

Board 330: Iron Range Engineering Academic Scholarships for Co-Op Based Engineering Education

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

1. Introduction

This paper presents a description of the first 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 an experienced-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 first year of implementation, then a quantitative description of students' community and belonging at IRE.

1.1 Iron Range Engineering

IRE students complete lower-division coursework at community colleges around the nation [1]. Then students join IRE for one semester on campus for preparation 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, and 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 their first semester after joining IRE; 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 as little as four and half years of school and work combined, students graduate with a Bachelor of Science in Engineering with a focus area if desired (i.e. 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 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 to support 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, and support students 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, to dependents for example.

In the two semesters of implementation, there are six IRE STEM Scholars. Four identify as female and two as male. Two have completed their first semester of IRE and have moved on to co-op experiences and four 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 are feeling 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 will support the larger student 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 present on things such as their co-op experiences, connect with others, and demonstrate their technical, design, and professionalism skill building. Descriptive statistics and exploratory qualitative approaches were used to analyze this initial data.

2.1.1 Survey Instrument

During EngFest, students were given a survey consisting of items on engineering belonging [4], engineering identity 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 3school community items, such as "I feel there is a sense of community at this school." The items on engineering belonging and identity are score on a anchored scale of 0 to 6 and have previously been tested on a similar population [6].

2.1.2 Description of Participants

Out of the 99 enrolled students, n=85 Iron Range Engineering students responded to the survey. Of these students, 34% identified as first generation college students, 30% as nontraditional (over the age of 24),

23.5% 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.

Table 1: Demographic comparison of IRE students (2022) and national engineering graduates (2021)

Demographic Categories	IRE	National Engineering 2021 [7]
American Indian or Alaska Native	6%	0.4%
Asian or Asian American	0%	14.7%
Black or African American	6%	4.4%
Hispanic, Latino, or Spanish Origin	8%	12.1%
Middle Eastern or North African	0%	*
Native Hawaiian or Pacific Islander	1%	0.2%
White	67%	60.7%
Multiracial	11%	3.7%
Female	18.8%	22.5%
Male	77.7%	77%
Nonbinary, Transgender, Genderqueer	5.9%	0.5%

*(Reported with Asian or Asian American)

2.2 Results

Previous work has identified 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 scholar's 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 5.65 out of 6, to IRE 5.63 and to Integrated Engineering 5.72. These values are comparable to studies on similar populations [6].

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?” Overwhelmingly students describe gaining experience in engineering either through courses or through co-op as supporting their engineering belonging.

Some students actually noted that the job search process of seeking a co-op supported or hindered their feelings of belonging in engineering. For example, one student described “Yes. I found that during many interviews I have had I was respected as an engineer and not a student,” while another student stated, “I feel like I don’t have enough skills to go out into the world, and I’ve been told so by an interviewer. I no longer feel motivated to find a job, because I am scared that I won’t be enough.”

Some students specifically describe how it has helped improve their struggle with imposter syndrome. For example, one student stated that their interactions with co-workers on co-ops have supported their feelings of belonging: “They [co-ops] have done a lot to get rid of my imposter syndrome. All the people that I work with are very supportive and come to me with questions.”

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 dependant on obtaining a co-op after their first semester of preparation. All IRE Scholars have received a co-op starting the month after their first semester. These co-ops were all obtained by the students facilitated through one of the program’s career fairs. The average co-op pay is \$22.50 per hour (compared to the average at IRE for the first co-op of \$21.62 per hour), with 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 reflection, IRE STEM scholars identify as feeling “fairly prepared” for their upcoming semester and co-op while acknowledging that a significant amount of work has been done to help with preparation. One scholar indicates they have grown significantly during the Bell Academy. One IRE scholar identifies that obtaining the co-op has helped them feel more like an engineer, which is supported by strong quantitative data related to community and belonging for our IRE Scholars (Average 6 out of 6 for community items and 5 out of 6 on identity items). When asked about their overall motivation; all scholars indicated their current level of motivation being value-driven, meaning doing something because it fits with one’s own deeply held values. Reasons for indicating this level of motivation varied from bringing value to others helps motivate them individually to indicating that IRE emphasizes value.

3. Summary

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

4. 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] 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.

- [3] J. C. Greene, V. J. Caracelli, and W. F. Graham, “Toward a Conceptual Framework for Mixed-Method Evaluation Designs,” *Educ. Eval. Policy Anal.*, vol. 11, no. 3, pp. 255–274, Sep. 1989, doi: 10.3102/01623737011003255.
- [4] A. Kirn *et al.*, “Intersectionality of Non-normative Identities in the Cultures of Engineering,” in *2016 ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 25448. doi: 10.18260/p.25448.
- [5] 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.
- [6] 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.
- [7] “Engineering and Engineering Technology by the Numbers 2021.pdf.”
- [8] 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.