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Building Inclusive Mentoring Networks in STEM: Strategies, Impacts, and Lessons Learned

Hart, R., Prichard J., & Smeltekop, H.

University of St. Thomas - Minnesota

This manuscript explores how a four-year midwestern university transformed its STEM advising and mentoring culture to support students underrepresented in the sciences. Prior to program implementation, students with these identities showed significantly lower retention than the general student body. The HHMI-funded STEM Inclusive Excellence initiative created a comprehensive equity-focused mentorship training plan. Here we describe the impacts of the program on student experiences and retention outcomes and offer transferable strategies for similar institutional contexts. The initiative was grounded in culturally sustaining pedagogy and inclusive excellence frameworks, emphasizing relationship-centered mentoring and validation of students' lived experiences. Drawing from theories of cultural capital, the program addressed the hidden curriculum of higher education and helped faculty build skills in identity-focused advising and mentoring in monthly meetings with advisees. Community cultural wealth and equity-minded practice served as guiding concepts to shift institutional culture and expand capacity for inclusive student support. The STEM Inclusive Excellence team implemented faculty development through workshops, semester-long learning communities, and discipline-specific trainings. Faculty taught first-year experience courses linked to advising and incorporating student-led peer mentoring. Mixed methods informed the evaluation: disaggregated institutional retention data, qualitative and quantitative student feedback from surveys over four years, and faculty reflections guided iterative improvement. Retention of underrepresented science-interested students rose to match university-wide rates despite the impact of the COVID-19 pandemic and racial reckoning in our Twin Cities community. Lessons include the importance of trust-building, sustained leadership support, and embedding inclusive practices within existing structures. This ensured relevance, scalability, and institutionalization across disciplines. Long-term change requires both top-down commitment and grassroots innovation in creating networks that empower faculty and normalize inclusion as an integral part of STEM education.

Keywords: STEM, higher education, inclusive advising, mentoring.

Introduction

National Center for Education Statistics data consistently show that underrepresented racial/ethnic minority (URM) students have lower STEM degree completion rates than white students (Whitcomb & Singh, 2021). Similarly, first-generation students are also less likely to persist in and complete STEM degrees. Chen (2013) found that first-generation students in STEM majors had a 48% completion rate, compared to 61% for continuing-generation students. First-generation and URM students often face financial stress, lack of mentorship, and fewer academic resources, which negatively affect performance and retention in demanding STEM disciplines.

In response to these opportunity gaps, in 2017 the Howard Hughes Medical Institute (HHMI) launched the Inclusive Excellence (IE) grants program to support capacity-building institutional transformation to remove barriers that impede success in STEM education "for all but historically well-represented students." The HHMI IE program challenged institutions to revise the model of education to "fix the university, not the students". In 2019, the University of St. Thomas (MN) was one of 57 institutions of higher learning awarded one of these 5-year grants. As part of the HHMI IE program, the College of Arts and Sciences (CAS) piloted a new model of academic advising and mentoring within science programs. This paper describes the successes in closing the retention gap when transforming academic advising to center relationships and employ strengths-based mentoring that validates students lived experiences.

The University of St. Thomas is a private high access, urban university. Data from the incoming classes of full-time first year students from 2004-2012, show that only 41% of students of Color and 45% of first-generation college students interested in science graduated from St. Thomas with a science degree, compared to 68% of White students and 70% of continuing generation college

students. Student outcomes data showed that the first year of college – when students struggle with adjusting to a new social and educational environment, take large lecture courses in introductory chemistry, biology, and calculus, and are assigned general academic advisors from any field rather than advisors from their prospective majors – was the period of greatest vulnerability to attrition from the sciences. Quantitative data from campus climate surveys and student health and engagement assessments, as well as qualitative data from focus groups of STEM students, indicate that underrepresented students' experiences of microaggression, feelings of social isolation, financial strain, stress, and inadequate advising and mentoring contributed to these inequities in retention in the sciences. Underrepresented students were also less likely to report using collaborative learning strategies or to say that courses they took connected with their prior experiences and knowledge.

Literature Review

Hidden Curriculum & Cultural Capital

The evidence suggests that systemic inequities—both inside and outside the classroom—contribute to lower STEM success rates for first-generation and URM students. The hidden curriculum of higher education refers to the unspoken norms, values, expectations, and cultural codes that students are expected to navigate in order to succeed—but which are rarely explicitly taught. Smith (2013) argues that colleges must intentionally mentor at-risk students to decode the hidden curriculum, thereby democratizing access to the implicit knowledge that undergirds academic success. This mentoring process includes culturally responsive mentoring and proactive guidance on academic and social norms to empower students. Mentoring grounded in cultural capital theory (Bourdieu, 1986) equips students with the tools and knowledge privileged students often receive informally, disrupts structural inequality by making cultural knowledge explicit and accessible, and promotes equity by recognizing and integrating students' own cultural capital into their academic success.

Strengths-based mentoring can be a powerful approach to support students' learning in college science disciplines by focusing on students' existing assets—such as personal traits, cultural knowledge, prior experiences, and individual talents—rather than deficits or perceived shortcomings. Yosso's (2005) critical reframing of cultural capital (Bourdieu, 1986) as "community cultural wealth" informs why mentors who focus on helping students recognize and value their strengths (e.g., curiosity, resilience, problem-solving skills), may boost self-efficacy and a sense of belonging in scientific communities. Mentors also share their own growth experiences. Estrada et al. (2016) found that underrepresented students with a strong science identity were more likely to persist in the sciences, but that URM students are less likely to develop such identity without supportive environments. Shadduck (2017) notes that relationship-building between faculty and students is key to student success.

Social Unrest & Pandemic

The racial reckoning of 2020, spurred in part by the murder of George Floyd a few miles from the college campus, and the COVID-19 pandemic had significant, well-documented impacts on college student success, especially for students of color, low-income students, and other marginalized populations (McClure et al., 2021). The convergence of a global health crisis and heightened social awareness of racial injustice exacerbated existing inequities in higher education, impacting academic performance, mental health, retention, and engagement. Means & Neisler (2020) found that Black and Hispanic students reported more obstacles to remote learning and less confidence in succeeding academically during the pandemic. Liu et al. (2020) found that racial/ethnic minority students reported higher levels of pandemic-related anxiety and distress due to both racial discrimination and health disparities. Squire (2021) demonstrated that Black students experienced increased psychological stress due to campus racial climate and the expectation to educate others or participate in DEI efforts, that added emotional labor and burnout—particularly among Black and other racially minoritized students.

Program

Advisor Training

The St. Thomas HHMI IE program trained 23 faculty members on culturally responsive mentoring practices to better support STEM students from historically marginalized groups. The initial training consists of a six-week summer course over six topics: reflecting on healthy advising and mentoring relationships, understanding cultural values, understanding an advisee's journey, identifying and handling biases and stereotypes, using strengths-based advising, and sharing the 'hidden curriculum', unwritten rules, unofficial assumptions, and values that are part of academic culture (Smith, 2013). The Intercultural Development Inventory® (IDI®) (Hammer, 2009) was administered to each advisor at the onset of the training program to encourage reflection on intercultural competence. The training was followed by monthly meetings as an Advisor Learning Community, designed to provide opportunity for group reflection on advising practices and provide additional cultural awareness training. Faculty mentors were instructed to schedule monthly meetings with their advisees to discuss goals and plans, aspects of the hidden curriculum when necessary, and any other concerns about their college experience.

Advising Structure

Rather than being paired with a first-year advisor from any academic field, science students from historically marginalized groups were paired with inclusive excellence-trained STEM faculty members who encouraged monthly meetings with each advisee. This high-touch mentoring model allows students and faculty to develop deeper relationships and discuss a broader range of topics important to student success. The mentor advising meetings include discussion of benchmarks toward career-building, including support to apply for summer research fellowships, opportunities for shadowing, and networking skills and practice. Faculty were also encouraged to support preparation and application for internships and recruitment fairs; and assist where needed, with resume and portfolio development.

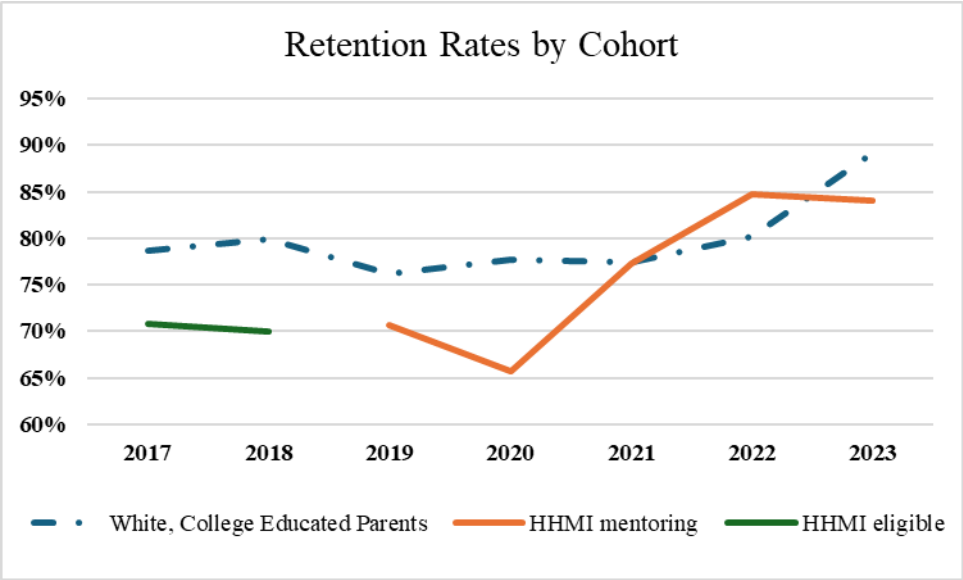
Demographics

Five cohorts (n = 92 – 138) of HHMI IE science students were mentored in the program, for a total of 534 students over five years. On average, the cohorts were 61% female, 63% first-generation college students, and 70% students of color. Most common race/ethnicities were white (30%), Black of African American (22%), Asian (primarily Hmong and Vietnamese, 17%), Hispanic/Latino (15%), and multiracial (13%).

Student Outcomes Data

On average over the five years, 77.2% of students in the program were retained, 19.2% withdrew from university, and 3.5% were dismissed or suspended. For students entering college in 2020, at the height of the pandemic and the racial reckoning, retention fell to 66%. Over the five years of the program, student outcomes data for the HHMI IE cohorts matched or exceeded that of traditionally advantaged students.

Figure 1:
Change in retention rates over time before and during the 2019 – 2023 HHMI Inclusive Excellence grant.



This graph illustrates rates of retention for incoming full-time first year students over time. Students are considered retained if they are either actively enrolled in courses or have subsequently graduated. In 2019, the College of Arts and Sciences was awarded a five-year HHMI Inclusive Excellence Grant to support intensive mentoring for students in the sciences with historically disadvantaged backgrounds (first-generation college students, racial or ethnic minorities, and/or students with high financial need). Students in the HHMI eligible group are science-interested students with historically disadvantaged backgrounds.

Student Assessment of Inclusive Advising

Students participating in the Inclusive Excellence cohort were invited to complete an anonymous survey at the end of their first year in the program. The survey utilized Likert-type items to measure respondents' degree of agreement or disagreement with a variety of statements relating to experiences working with their advisor, their feelings of effectiveness with their studies, and overall satisfaction and sense of belonging at the university. Each item employed a 5-point ordinal scale, allowing for quantification of subjective responses. Lower

numerical values indicate stronger agreement, while higher values reflect greater disagreement.

A series of one-way ANOVAs were conducted to examine whether students' perceptions and experiences differed based on the frequency of meetings with their advisor (less than once per month vs. once or more per month). As shown in Table 1, significant group differences emerged on several items. Students who met with their advisor at least once per month reported feeling more seen, heard, and understood by their advisor, $F(1, 160) = 11.82$, $p < .001$, $\eta^2 = .069$, and reported greater satisfaction with their overall experience at the university, $F(1, 160) = 19.84$, $p < .001$, $\eta^2 = .110$. They also expressed more trust in their advisor, $F(1, 160) = 4.78$, $p = .030$, $\eta^2 = .029$, and were more likely to report that their advisor was helpful in supporting their academic performance, $F(1, 160) = 7.02$, $p = .009$, $\eta^2 = .042$. No significant differences based on meeting frequency were observed on some items, including perceptions of advisor availability, shared life experiences with advisors, and students' sense of belonging at the university. Overall, meeting with an advisor more frequently was associated with more positive student perceptions across several key dimensions of the advising experience. These analyses cannot determine causality, but the most parsimonious explanation of the increased retention in the targeted groups is that the advising intervention was helpful to students' success in college.

The survey included an open-ended question

Table 1.

Student Perceptions of Inclusive Advisor/Mentor Relationship: One-Way Anova

Student Perceptions	M (SD): <1meeting/ month	M(SD) ≥1meeting/ month	F	p	η^2
I found my experience with my advisor to be positive.	1.74 (0.85)	1.45 (0.77)	4.17	0.04	0.025
I found my advisor to be helpful in my academic performance.	2.21 (1.15)	1.74 (0.89)	7.02	0.01	0.042
I felt seen, heard, and understood by my advisor.	1.90 (0.91)	1.41 (0.71)	11.82	0.01	0.069
I have a relationship of trust with my advisor.	1.95 (0.92)	1.60 (0.85)	4.78	0.03	0.029
My advisor was available when I wanted to connect with them.	1.72 (0.79)	1.49 (0.89)	2.08	0.15	0.013
I understand the resources available to me through my advisor.	2.13 (1.13)	1.45 (0.72)	19.84	<.001	0.11
I feel my advisor and I share some life experiences in common.	2.46 (1.12)	2.12 (0.96)	3.4	0.07	0.021
It is important for me to work with an advisor who has similar life experiences to me.	2.28 (0.92)	2.10 (1.04)	0.98	0.32	0.006
I am satisfied with my overall experience at the University.	1.92 (0.83)	1.62 (0.76)	4.26	0.04	0.027
I was effective at studying and learning.	2.41 (1.12)	1.89 (0.93)	7.89	0.01	0.049
My first year helped me to define my career goals.	2.16 (1.14)	1.97 (1.00)	0.92	0.34	0.006
I am satisfied with my academic performance this year.	2.59 (1.09)	2.07 (1.01)	7.29	0.01	0.046
I feel like I belong here.	2.30 (1.08)	1.80 (0.93)	7.33	0.01	0.046

Total sample sizes were n = 123 (≥1 meeting/month) and n = 39 (<1 meeting/month). Degrees of freedom for all ANOVAs were (1, 160). M = Mean; SD = Standard Deviation; η^2 = Eta squared. p values < .001 are reported as < .001. 1= strongly agree, and 5= strongly disagree.

asking students how the inclusive advising program might be improved. Students expressed appreciation for the program and suggested several key areas for enhancement. A consistent theme was the call for clearer communication and more consistent promotion of program events and resources, as some students were unaware of what the program offered. Others recommended more structured interactions, including required or more frequent meetings with advisors, group events to foster community, and better matching of advisors to students' majors, backgrounds, and identities. Additionally, several students requested more academic support, such as clearer degree planning, study groups, and career guidance, as well as improved access to research and co-curricular opportunities. Greater inclusivity, advisor diversity, flexible scheduling, and mental health support were highlighted as additional improvements suggested by a few of the students surveyed.

Conclusion

The University of St. Thomas' implementation of the HHMI Inclusive Excellence funded advising initiative demonstrates that relationship-centered, strengths-based, and culturally responsive academic advising is an effective practice for improving retention and engagement among underrepresented racial/ethnic minority (URM) and first-generation undergraduate science students. Specifically, assigning first-year science students from historically marginalized backgrounds to STEM faculty trained in inclusive mentoring led to retention rates that matched or exceeded those of traditionally advantaged students. The intervention was impactful during the first year of college—a critical period when students are vulnerable to attrition due to academic rigor, inadequate advising, and social isolation.

Frequent mentoring—defined as at least one advisor meeting per month—was associated with significantly higher levels of student trust, satisfaction, and feelings of being seen and understood, based on student self-assessmentsBy explicitly addressing the 'hidden curriculum' of higher education and validating students' lived experiences, this advising model supports science identity formation and counters the systemic barriers that typically hinder success for these populations in higher education STEM pathways Furthermore, this model offers long-term value and sustainability; following an initial investment in advisor training, faculty can integrate and sustain these relational advising practices over time, fostering lasting cultural change in how support is delivered within STEM education.

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