PURM
Perspectives on Undergraduate Research & Mentoring

Centering Student Voices: A Case Study of an Evolving Culturally and Structurally Responsive Undergraduate STEM Mentorship and Skills Development Program

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Introduction

Over the last several decades, federal agencies and prosocial grant-making institutions invested millions of dollars in attracting and supporting Black/African American students to thrive in science, technology, engineering, and mathematics (STEM) graduate programs. While many of these efforts have tested promising strategies, many continue to rely on transforming students rather than broader institutional structures (Posselt et al., 2021). Moreover, when considering historically marginalized groups within STEM education, the need for belongingness and science identity must be addressed (Collins, 2018). Collins (2018) notes that providing Black/African American and other minoritized students with opportunities, strategies, and experiences to develop identities as scientists of color can promote a sense of belonging and increased participation in STEM. Furthermore, the perceived sense of belonging of a student of color is a significant contributor to college achievement, retention, and persistence (Strayhorn, 2019). One mechanism for promoting the development of science identity and sense of belonging is undergraduate research experiences. There is a growing literature that describes the impact of participation in undergraduate research specifically on historically minoritized racial/ethnic groups. These studies highlight the need for early, structured experiences (i.e., a program with oversight and curriculum) that included apprenticeship-style mentored research (e.g., Hurtado et al., 2009; Galvez et al., 2024). However, while many undergraduate programs include components to build science research knowledge, skill, and interest (Galvez et al., 2024) as well as self-efficacy and science identity (Hurtado et al., 2009), they do not necessarily address structural and cultural issues which can impede the success of historically marginalized students. Namely, although it is important to reduce barriers to access to valuable STEM experiences like undergraduate research, providing students access to mentors who are trained to value the assets that diverse student groups bring is of critical importance (Corneille et al., 2020).

Increasingly, members of higher education systems, particularly in STEM, experience a need for thoughtful, purposeful, and intentional mentorship. Indeed, it has been long recognized that STEM research mentors, and their undergraduate research students, benefit when the mentors receive formal training (e.g., Pfund et al., 2006). Mentoring relationships are especially critical for the advancement and academic success of minoritized students (Estrada et al., 2018, Lopatto, 2007;

Ramos & Park, 2024). Most of these studies seem to prioritize mentorship of graduate students or new faculty from minoritized backgrounds. However, agencies that fund pathways programs for historically marginalized students, such as the Alfred P Sloan Foundation, recognize the need to train mentors to be culturally responsive in their support of diverse undergraduate students—a need reflected in the prevalence of this approach among recent grant awardees such as Texas State University, University of Colorado-Boulder, University of Guam, University of the Virgin Islands, and Universidad Interamericana de Puerto Rico (Alfred P. Sloan Foundation, 2023). Academic socialization, particularly with or supported by those considered to be good mentors, positively affects historically underserved students within these systems, which highlights the need to ensure said mentorship is both culturally and structurally relevant and responsive (Davis, 2008). Mentoring that is not culturally-responsive, in fact, can have a strong negative impact (Brown et al., 2021).

Consequently, an urban predominantly black institution (PBI) and a primarily white (PWI) public STEM-focused land grant research-intensive institution partnered to develop an evolving joint undergraduate research mentoring program aimed at reducing barriers to graduate education for undergraduate students historically excluded and minoritized in STEM fields (particularly Black/African American students). The overarching goal of this project is to bring about systemic change at both institutions. Critically, we seek to increase the educational attainment of the PBI undergraduate STEM students by increasing their science identity and sense of belonging not solely by student-focused interventions but importantly by training their research mentors in culturally-responsive mentoring techniques.

This case study analyzes the evolving culturally responsive mentorship and skills development program built by these partner universities. The program offers student career-preparedness training in durable cognitive and non-cognitive skills to prepare them for research experiences and the STEM workforce. Key elements of the program are structured mentoring professional development for both mentors **and** mentees and a rigorous assessment plan that centers student voices. After detailing the undergraduate research mentoring model employed in the case and our evaluation approach to document learning gains and inform programmatic improvements to support students, we discuss implications of such programs for the reduction of structural barriers to research opportunities and early-stage support of STEM career readiness for undergraduate students of color.

Theoretical Foundations for Program Design and Evaluation

To help us work toward our goal of bringing about systemic change at the two partnering institutions our work is informed by multiple theories that have guided our program design and its evaluation. In the context of our program, culturally and structurally responsive education is aligned with our goals to dismantle barriers for Black/African American students and advance our theory of change. Extending from the work of Ladson-Billings (1995), culturally and structurally responsive education, proposed by Corneille and colleagues (2020), is an evidence-based framework that posits increased participation in STEM and is mediated by the development of science identity, positive self-schemas, knowledge and skills for STEM careers, and increased resilience that results from access to structurally and culturally responsive education. Their theory understands that within cultural and structural responsiveness, there persists the need for positive psychosocial factors such as generating positive self schemas, boosting resilience and developing a STEM identity to achieve increased participation (Corneille et al., 2020). As such, this mentorship and skills development program seeks to dismantle structural barriers to participation and reform educational practices and opportunities by creating student and faculty communities. To support our theory of change and goal for the achievement of culturally and structurally responsive education, the change theory of expectancy value theory (EVT) was incorporated in the implementation and evaluation of our program. Reinholz and colleagues (2021) note that change theories appreciate the complexity of educational systems and stakeholders therein, thus allowing for effective application of such theories for the betterment of these systems. EVT allows us to address the components of motivation, create community and exchange of ideas within and across both institutions to support student attainment.

To gain insight into the motivational factors that could affect participation in and uptake of knowledge and skills, we used the EVT framework as an analytical lens to guide our approach to data collection and program refinement. EVT is a theory of motivation based on the premise that a person's accomplishment of “achievement tasks” is generally based on the individuals’ proclivity to succeed and their expectation of such success (Wigfield, 1994, p. 50). Atkinson (1957) informs that motivation is the product of expectancy, motive and incentive; such that the aspect of expectancy is driven by the value an individual sees within a task - later described by Wigfield and Eccles (2000) as subjective task values. These subjective task values consist of values that can be intrinsic (enjoyment), utility (usefulness for goals), attainment (alignment with identity and perceived importance), and cost (toll and time investment) (Wigfield & Eccles, 2000). Therefore, it is of no surprise that EVT has been used to examine graduate student and faculty motivation to engage in professional development or adopt certain pedagogies (Finelli et al., 2014; Goodwin et al., 2021). For this program, EVT allows for the augmentation of our understanding of the factors affecting undergraduate students and graduate and faculty mentors’ motivation to adopt and sustain the inclusive mentoring practices informed by intercultural competencies. Using EVT, we are also able to examine the values related to participation by the undergraduates in our program, how those values change through participation, and future career intentions in STEM. Together, these are important for empowering students while transforming the mentors and STEM programs at both institutions.

Case: Partnering in Research Mentoring of Minoritized Students in STEM (PReMMiSS)

With seed grant funding and institutional support we created the PReMMiSS program to support STEM undergraduate students from Chicago State University (CSU) through professional development and networking and reducing barriers for access to STEM research opportunities with mentors trained in culturally responsive mentoring. Below we describe the institutions in the partnership and the program.

Institutional Partners

Chicago State University (CSU) is a public, urban, predominantly Black institution (PBI) of about 2300 students: 69% female, nearly 71% identifying as Black, and 92% of the undergraduates receiving need-based financial aid (NCSES, 2021). Despite notable success in nurturing at-risk minoritized STEM students, the percentage of CSU’s Black students who continue on to graduate STEM programs reflects the dire national landscape—only 5% of STEM doctoral recipients nationwide identify as Black (Collins, 2018). Purdue University is a predominately White (PWI) public land grant research university and similarly suffers systemic challenges to diversity in recruitment and retention, with only 4.4% of graduate students in 2023-2024 identifying as Black (Strayhorn, 2019). We recognize that institution-specific structures and campus culture contribute to student barriers, which in turn, impact student retention and research as they navigate towards degree progression in pursuit of graduate STEM programs.

PReMMiSS Program Description

The PReMMiSS program aims to address aspects of both structurally and culturally responsive education to increase STEM undergraduate student attainment and dismantle barriers (see Figure 1). We matched CSU undergraduate students with both CSU and Purdue professors for one-to-one research mentorship. Students were also matched to graduate students with similar life experiences to bolster good mentor-mentee relationships. Mentoring relationships are critical for advancement of minoritized students and success in post-baccalaureate studies (Estrada et al., 2018). However, mentoring that is not culturally-responsive can have a strong negative impact (Brown et al., 2021).

Therefore, based on input from our advisory board, a student advisory council, and baseline data from formative assessments, we adapted and deployed professional development materials in intercultural competence for all mentors and mentees participating in the program.

Consequently, we created a joint mentorship community of practice between the two institutions. In STEM fields, communities of practice (CoP) exist as a means to boost collaboration and the achievement of goals through sharing of knowledge and expertise (Townley, 2020). In the context of this case study, the goals of removing barriers to research experiences and increasing retention and progression to graduate studies unify the two partner institutions and bolster this professional community, in turn strengthening the program. We began the CoP with a workshop series for mentors exploring attitudes and beliefs, then built on that foundation to develop key skills and mentoring strategies. Mentors, for example, were guided through reflection on their biases and stereotypes and focused on skill-building in empathy and adaptive communication (see Supplement Table 1 for further details of workshop topics). Furthermore, the community of practice framework for mentor training was vital to workshop success because of the co-learning involved; CSU and Purdue mentors engaged in workshops virtually, sharing with each other their motivations for mentoring, their expectations of mentees, and their experiences working with students from a diverse range of backgrounds. By reshaping the mentoring practices of the faculty involved to be more culturally responsive, we are shifting the adaptive burden from mentees to mentors and reconstructing the system that underlies undergraduates' path to further STEM education and research.

The professional development programs that students participated in included time spent in residence at both campuses during the summer bracketed by year-long support at CSU. Students participated in career development and mentee training workshops both before and after the summer program, with team leaders and graduate students coming up from Purdue to join CSU facilitators for in-person events throughout the year. During the spring before the summer experience, the focus was on motivating and enabling students to engage with their mentors and each other. For the fall after the experience, the focus was on helping students prepare for their next career step, whether that was joining a CSU professor's laboratory, applying for summer research positions, or completing more rigorous coursework.

During the summer, the first session (six weeks in Year 1 and five weeks in Year 2) was similar to an NSF supported program conducted by Sabella and colleagues (2017) modeled after the University of California - Berkeley Compass Project by Corbo and colleagues (2013) and aligned to build on the specific strengths of historically minoritized STEM students recently identified in an internal study. This portion of the summer program took place at CSU and was designed to provide authentic science experiences, develop metacognitive skills, introduce a variety of career options, and build robust networks. The program ran 6 hours each weekday to meet student needs regarding job and family responsibilities (see Supplemental Table 2 for the list of topics and activities). This time at their home institution facilitated community among the CSU students, aiming for a collective sense of belonging.

For the final three weeks of the program, the students moved to Purdue University to engage in mentored laboratory research. The Purdue session began with a joint workshop that brought together mentors and mentees to learn about differences in cultural values and communication styles. In addition to participating in research laboratory activities supervised by their Purdue faculty mentors, students met with summer research program leaders to learn more about future research opportunities and their application processes, spent time with their graduate student mentors, and attended social events with their cohort and other undergraduate research interns on campus at the time. This exposure to a research-intensive institution supported by a cohort and multiple culturally-trained mentors in an inclusive environment was meant to foster belongingness and science identity.

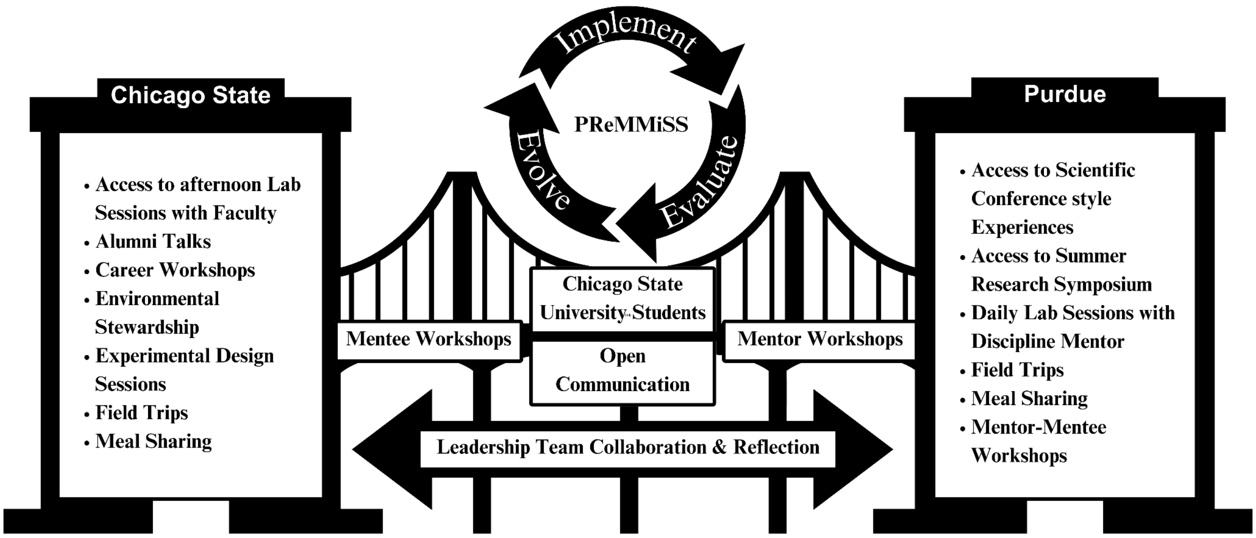

Figure 1. *PReMMiSS Program Components and Evolution*

Figure 1 provides an overview of the program showing some of the key features provided by each institution alongside those which unified the efforts of the project collaborators. In this figure, the bridge and the various features documented within signify the connection between the institutions and some of the efforts to maintain this connection. All activities listed were designed and implemented with consideration of the culturally and structurally responsive education model depicted by Corneille and colleagues (2020). Evaluation and evolution are made possible through analyses using EVT and collaboration among all stakeholders.

Evaluation Approach

This project has been assessed with a research study (IRB-2023-153) examining the longitudinal changes in several key outcomes for various participants, including: *belongingness* and *science identity* of undergraduate students; *mentoring skill*, *confidence*, and *motivation* of mentors; and *intercultural competence* of all involved. The study employed a mixed methods design that combined quantitative (pre/posttest comparison of data from validated self-report measures of the key constructs listed above) with qualitative (analysis of response to open survey questions, learning artifacts, and conversations with students as well as coding of interview data) approaches. Here we describe our qualitative data specifically *centering student voices* from our end-of-program reflection interviews. We have used inductive and deductive thematic coding to describe the data from these student interviews (Braun & Clarke, 2012), using EVT as one of the deductive analytical lenses through which to view some of our data. These data provide us with insights into our impact, achievement of our goals, and were used to drive revisions to the program.

Evaluation, Outcomes, and Program Evolution

Year 1

Ten CSU students participated in the full PReMMiSS program (professional development activities, mentorship workshops, and summer program). Ten Purdue faculty, five CSU faculty, and three Purdue graduate students received mentor training and engaged with the CSU students in Year 1. We collected several forms of evaluation data during the first iteration of the mentorship and research program, including pre- and post- surveys, several meetings with students throughout the summer program for feedback and adjustments, and an hour-long end-of-summer interview with students. Students were asked questions about their perceptions of every part of the program, how their science identity or future goals have changed from it, and any areas for improvement they could suggest. Faculty and graduate student mentors were also interviewed and asked for feedback and impressions of their students' experiences. Survey responses to free-response questions and interview transcripts were analyzed for common themes and areas that needed and were able to be improved.

Emergent themes from students' end-of-summer interviews and alignment to constructs within EVT (defined by Wigfield & Eccles, 1992), including example quotes, are summarized in Table 1. Overall, most students (7 of 9) expressed feeling an increased drive to pursue further STEM education from both the CSU and Purdue portions of the program due to gains that align with EVT's utility value - the usefulness/enabling for someone being able to do something in their present or future plans and is further subdivided into intrinsic, extrinsic, and social utility. Intrinsic utility values (personal and professional development) included gaining useful laboratory skills, confidence in their own independence and communication skills, and increased knowledge of the diversity of careers within STEM fields. They also expressed an increased empathy and understanding of others and other "soft" skills necessary for working as a team in any career; these can be characterized as social utility, a desire to make societal contributions or help others. Finally, students' science identity and sense of belonging in a STEM environment, characterized as EVT attainment value (alignment with the personal sense of self or their values) increased as a result of the program.

Some of the issues brought up by students, such as difficulty with transportation back and forth between Purdue and Chicago during the summer research portion, may just be unavoidable costs of participation (defined within EVT as any negative aspect of engaging in a task - Wigfield & Eccles, 1992). Some actionable suggestions from undergraduate participants included matching students with research laboratories that more directly align with their interests, having more communication with program directors before and throughout the program, and being prepared to deal with the potential culture shock of moving from a PBI (CSU) to a PWI (Purdue) for 3 weeks over the summer. There were also a few mentoring workshops that students thought could be adapted to resonate more with them, and all of these suggestions were taken into account when adjusting all parts of the program for the implementation of Year 2.

Table 1. *Emergent Themes and Quotations from Year 1 Post-Program Student Interviews (n=9) with Constructive Criticism in Gray.*

Theme	**Example Quotations**
CSU Professional Development Portion	
Increased drive to pursue further STEM education *(EVT intrinsic utility)*	"I felt like I'm definitely more optimistic for the future after I'm done with my undergraduate studies and stuff and get my degree. I would like to go straight into grad school. So I think this kind of like, even though it wasn't what I was expecting, it definitely reignited my drive. Or the desire to get my degree and become a biologist."
Learned about the diversity of research areas within STEM *(EVT intrinsic utility)*	"I was exposed to various different research, various different people...I was able to see that my major...wasn't like only one path, like I could take multiple different paths if I wanted to or...it gave me a bit of a better sense of where, what I was trying to do with my career."

Gained laboratory skills *(EVT intrinsic utility)*	"With us being at Chicago State for six weeks, the data analysis and using pipette pipettes and just like all the other sciency things I guess you can say, actually helped me with my classes that are coming up. So I'm in analytical chemistry now. Pipetting going over that really helped because the percent error is very low. And so I think it did help me gain a lot more knowledge and a lot more skills that I'm using now in my classes."
Mentoring Workshops	
Gained self-awareness *(EVT intrinsic utility)*	"I feel like this program allowed me to be more open to my feelings and...I wasn't cut down or I wasn't, like, think twice before I speak...I feel like I was very open about the way that I felt and...open about my opinions with others." "I definitely didn't talk about myself much as a person before the workshop, so they definitely gave me an outlook on how I perceive myself as well as how others perceive me. That was really cool. It definitely made me more aware of my surroundings."
Became more empathetic towards others *(EVT social utility)*	"Empathy always sticks out to me because you always have to be mindful of the next person and you don't want to say the wrong thing but you have to be mindful that the wrong thing doesn't get taken out of context. So empathizing with the next person is always good, understanding where people come from and how they might be different...being empathetic to your professors...be understanding of their time."
Need for workshop adjustments	"We did some on conflict resolution, but I don't think, at least not within myself or any of the other students that I know, that there were too many conflicts that we had with our PIs...So I feel like it could have been useful if someone were in that situation...But just the way it was executed really didn't. I don't think I walked away with anything for that. Student suggestion(s) for improvement: Giving situational examples, maybe examples of where we could create the prompts, you know, maybe in ways that PIs or grad students and the research students would maybe bump heads, scheduling conflicts or misunderstandings or not enough familiarization with the materials we've been covering that might have helped in some areas...I feel like the topic for conflict resolution was just generalized and not specific to what we're doing."
Purdue Research Experiences Portion	
Improved science identity/increased excitement about STEM research *(EVT intrinsic value & attainment)*	"It was much more than I expected it to be. I called my parents, my mom and dad every single day to tell 'em "look what I'm doing! Look what I'm doing!" I recorded it. I told my friends...this was a great experience. And every day was just a bigger surprise of how hands-on everything was." "I'm very curious when it comes to science, and chemistry is like one of my biggest passions...we'd never been exposed to everything that not only my major has to offer for me, but the different things, like how you can apply to all the different fields was a very...it just gave me more of this feeling of like,

	'I want to keep going…and I want to like actually take this more serious'…I feel like Chicago and Purdue did…very decent work when it came to being more inspired and being more I feel…the passion that I have for chemistry."
Experienced personal growth (independence, confidence, versatility) *(EVT intrinsic utility)*	"They gave me a lot of confidence…(graduate mentor) was like, 'here's what we're doing, now you do it.' And I was like, 'you have enough, like, faith in me to do this?' I'm like oh my goodness. And because she…had so much faith in me to do it on my own. And she was also like guiding me. I felt more confident. I felt like I could actually accomplish these things."
Gained laboratory experience and skills *(EVT intrinsic utility)*	"I think what I gained from it probably was the most, attention to detail in the lab, but also working, working the machines as well. I would say that too, because he did help us a lot with it."
Needed tools to prepare for transitioning to a predominantly white environment	"Also being in a foreign place, I'm going to be completely honest, I'm around mostly black and brown people. So it was very different to be around people that are not black and brown."
Wanted a laboratory match that fits better with their interests	"Even though I'm a biology student, I definitely like to do more chemistry stuff…that's kind of what I wanted to do. I believe I've vocalized that. But, you know, I don't think my…wishes were really clear…which is fine, because ultimately, if I got the lab experience, irrespective of whatever field it was in, I would have been satisfied…But yeah, yeah just it wasn't what I was expecting."
Logistical issues (transportation, communications, housing, etc.) *(EVT cost)*	"We all had to go home and then come back and…me personally, I didn't have transport. I have transportation now, but I didn't have transportation at the time. Reliable transportation to go back and forth…that was kind of…a little challenging, trying to figure out the transportation."

In addition to the perspectives shared by the CSU students in the post-summer reflection interviews, there were other notable impacts. The program overall has had a significant impact on CSU culture, as students are more engaged with departmental activities. 7 of the 11 participated in summer research experiences this past year and are now expressing interest in graduate school, which is especially significant as many of our program participants were not initially considering graduate school. In fact, it is important to note that the CSU student demographic encompasses students who are least likely to consider graduate school due to family and financial situations. Additionally, 10 out of 11 (91%) of these cohort 1 students continued in their degrees in Fall 2023 at CSU and 8 out of 9 (89%) of cohort 2 students continued in Fall 2024, which far exceeds CSU's usual retention rates (Table 2).

Table 2. *Retention Comparison for All Biology, Chemistry, and Physics Majors at CSU Compared to Students from Cohort of the PReMMiSS Program. Numbers in Parentheses Indicate Students Retained out of the Non-Graduating Students from the Prior Year (CSU Internal Records, Used with Permission).*

	PReMMiSS Cohort Retention at CSU	Biology	Chemistry	Physics
F22 → F23	91% (10 of 11)	53% (47 of 88)	60% (6 of 10)	44% (7 of 16)
F23 → F24	89% (8 of 9)	67% (55 of 82)	69% (9 of 13)	82% (9 of 11)

Program evolution

During the second year of the program, we had nine CSU students, nine faculty mentors at Purdue and CSU, and 3 program-level graduate students at Purdue participate. The first year of the PReMMiSS program set the framework for how we would proceed in year two. Based on our experiences running the program and listening to student voices via informal and formal mechanisms, we made several changes to the mentoring and summer program to better serve the students. Table 3 provides details on the components of the program and how they changed based on our evaluation data. The changes made to the program fall into three categories: 1) Enhancing overall student support through additional personnel and advocacy, 2) Intentional framing of the program to the students and preparation, 3) Increased support structures for students while they were at Purdue University.

Firstly, with support from a Department of Education Minority Science and Engineering Improvement Program grant at CSU, a student navigator was added to our PReMMiSS team (author RL). In addition to their other duties outside of our program, they have been able to increase bandwidth to run the CSU summer program, aid in the professional development of students, and prepare them for their time at Purdue, importantly advocating for them and their needs in advance (e.g., accessibility features in the dormitories).

While running the program in our first year, we were entrenched in cycles of listening and development throughout, which sometimes led to some instances of incomplete communication with the students. In year 2, we were intentional about the framing of the summer experience so that expectations were in better alignment with the goals and designed purpose of the summer program. This framing was especially important for the brief laboratory experience at Purdue, as some students in cohort 1 shared that they expected an experience more directly aligned with their specific scientific interests. We coordinated with the CSU student navigator to create a “mentoring goals and expectations” reflection worksheet (see Supplemental Materials) for the students to complete before coming to Purdue and to share with their mentor(s). The components of the worksheet built from the mentoring literature (Golde, 2010; Pfund et al., 2014). The goal of this exercise was to provide a communication and conversation mechanism to help the mentor and mentee understand each other’s needs and expectations from the start. We also adjusted the content of the final student mentorship training workshop to provide the students with reflective and practical tools to navigate potential challenging experiences they might have entering a predominantly white community and institution, as suggested by multiple students from our first cohort. This summer workshop included activities to explore dealing with ambiguity and perspective taking.

Finally, to better support students while they were at Purdue, we expanded the mentorship community of practice beyond the original faculty and graduate student mentors to include representatives from each of the research laboratory groups (graduate students, postdoctoral fellows, and laboratory managers), some of whom would interact with the students even more than the faculty. This pre-summer mentoring professional development was intended to support a broader range of less formal mentors with culturally responsive mentoring knowledge and skills aligned with our theoretical framework to enact structure changes towards inclusivity. We also included more logistical support for the students by assigning one of the program graduate students to be on call each week and to meet more consistently with the students for meals and activities (e.g., Sunday game night). We are currently gathering and reviewing evaluation data again for cohort 2 to understand the ongoing impact of our program, reflect on the changes we made, and identify new ways to continue supporting the students.

Table 3. *Evolution of the PReMMiSS Program Based on Student Feedback*

Program Component	Year 1 (Spring-Summer 2023)	Changes Year 1 → 2	Year 2 (Spring-Summer 2024)
Mentoring workshops (see Supplemental Table 1)	• Culturally responsive mentoring • 5 CSU, 9 Purdue faculty mentors • 2 CSU faculty leads • 21 CSU students	• Developed 3 onboarding workshops for new faculty and graduate mentors • Altered the pre-Purdue workshop to better equip students with reflective and resiliency tools for coming to a PW Institution and community. • Added additional people from each laboratory at Purdue to provide culturally responsive mentoring development	• Culturally responsive mentoring • 5 CSU, 8 Purdue faculty mentors • 2 CSU faculty leads • 21 CSU students
CSU professional and skills development (see Supplemental Table 2)	• 11 CSU students • 9 CSU faculty • 6 weeks of professional skill building, networking, reflection, and career exploration	• Student navigator ran the CSU summer program with revisions and increased student contact and advocacy • Integrating talks from CSU alumni as models of success in scientific fields • Emphasized skills that cohort 1 students reported as needed in their Purdue experience and next classes • Added pre-Purdue mentoring reflection assignment to discuss with mentors early in the visit	• 9 CSU students • 9 CSU faculty mentors • 5 weeks of professional skills building, networking, reflection, career exploration, and preparing for Purdue
Purdue research experience	• 7 Purdue faculty mentors • 5 Purdue graduate student mentors • 10 CSU students • Students	• Graduate student on call for each of the 3 weeks (and general assistant graduate student) and reduced programming so students had downtime • Housed in residence hall with other students from a diversity of observable and hidden identities at	• 8 Purdue faculty mentors • 4 Purdue graduate student mentors • 9 CSU students • Students embedded in

	embedded in research labs ● Students lived in apartment- style dorms ● Professional and community building experiences	Purdue for summer programs ● Reduced number of program-level grads	research laboratories ● Students lived in traditional dorms ● Professional and community building experiences

Conclusion

The overarching goal of the PReMMiSS program was to support CSU STEM student attainment by removing barriers to their success through structurally and culturally responsive educational activities and mentoring. These efforts included supporting students' personal and professional development for career readiness, developing faculty mentors specifically equipping them with culturally responsive mentoring approaches to recognize and leverage their assets, and centering student voices in our evaluation and program evolution. Through sharing our experiences running the program and highlighting how we centered student voices throughout (i.e., program design, evaluation, and revision), we provide an important model for other programs with similar goals. Our student-centered approach has allowed us to create a program responsive to student needs and perspectives to allow for the better realization of its potential and achievement of its programmatic goals with and for the students.

Of critical importance in our program, though not the primary focus of this manuscript, is the community and partnership that has been fostered beyond the intentionally formed faculty and graduate student community of practice for mentors. This community helps to foster a value for culturally responsive mentorship in the colleges of science at both institutions. Additionally, we have observed that the students in each cohort have formed bonds of care and connection during and beyond their formal participation in the PReMMiSS program; student participants formed an emergent student CoP. For example, during the second summer research experience at Purdue, the students worked together to make sure that everyone knew where to be and on their own initiative they organized a sharing session several times during the week to talk about what they learned in their research labs that day. In addition to the students' community, through the work in developing, implementing, and reflection, the project team itself has formed a community of practice which undergirds the entire program as represented in Figure 1. We have matured into a more cohesive group by listening to and learning from each other with mutual respect and humility that models the 5Cs of community building: commitment, collegiality, communication, consensus, and continuity (Pelaez et al., 2018). Similar studies have shown that development of similar communities consisting of faculty and non-faculty have greater positive impact on student outcome (Nicholson et al., 2017; Ramos & Park, 2024). We contend that our diverse perspectives and the strong cross-institutional and intercultural relationships we have forged have positively impacted student experiences in the program.

Acknowledgments

This work was made possible through support from the Alfred P. Sloan Foundation (Grant 2022-19555), the Graduate School and College of Science (Purdue University) and a Department of Education Minority Science and Engineering Improvement Program grant (P120A230034; Chicago State University). Many thanks to Kelsey Patton for her contributions to the mentoring workshops, and to Peristera Paschou for her institutional support of this project.

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Supplementary Materials

Supplemental Table 1. *Overview of Mentoring Program for CSU Student Mentees and Purdue and CSU Mentors (Year 1)*

		Focus	Objectives	Format
Spring 2023				
Mentees	Workshop 1	Mentorship	Motivation, Needs analysis, Science identity	In Person
	Workshop 2	ICC	Curiosity, openness	Virtual
	Workshop 3	Mentorship	Relationship building, Communication skills, Goal setting	Hybrid
Mentors	Workshop 1	Mentorship	Motivation, Needs analysis, Culturally-responsive mentoring	Virtual
	Workshop 2	Mentorship	Motivation, Needs analysis, Culturally-responsive mentoring	In Person
	Workshop 3	DEI	Mentoring strategies, implicit bias/stereotyping, microaggressions	Virtual
	Workshop 4	DEI	Unintentional harm, identity-based rejection sensitivity	Virtual
Summer 2023				
Mentees	Workshop 4	DEI	Rejection sensitivity, professional writing	In Person
Mentors	Workshop 5	ICC	Empathy	Hybrid
Both	Workshops 5 & 6	ICC	Communication/conflict styles	In Person
Fall 2023				
Mentees	Workshop 6	Mentorship	Science identity and career planning	Hybrid
Mentors	Workshop 7	DEI	Resilience	Virtual
	Workshop 8	DEI	Science identity	Virtual

Supplemental Table 2: *CSU Professional Development and Skill-Building Activities*

Professional Development	Skill-Building
• Writing professional emails • Interviewing • Building STEM resumes • Writing personal statements and cover letters • Practicing elevator pitches • Networking with alumni	• Keeping lab notebooks • Designing experiments • Creating intentional community • Reading research articles • Constructing posters • Presenting short talks • Engaging in mentoring relationships • Developing scientific identity

Supplement 3: *Reflection Worksheet*

Mentoring Plan Worksheet

This worksheet has two parts: 1) an expectations scale exercise (Advisor = Mentor) and 2) mentoring goals and needs exercise.

EXPECTATIONS

Student-Advisor Expectation Scales

Read each of pair of statements describing end points on a continuum. Estimate your position and mark it on the scale. For example, if you believe very strongly that it is the advisor's responsibility to select a research topic for the student, on scale #1 you should circle '1'. If you think that both the advisor and student should be equally involved, circle '3'.

Contact & Involvement		
4. The advisor should determine when to meet with the student.	**1 2 3 4 5**	The student should decide when to meet with the advisor.
5. Faculty-student relationships are purely professional and personal matters are not appropriate.	**1 2 3 4 5**	Close personal relationships are essential for successful advising.
6. The advisor should check regularly that the student is working consistently and on task.	**1 2 3 4 5**	Students should work independently without having to account for how they spend their time.
7. The advisor should be the first place to turn when the student has problems with the research project.	**1 2 3 4 5**	Students should try to resolve problems on their own, including seeking input from others, before bringing a research problem to the advisor.
8. The advisor is responsible for providing emotional support and encouragement to the student.	**1 2 3 4 5**	Emotional support and encouragement are not the responsibility of the advisor – students should look elsewhere.

Support		
15. The advisor is responsible for introducing the student to others in the field, especially at conferences.	**1 2 3 4 5**	Students are responsible for building their networks in the field.
16. The advisor is responsible for providing career advice and preparation to the student.	**1 2 3 4 5**	Career advice and preparation are not the responsibility of the advisor – students should look elsewhere.

Original from Ingrid Moses, 1985, Higher Education Research and Development Society of Australasia. Adapted by Margaret Kiley and Kate Cadman, 1997, Centre for Learning & Teaching, Univ. of Technology, Sydney. Further adapted by Chris M. Golde, 2010, Stanford University.

<u>YOUR GOALS</u> (Part of the W.H. Freeman Entering Mentoring Series, 2014)

Take some time to think about and write down your research and professional goals. Try to think of some near-term (this summer), short-term (next year), and longer-term (next 5 years) goals.

Near-term goals (this summer)	Short-term goals (next year)	Longer-term goals (next 5 years)
e.g. complete a set of experiments; learn science communication skills	*e.g. get a position in a research lab at my institution*	*e.g. get accepted into a Master's or Ph.D. program; get a job at a biotech company*
1.	1.	1.
2.	2.	2.
3.	3.	3.

<u>IDENTIFY YOUR MENTORSHIP NEEDS</u> (from W.H. Freeman Entering Mentoring, 2014)

Identify competencies that you will need to gain expertise to reach your goals. Circle the ones from the table below that you would like to learn and add new ones!

Designing experiments	Giving and receiving feedback
Speaking in front of groups	Learning specific data collection techniques
Establishing goals	Time management
Reading research literature	Writing research papers
Collaborating effectively (e.g., lab team)	Preparing research posters
Managing and analyzing data	Recordkeeping/lab notebooks
Knowing career paths	Mentoring and being mentored
Writing strong personal statements	Describing your research for a variety of audiences
Confidence in building relationships	Ability to identify issues and willingness to ask for help
Increased ability to perform tasks independently	

<u>YOUR CONCERNS</u>

- What questions or concerns do you have about interacting with your mentor(s) this summer?
- What support(s) do you think you will need to be successful this summer?
- Other concerns?