peer mentors, and enhancing undergraduate researchers' scientific communication skills through presenting their research findings at the end of the program, (Shanahan et al., 2015) and allowed us to reimagine these practices to meet a critical moment by offering a fully remote experience. Since transitioning back to in-person experiences, we continue to take the lessons learned from remote programming and practice continuous iteration to further enhance successful undergraduate research mentoring experiences. For example, since 2023, the length of the summer research program and the total number of scholars per year have changed. The program is now eight weeks, from June to August, to accommodate academic schedules at scholars' home institutions. The number of participants has been reduced to an average of 16 scholars per cohort due to changes in funding sources critical to supporting scholars' participation. While the cohort has been reduced by almost half, the smaller cohort has enabled more hands-on mentoring experiences in research environments and opportunities to deepen one-on-one relationships between scholars and near-peer mentors. In 2025, an additional community-building and engagement layer was added that focused on exploration and practice in conflict prevention, collaborative resolution tools, skills, and frameworks within team dynamics to maximize success. This expands upon the restorative justice-based practices offered during the remote experience while offering collaborative solutions and helping clarify expectations.

Our commitment to acknowledging and honoring students' social identities through how they express themselves is a cornerstone of our community. Since returning in-person, we have continued to grow community and a sense of belonging amongst scholars by fostering near-peer mentoring experiences and connections to the Stanford community within research settings and beyond. For example, since 2023, we have introduced a Summer Resident Assistant (SRA) as part of the on-campus housing experience. The goal for the SRA of SSRP reflected the need to fully connect the visiting undergraduate research scholars to the Stanford community. To further enhance a sense of belonging and connections, SSRP has implemented an additional peer mentoring experience with the ADVANCE Summer Institute, an intensive summer program for incoming and matriculated Biosciences Ph.D. graduate students. The goal of the SSRP-ADVANCE peer mentoring experience is to foster connections with other like-minded scientists who recently went through the Ph.D. admissions process, in hopes that both visiting undergraduate scholars in SSRP will retain connections with Stanford beyond their research experience. As we continue to innovate and tailor summer research programs to serve diverse cohorts of students, we hope our work provides a foundational structure that others can follow. Using a learning-centered approach to design program goals that holistically address students' development of scientific identity, an REU-style program can improve student outcomes and emphasize gained experience, materials preparation, and community/network building. While our detailed model may not be a perfect fit for all programs, the driving principles remain a universal resource applicable to all.

Acknowledgments

Thank you to all the collaborators, mentors, and students who have helped make this publication a reality. Our sincerest gratitude to Dr. Terrance Mayes, Dr. Ayodele Thomas, Samar Fahmy, Dr. Bryan Thomas, Jr., Dr. Judith Ned, Dr. Jennifer R. Cohen, Dr. Amber Moore, Dr. James Harden, Dr. Oscar Diaz, Maria Manzanares Vargas, Dr. D'Anne Duncan, Joel Dalton, Dr. Pamela Gaddi, Dr. KC Huang, Shelly Rasnick, Anika Green, Monica Devlin, Dr. Ami Bhatt, and Dr. Miriam Goodman. We especially would like to thank our thought partners and collaborators from the Stanford Summer Research Program—Amgen Scholars Program, including Amgen Program Directors and Global Program Office staff.

To our SSRP program alums and former program leaders, you are the heart and driving force behind our work, including this paper. Continue to shine your light brightly, lead fiercely, and find your hype crew!

References

Amgen Foundation. (2007). Amgen Foundation and Leading Universities Invite College Students to Apply for Amgen Scholars Program [Press Release]. Amgen. https://www.amgen.com/newsroom/press-releases/2007/12/amgen-foundation-and-leading-universities-invite-college-students-to-apply-for-amgen-scholars-program

Association of American Medical Colleges. (n.d.). Core Competencies for Entering Medical Students. AAMC. Retrieved May 22, 2023, from https://www.aamc.org/services/admissions-lifecycle/competencies-entering-medical-students

Bailenson, J. N. (2021). Nonverbal Overload: A Theoretical Argument for the Causes of Zoom Fatigue. Technology, Mind, and Behavior, 2(1). https://doi.org/10.1037/tmb0000030

Barman, A. (2024). A Novel Near-Peer Mentoring Model Involving Doctoral Students in an Interdisciplinary Client-Facing Project-Based Learning Course. 2024 IEEE Frontiers in Education Conference (FIE), 1-9. https://doi.org/10.1109/FIE61694.2024.10893381

Bowen, R. S. (2017). Understanding by Design. Vanderbilt University Center for Teaching. https://cft.vanderbilt.edu/guides-sub-pages/understanding-by-design/

Byars-Winston, A., Womack, V. Y., Butz, A. R., McGee, R., Quinn, S. C., Utzerath, E., … Thomas, S. B. (2018). Pilot study of an intervention to increase cultural awareness in research mentoring: Implications for diversifying the scientific workforce. Journal of Clinical and Translational Science, 2(2), 86–94. https://doi:10.1017/cts.2018.25

Carlton, M. T. (2015). First Generation Students and Post-Undergraduate Aspirations. SAGE Open, 5(4). https://doi.org/10.1177/2158244015618433

Casey, N. (2020, April 4). College Made Them Feel Equal. The Virus Exposed How Unequal Their Lives Are. The New York Times. https://www.nytimes.com/2020/04/04/us/politics/coronavirus-zoom-college-classes.html

Clance, P. R., & Imes, S. A. (1978). The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. Psychotherapy: Theory, Research & Practice, 15, 241–247. https://doi.org/10.1037/h0086006

Collins, J., Polen, A., Jernigan, I., Colón-Burgos, D., McSweeney, K., & Spandri, M. (2022). An Analysis of Virtual Research Experiences for Undergraduates Programs in Light of the COVID-19 Pandemic. Bulletin of the American Meteorological Society, 103(3). https://journals.ametsoc.org/view/journals/bams/103/3/BAMS-D-20-0231.1.xml

Collins, K. H. (2018). Confronting Color-Blind STEM Talent Development: Toward a Contextual Model for Black Student STEM Identity. Journal of Advanced Academics, 29(2), 143–168. https://doi.org/10.1177/1932202X18757958

Cooper, K. M., Schinske, J. N., & Tanner, K. D. (2021). Reconsidering the Share of a Think–Pair–Share: Emerging Limitations, Alternatives, and Opportunities for Research. CBE—Life Sciences Education, 20(1). https://doi.org/10.1187/cbe.20-08-0200

Dweck, C. (2016, January 13). What Having a “Growth Mindset” Actually Means. Harvard Business Review. https://hbr.org/2016/01/what-having-a-growth-mindset-actually-means

Estefan, M. (2021). Show Them You Care. Inside Higher Ed. https://www.insidehighered.com/advice/2021/02/03/four-ways-help-build-supportive-person-or-online-classrooms-generate-equity-among

Gannon, K. (2023, May 22). Why Calls for a ‘Return to Rigor’ Are Wrong. The Chronicle of Higher Education. https://www.chronicle.com/article/why-calls-for-a-return-to-rigor-are-wrong

Goodman, Miriam B. “Ten Simple Rules for Maximizing Summer Research Experiences for Students, Mentors, and Research Groups.” PLOS Computational Biology 21, no. 11 (2025): 1–7. https://doi.org/10.1371/journal.pcbi.1013731

Google. (n.d.). Google Jamboard: Whiteboard App for Business. Google Workspace. Retrieved May 25, 2023, from https://workspace.google.com/products/jamboard/

Gottlieb, M., Davenport, D., Landry, A., Bailey, J., Westrick, J., & Daniel, M. (2025). Holistic Review in Applicant Selection: A Scoping Review. Academic Medicine: Journal of the Association of American Medical Colleges, 100(2), 219–228. https://doi.org/10.1097/ACM.0000000000005891

Jack, J., & Sathy, V. (2021, September 24). It’s Time to Cancel the Word ‘Rigor.’ The Chronicle of Higher Education. https://www.chronicle.com/article/its-time-to-cancel-the-word-rigor

Jackson, M., & Tran, N. (2020, November 5). Thriving Because Of, Not Despite, Their Identity. Inside Higher Ed. https://www.insidehighered.com/views/2020/11/06/first-generation-students-often-view-their-identities-source-influence-and-power

Love, B. L. (2019, February 13). “Grit Is in Our DNA”: Why Teaching Grit Is Inherently Anti-Black. Education Week. https://www.edweek.org/leadership/opinion-grit-is-in-our-dna-why-teaching-grit-is-inherently-anti-black/2019/02

McGee, E. O., Botchway, P. K., Naphan-Kingery, D. E., Brockman, A. J., Houston, S., & White, D. T. (2022). Racism camouflaged as impostorism and the impact on Black STEM doctoral students. Race Ethnicity and Education, 25(4), 487–507. https://doi.org/10.1080/13613324.2021.1924137

National Academies of Sciences, Engineering, and Medicine. (2023). Research on admissions. In Sharing exemplary admissions practices that promote diversity in engineering: Proceedings of a workshop (pp. 33–42). The National Academies Press. https://doi.org/10.17226/27278

National Center for Science and Engineering Statistics (NCSES). (2023). Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023 (Special Report No. 23–315). National Science Foundation. https://ncses.nsf.gov/pubs/nsf23315/report

National Institutes of Health. (2019). Notice of NIH’s Interest in Diversity (NOT-OD-20-031). National Institutes of Health. https://grants.nih.gov/grants/guide/notice-files/NOT-OD-20-031.html

National Postdoctoral Association. (n.d.). NPA Core Competencies. National Postdoctoral Association. Retrieved May 22, 2023, from https://www.nationalpostdoc.org/page/CoreCompetencies

National Science Foundation. (2021, July 29). NSF partnerships expand National AI Research Institutes to 40 states. NSF - National Science Foundation. https://new.nsf.gov/news/nsf-partnerships-expand-national-ai-research

Office of Student Conflict Resolution. (n.d.). Restorative Justice Circles. University of Michigan. Retrieved May 25, 2023, from https://oscr.umich.edu/article/restorative-justice-circles

Office of the Vice Provost for Graduate Education. (n.d.). The Six Professional Competencies | Office of the Vice Provost for Graduate Education. Stanford University Office of the Vice Provost for Graduate Education. Retrieved May 25, 2023, from https://vpge.stanford.edu/professional-development/competencies-grad-grow

Padlet. (n.d.). Padlet: Beauty will save the work. Padlet. Retrieved May 22, 2023, from https://padlet.com/

Parrington, B. A., & Giardino, W. J. (2021). Zooming into the Lab: Perspectives on Maintaining Undergraduate Biological Research through Computationally Adapted Remote Learning in Times of Crisis. Journal of Microbiology & Biology Education, 22(1). https://doi.org/10.1128/jmbe.v22i1.2563

Peña, C., Ruedas-Gracia, N., Cohen, J. R., Tran, N., & Stratton, M. B. (2022). Ten simple rules for successfully supporting first-generation/low-income (FLI) students in STEM. PLOS Computational Biology, 18(10), e1010499. https://doi.org/10.1371/journal.pcbi.1010499

Pfund, C., Branchaw, J. L., McDaniels, M., Byars-Winston, A., Lee, S. P., & Birren, B. (2021). Reassess–Realign–Reimagine: A Guide for Mentors Pivoting to Remote Research Mentoring. CBE—Life Sciences Education, 20(1), es2. https://doi.org/10.1187/cbe.20-07-0147

Pointer, L. (2020, May 28). Restorative Circles: A Powerful Tool for Community Healing—The Blue Review. Boise State University. https://www.boisestate.edu/bluereview/restorative-circles/

Posselt, J. (2018). Normalizing Struggle: Dimensions of Faculty Support for Doctoral Students and Implications for Persistence and Well-Being. The Journal of Higher Education, 89(6), 988–1013. https://doi.org/10.1080/00221546.2018.1449080

Rayford, Taiylor, Nidia Ruedas-Gracia, Molly Goldstein, et al. “Educational Enrichment: The Benefits of Near-Peer Mentoring for Undergraduate Engineering Students.” 2022 ASEE Annual Conference & Exposition Proceedings, August 2022, 40697. https://doi.org/10.18260/1-2--40697.

Rodríguez-Becerra, J., & Pernaa, J. (2023). Computational science and STEM education. Frontiers in Education, 8. https://www.frontiersin.org/articles/10.3389/feduc.2023.1130133

Ruedas-Gracia, N., Botham, C. M., Moore, A. R., & Peña, C. (2022). Ten simple rules for creating a sense of belonging in your research group. PLOS Computational Biology, 18(12), e1010688. https://doi.org/10.1371/journal.pcbi.1010688

Schoolcraft. (2026). Restorative Practices at Schoolcraft Community Schools - Circle Questions. https://sites.google.com/schoolcraftcs.org/restorativepractices/circles/circle-questions?authuser=0

Shanahan, J. O., Ackley-Holbrook, E., Hall, E., Stewart, K., & Walkington, H. (2015). Ten salient practices of undergraduate research mentors: A review of the literature. Mentoring & Tutoring: Partnership in Learning, 23(5), 359-376. http://dx.doi.org/10.1080/13611267.2015.1126162

Software Carpentry. (n.d.). Our Lessons. Software Carpentry. Retrieved May 22, 2023, from http://software-carpentry.org//lessons/

Stanford Biosciences Office of Graduate Education. (n.d.-a). Criteria and Application Requirements. Office of Graduate Education. Retrieved May 22, 2023, from https://oge.stanford.edu/inclusion/programs-for-students/ssrp-amgen-scholars-program/criteria-and-application-requirements/

Stanford Biosciences Office of Graduate Education. (n.d.-b). Inclusion & Belonging. Office of Graduate Education. Retrieved May 22, 2023, from https://oge.stanford.edu/inclusion/

Stanford Biosciences Office of Graduate Education. (n.d.-c). Office of Graduate Education. Office of Graduate Education. Retrieved May 22, 2023, from https://oge.stanford.edu/

Stanford Medicine Department of Genetics. (n.d.). Genomics Diversity Summer Program. Stanford Medicine Department of Genetics. Retrieved May 22, 2023, from https://med.stanford.edu/genetics/education/genomics-diversity-program.html

Street, F. (2015, March 2). Carol Dweck: A Summary of The Two Mindsets. Farnam Street. https://fs.blog/carol-dweck-mindset/

Tanner, K. D. (2013). Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity. CBE—Life Sciences Education, 12(3), 322–331. https://doi.org/10.1187/cbe.13-06-0115

Taylor, S. D., Veri, M. J., Eliason, M., Hermoso, J. C. R., Bolter, N. D., & Van Olphen, J. E. (2019). The Social Justice Syllabus Design Tool: A First Step in Doing Social Justice Pedagogy. Journal Committed to Social Change on Race and Ethnicity (JCSCORE), 5(2), 133–166. https://doi.org/10.15763/issn.2642-2387.2019.5.2.132-166

The Office of Ethical Development and Restorative Practices. (n.d.). Restorative Justice Opportunities. University of San Diego. Retrieved May 25, 2023, from https://www.sandiego.edu/conduct/restorative-justice/opportunities.php

Tulshyan, R., & Burey, J.-A. (2021, February 11). Stop Telling Women They Have Imposter Syndrome. Harvard Business Review. https://hbr.org/2021/02/stop-telling-women-they-have-imposter-syndrome

UCSF Restorative Justice Practices. (n.d.). "Facilitator Inquiry: Holding a Healing-Centered Circle." https://restorativejustice.ucsf.edu/document/holding-a-healing-centered-circle

UCSF Restorative Justice Practices. (n.d.). Resources | Restorative Justice. https://restorativejustice.ucsf.edu/content/resources

University of Michigan - Student Resolution Resources. (n.d.). "Restorative Justice Circles." https://srr.umich.edu/restorative-justice-circles

Urias, D., & Gallagher, P. (2012). Critical Features and Value in Assessing a Research Experience for Undergraduates: The Case of Engineering Cities. Journal of STEM Education, 13, 30–42.

U.S. Citizenship and Immigration Services. (2022, November 3). Consideration of Deferred Action for Childhood Arrivals (DACA). U.S. Citizenship and Immigration Services. https://www.uscis.gov/DACA

Vargas, M. M., Peña, C., Kobak, K. C., & Stratton, M. (2023). Ten simple rules for students navigating summer research experiences for undergraduates (REU) programs: From application to program completion. PLOS Computational Biology 19(11), e1011573. https://doi.org/10.1371/journal.pcbi.1011573

Verderame, M. F., Freedman, V. H., Kozlowski, L. M., & McCormack, W. T. (2018, May 31). Point of View: Competency-based assessment for the training of PhD students and early-career scientists. eLife; eLife Sciences Publications Limited. https://doi.org/10.7554/eLife.34801

Womack, Veronica Y., Christine V. Wood, Stephanie C. House, et al. "Culturally Aware Mentorship: Lasting Impacts of a Novel Intervention on Academic Administrators and Faculty." PLOS ONE 15(8), e0236983. https://doi.org/10.1371/journal.pone.0236983