BOARD # 416: NSF S-STEM: Iron Range Engineering Academic Scholarships for Co-Op Based Engineering Education

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Introduction

This paper presents a description of the third year of implementation of the Iron Range Engineering STEM Scholars, funded by the NSF S-STEM award (Award #2221441). The scholarship program includes financial support as well as additional mentorship support for scholarship recipients within the Iron Range Engineering (IRE) program. The paper outlines the format of the scholarship program and a summary of the scholars and their experiences.

Iron Range Engineering

IRE students complete lower-division coursework at community colleges around the nation [1]. Students then join IRE for one semester, named Bell Academy, on campus; this semester is focused on developing students' professional, design, and technical skills. After this first semester, students earn their degree while working in a co-op and earning an engineering salary (average $21.5k per semester). Students remain full-time students through the co-op based learning format by taking 1-credit hour technical competencies and design, seminar, and professionalism coursework. They earn course credit for coursework related to their valuable co-op experience by applying and further developing their professional, design, and technical skills. Approximately 97% of students obtain a co-op in the first semester after Bell Academy; however, students who do not obtain a co-op complete industry projects to develop skills and earn credits through this experience.

After five semesters at IRE, and in as little as four and half years of academic and professional engineering work combined, students graduate with a Bachelor of Science in Engineering degree, with a focus area if desired (e.g. Chemical, Electrical, Mechanical Engineering). IRE is in the Department of Integrated Engineering at Minnesota State University, Mankato (MSU, Mankato). This model is intended to be a financially sustainable option for students, as community colleges typically have more affordable tuition costs, and the income they earn on co-op while earning their degree can offset the tuition costs at MSU, Mankato. The cost for five semesters at IRE is $67k, and on average, students earn $68k while attending school.

IRE STEM Scholars

IRE STEM Scholars is a scholarship and mentorship award for incoming IRE students. It supports students financially in completing the first semester of IRE, the only semester in which students are not earning an engineering income, to help with the costs of tuition. IRE STEM Scholars are also supported in obtaining their first co-op and completing their educational requirements in a timely manner. The program is intended for low-income, high achieving students who otherwise would not have access to a financially sustainable engineering degree. The first semester of tuition is often a barrier for low-income students, particularly nontraditional students who may have other financial responsibilities. Cohort bonding across all students at IRE is crucial to help students develop their sense of belonging and engineering identity.

Methods

As part of this larger concurrent mixed-methods study exploring the development of identity and belongingness of students in a co-op based engineering program, this paper presents a summary of current descriptions of students' engineering identity and belonging.

Survey Instrument

The survey consisted of items on engineering belonging [2], engineering identity [3], co-op information, and demographics. The items on engineering belonging and identity are scored on an anchored scale of 0 to 6 and have previously been tested on a similar population [2]. Results from two consecutive distributions of the survey were used, so that if a participant filled out the 2023 distribution but not the 2024 distribution, their 2023 data were included. For the full survey instrument, refer to [4]. Welch's two-sample t-test for equal means was conducted to compare the overall engineering identity and sense of belonging for the IRE STEM Scholars compared to the other students going through the IRE program.

Interviews

Semi-structured interviews were conducted with n=6 IRE STEM Scholars to support our understanding of their engineering identity and belonging while on co-op. The interview protocol focused on their engineering identity (i.e. "What characteristics of yourself make you like an engineer?") and sense of belonging (i.e. "What experiences have you had that you feel may contribute to feelings of belonging in engineering?"). For more information on the interview protocol and procedures, refer to our work-in-progress [5]. Supporting evidence from preliminary analysis is presented here.

Table 1: Demographic comparison of IRE STEM Scholars (2024), IRE students (2024), and national engineering graduates (2021)

	STEM Scholars 2024	IRE 2024	National Engr. 2021
American Indian or Alaska Native	0%	1%	0.40%
Asian or Asian American	10%	9%	14.70%
Black or African American	3%	5%	4.40%
Hispanic, Latino, or Spanish Origin	27%	15%	12.10%
Middle Eastern or North African	0%	0%	*
Native Hawaiian or Pacific Islander	0%	0%	0.20%
White	47%	56%	60.70%
Multiracial	13%	6%	3.70%
Female	41%	33%	22.50%
Male	51%	65%	77%
Nonbinary, Transgender, Genderqueer	8%	4%	0.50%

Description of Participants

For the quantitative analysis, n=128 participants are included from the 2023 and 2024 survey distribution, 31 of whom are IRE STEM scholars. In the six semesters of implementation, there have been 48 IRE STEM Scholars. The most recent demographic data shows 47% of scholars identify as having a disability, 48% are first generation college students, and 29% are over the age of 24. This compares to the larger population of IRE enrolled in 2024, in which 33% of IRE

students identify as having a disability, 36% identify as being first generation college students, 35% are over the age of 24. Racial and Gender identities are reported in Table 1.

Results and Discussion

Previous work has shown that low-income, first-generation engineering students often struggle with thoughts of belonging in engineering [6]. Although the results are promising, future data may provide insight into our scholars' identity and belonging development, particularly if there are key differences from the larger body of IRE students.

Engineering Identity and Belonging in a Co-op Based Learning Model
The average feelings of belonging for all students was 5.5 out of 6, and the average engineering identity scores for all students was 5.4. These values are comparable to studies on similar populations [2]. The average engineering identity and sense of belonging for the IRE STEM Scholars was then compared in a t-test ($\alpha = 0.05$). It found a significant difference in the IRE STEM Scholars Engineering identity (p-Value = 0.03) and no significant difference in their sense of belonging (p-Value = 0.66). Table 2 shows these descriptive statistics and t-test values.

Table 2: Descriptive statistics and t-test results for Engineering Identity and Sense of Belonging for IRE STEM Scholars and all other IRE students

	Engineering Identity		Sense of Belonging	
	Non-STEM Scholars	STEM Scholars	*Non-STEM Scholars*	STEM Scholars
Mean	5.48	5.15	5.53	5.47
Std. Dev.	0.55	0.80	0.55	0.67
Kurtosis	1.64	1.80	2.06	4.19
Skewness	-1.45	-1.44	-1.69	-2.15
Count	97	31	98	31
df	40		44	
P(T<=t) two-tail	0.03		0.66	

These findings align with the exploratory analysis of qualitative data, in which participants indicate co-op experiences helping to support their confidence and recognition as an engineer, but also participants indicate feeling like their personal identities are ones that they don't see reflected in engineering, particularly with the people that they work with.

For example, in response to the question "What characteristics of yourself make you unlike an engineer?" scholars responded:

> "The parts of me that I know that I don't feel like an engineer because these are the parts that I typically tend to want to hide or not really bring out in a more professional space are definitely things like my background, coming from a family where… I'm the most educated person in my family. …. Being even like being somebody who identifies as queer, that's also something that I, I struggle with when it comes to like more professionalism. And then also being somebody who has experienced several mental health challenges…. being somebody who I guess just comes from a very non-conventional background."

> "I feel like it takes me a long time to understand what's going on. So at work, for example, I probably need something explained a couple of times."

When asked about "What experiences have you had that you feel may contribute to feelings of belonging in engineering?" responses focused on feeling a sense of community with their cohort or with individuals on their co-op:

> "A lot of my belonging in engineering, I think, has. Has come from those specific experiences, from talking about things that I was interested in and then also finding other People who are also interested in that. The, the excitement, sharing, the, the sharing of. I don't know, like, I think a lot of that is, is really the experiences that I've had with individuals and sharing our interests."

Co-Op Experiences of IRE Scholars

A significant necessity to the financial viability of IRE and the financial success of the IRE STEM scholars is dependent on obtaining a co-op after their first semester of preparation. Most scholars have received a co-op shortly after their first semester; for our most recent cohort, 11 of the 12 scholars had a co-op by the first month after Bell Academy. The average co-op pay for IRE scholars is comparable with the program average, at $25 per hour, for an average of 40 hours of work per week. Co-op contracts range from eight months to indefinitely. Average hours worked and months on first co-op are also comparable to the IRE average (39.6 hours per week and 10.2 months on first co-op).

In response to the prompt "Please tell us a little about any job search goals you've had and if you feel that you've met those (i.e. location, discipline, or specific company)," we see many of our scholars reaching their job search goals, with only two indicating not being able to get a co-op in their desired discipline and one not finding a co-op close to home.

Summary

In summary, progress is being made in our project goals of recruitment, retention, and development of knowledge, skills, and abilities. Scholars are finding a sense of community through their co-op experiences and peers in their cohort. Co-op experiences have been financially beneficial, and most of the IRE STEM Scholars are reaching their co-op goals and gaining experience in areas of engineering that will be beneficial to their future careers.

References

[1] B. Johnson and R. Ulseth, "Iron Range Engineering Model," in *PBL in Engineering Education*, A. Guerra, R. Ulseth, and A. Kolmos, Eds., Rotterdam: SensePublishers, 2017, pp. 53–69. doi: 10.1007/978-94-6300-905-8_4.

[2] L. Benson, C. Bolding, J. Ogle, C. McGough, J. Murphy, and R. Lanning, "Engineering Students' Perceptions of Belongingness in Civil Engineering," in *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida: ASEE Conferences, Jun. 2019, p. 32737. doi: 10.18260/1-2--32737.

[3] W. C. Lee, A. Godwin, and A. L. H. Nave, “Development of the Engineering Student Integration Instrument: Rethinking Measures of Integration: Rethinking Measures of Integration,” *J. Eng. Educ.*, vol. 107, no. 1, pp. 30–55, Jan. 2018, doi: 10.1002/jee.20184.
[4] Bocharev, Neeko, Siverling, Emilie, Thonpson, Ellen, and Spence, Catherine, “Engineering Identity, Belonging, and Neurodiversity in a Co-Op Based Learning Program,” in *American Society for Engineering Education National Conference*, Montreal, Quebec, 2025.
[5] C. Spence, L. Nyberg, J. Chasmar, J. Nelson, and M. Tsugawa, “Working Full Time and Earning an Engineering Degree: Wellbeing in a Co-op-Based Engineering Program.,” in *American Society for Engineering Education National Conference*, Minneapolis, MN., under review 2022.
[6] J. M. Smith and J. C. Lucena, “Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering,” *Eng. Stud.*, vol. 8, no. 1, pp. 1–26, Jan. 2016, doi: 10.1080/19378629.2016.1155593.