Board 387: S-STEM: Iron Range Engineering Academic Scholarships for Co-Op Based Engineering Education

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1. Introduction

This paper presents a description of the second 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. IRE is a practice-based, upper-division engineering program, in which students recruited primarily from community colleges around the country, complete their 300- and 400-level engineering courses for a B.S. in Engineering while completing co-ops or industry projects. The paper outlines first the format of the scholarship program and a summary of the second year of implementation, then a quantitative description of students' community and sense of belonging at IRE.

1.1 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 also earn course credit for coursework related to their valuable co-op experience by applying and further developing their professional, design, and technical skills. Approximately 95% 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 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 (MNSU, Mankato). In this study, IRE students were asked about their feelings of belonging to the school, program, and department. 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 MNSU, Mankato. The cost for five semesters at IRE is $67k and on average, students earn $68k while attending school.

1.2 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, such as dependents.

In the four semesters of implementation, there are 24 IRE STEM Scholars. Eight identify as female, thirteen identify as male, and three identify as transgender, nonbinary, and/or genderqueer. The first cohort had 2 scholars, and they have started their second year of co-op. The second cohort has 4 scholars, and they are completing their first year of co-op. The third cohort has 12 scholars who have started their first semester of co-op. The fourth cohort has 7 students who are currently completing their first semester. Cohort bonding across all students at IRE is crucial to help students develop their sense of belonging and engineering identity, and preliminary work has identified imposter syndrome as a key concern for IRE students' feeling of belongingness while on co-op [2]. In this study, we quantitatively assess students' feelings of belongingness and identity in the program and while on co-op as a measure to assess our work in creating bonding within the program and managing imposter syndrome. We also explore qualitatively how our IRE STEM Scholars feel about their upcoming co-ops.

2. Knowledge Generation

To better our understanding of how to recruit and retain low-income students, and better support them in obtaining an engineering degree and thriving, the IRE STEM Scholars program includes a concurrent mixed-methods study [3] to: (1) Identify key factors connected to co-op students' thriving, (2) Implement continuous improvement at a program level to better support IRE STEM Scholars, and (3) Establish and disseminate IRE as an accessible pathway for low-income status students to achieve an engineering degree, highlighting key support elements for other co-op programs to consider.

2.1 Methods

As part of this larger study exploring the development of identity and belongingness of students in a co-op based engineering program, this paper presents current descriptions of engineering students' identity and belonging in a co-op based program. This information supports the larger student body in providing a baseline for a longitudinal study. IRE students were surveyed at the end of the semester, during finals week, named "EngFest" to capture the conference and collaborative nature of the finals. EngFest is a conference-style gathering where all students in the program return to northern Minnesota for one week to share their co-op experiences, connect with the IRE community, and demonstrate their technical, design, and professionalism skill building. Descriptive statistics and exploratory qualitative approaches were used to analyze these initial data.

2.1.1 Survey Instrument

During EngFest, students were given a survey consisting of items on engineering belonging [4], engineering identity [5], co-op information, and demographics. Belonging was measured through 5 program community items, such as "I feel that I am a part of Iron Range Engineering"; 10 department community items, such as "There is a strong feeling of togetherness in the integrated engineering department"; and 3 school community items, such as "I feel there is a sense of community at this school" The items on engineering belonging and identity are scored on an anchored scale of 1 to 7 and have previously been tested on a similar population [6].

2.1.2 Description of Participants

Out of the 89 enrolled students, n=76 Iron Range Engineering students responded to the survey. Of these students, 41% identified as first generation college students, 30% as nontraditional (over the age of 24), 26% as having a disability, 5% as veterans. Further demographic breakdowns and the comparison to the national demographics of students graduating with a BS in engineering are shown below in Table 1.

Tabe 1: Demographic comparison of IRE students (2023) and national engineering graduates (2021)

Demographic Categories	IRE	National Engineering 2021 [7]
American Indian or Alaska Native	10%	0.4%
Asian or Asian American	0%	14.7%
Black or African American	4%	4.4%
Hispanic, Latino, or Spanish Origin	18%	12.1%
Middle Eastern or North African	0%	*
Native Hawaiian or Pacific Islander	1%	0.2%
White	62%	60.7%
Multiracial	6%	3.7%
Female	20%	22.5%
Male	71%	77%
Nonbinary, Transgender, Genderqueer	7%	0.5%

*(Reported with Asian or Asian American)

2.2 Results

Previous work has shown that low-income, first-generation engineering students often struggle with thoughts of belonging in engineering [8]. 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.

2.2.1 Engineering Identity and Belonging of IRE Students in Co-op Based Learning Model

The average feelings of belonging to the school were 6.4 out of 7, 6.5 to IRE, and to the department 6.4. These values are comparable to studies on similar populations [6]. Average engineering identity score is 5.9 out of 7.

Several themes emerged through the exploratory qualitative analysis of a prompt of "Has your co-op experiences impacted your feelings of belonging in engineering, and if so, how?" For our scholars who

have started in their co-op, industry experiences have helped with feeling like an engineer. For example, one scholar states: “It has made me feel much more confident in my engineering abilities and understanding, to be out on co-op and to be able to apply what I have learned to real world work.” However, scholars state how they have experienced barriers to their identity and sense of belonging while practicing engineering, with examples of misogyny.

For our scholars who have not yet started their first co-op, they have identified how the job search has impacted their feelings of belonging. Our two scholars who have not identified a co-op indicate feeling discouraged in the difficulty of the job search, with comments such as “. I'm not going to get accepted to every place but I can keep on apply and hope for it”. The scholars who have obtained a co-op identify validation through the job search process:

> “Finding a co-op has massively boosted my overall feelings about how I belong with engineering. Having that validation that someone thinks I may have what it takes outside of the education atmosphere.”
>
> “Being able to get interviews as well as offers for engineering positions makes me feel like I'm supposed to be an engineer more.”

Other scholars chose to answer the prompt focused on their experience in the program: “Yes, it lets me know people find my skills valuable and worth hiring.” It is clear from the responses that scholars have found a sense of community and belonging through IRE. However, there are concerns about feelings of belonging and identity with the broader engineering community: “I am worried about continuing to find a sense of belonging after I leave the program. I feel so much that I belong in the IRE community that I am worried I won't find a community like this again.”

2.2.2 Co-Op Experiences of IRE Scholars

A significant necessity to the financial viability of IRE and the financial success of our IRE scholars is dependent on obtaining a co-op after their first semester of preparation. All but two IRE Scholars have received a co-op starting the month after their first semester. The average co-op pay is comparable with the program average, at $24.88 per hour, and 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 location constraints are a major consideration for our scholars, one that limits options for co-op placement and could potentially be a obstacle in their pursuit of a financially sustainable pathway through engineering. We also saw many of our scholars meeting their location and discipline goals, including scholars who set very broad goals for both.

3. Summary

In summary, progress is being made in our project goals of recruitment, retention, and development of knowledge, skills, and abilities.

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