Looking Ahead: Structure of an Industry Mentorship Program for Undergraduate Engineering Students

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ABSTRACT

The matriculation, retention, and graduation of students is a critical and ongoing effort in undergraduate engineering education. Implementing measures is vital in increasing student motivation to continue pursuing engineering and is especially important for individuals from low-income and academically talented students. At the University of Illinois at Chicago, our NSF Scholarships in Science, Technology, Engineering, and Mathematics Program includes students from all six departments in the College of Engineering and includes multiple implementations such as a summer bridge program, faculty mentoring, and a service-learning project. Here, we define and implement a longitudinal Industry Mentorship (IM) program structure. While the implementation of this program is still ongoing, we present here the basic structure of the IM program, the rationale for the structure, and some preliminary results of implementation.

Key words: Industry mentorship, mentorship structure, mentor-mentee pairing, undergraduate, engineering

INTRODUCTION

The matriculation, retention, and graduation of students are critical in undergraduate engineering education. One mechanism of support is the National Science Foundation’s Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM), which provides financial assistance and
mentorship ("NSF Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM)" n.d.); (S. R. Burckhard et al. 2018); (Fortenberry et al. 2007). In S-STEM programs, and others like it, mentorship is commonly provided by faculty and peers (Voyles et al. 2011); (Wilson et al. 2012); (Touton et al. 2004). This mentorship provides insight into grades, study habits, and time management. Some programs include aspects of industry mentorship, which provides insight into current industry trends, skill crafting, professional networking, and facilitates development of engineering identity. Examples of industry mentorship include requiring periodic meetings between students and industry members to affirm and prepare for careers (S. Burckhard et al. 2018), curating selected co-ops/internship opportunities for students with local industry partners (Ranade and Smolleck 2003), pairing first-year student groups with local professionals whose practice relates to the group’s interest (Green, Niemi, and Roudkovski 2012), developing a year-long industrial mentorship program with an automated software for mentor-mentee pairing (Przestrzelski and Roberts 2019), and developing an online-based network for automated mentor-mentee pairing and mentorship (Single and Muller 2001) with options for site visits and shadowing (Anderson and Northwood 2002). While these programs are efficacious, they have varied structures for mentor-mentee pairing, limited guidance on interactions, and do not often extend beyond one year. Longitudinal mentorship is important to develop rapport, a sense of belonging, and engineering identity (Estrada, Hernandez, and Schultz 2018); (Byars-Winston and Rogers 2019); (Atkins et al. 2020).

The S-STEM program at University of Illinois at Chicago (UIC) started in 2017 and includes students from all six departments in the College of Engineering (Darabi et al. 2020). Our program includes a summer bridge program (Nazempour et al. 2019), first-year courses (Nazempour et al. 2019),
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2020), faculty mentoring, and a service learning project (Darabi et al. 2021), as shown in Figure 1. Here, we define and report on a novel industry mentorship (IM) program as part of S-STEM, which is innovative due to a longitudinal structure and new mentor-mentee pairing algorithm. All authors are personnel on the NSF grant, and in that capacity serve as faculty advisors for students in their particular department and also actively manage the funded program including development of the IM program and its components as discussed herein.

METHODS

We utilized a four-stage mentorship structure (Scerri, Presbury, and Goh 2020), shown in Figure 2. At each stage, there are distinct objectives for industrial mentors and mentees to complete, as outlined in Table 1. The timeline for the IM program is flexible but we recommend beginning after completion of introductory coursework and commitment to a major of study. Mentorship should then continue through the student’s graduation. All relevant documents for the IM program can be provided upon request.

Stage 1: Participant Pairing

Local industry mentors are recruited from College alumni, College and Departmental advisory boards, and program faculty contacts. Pairing is based on both surface- and deep-level similarities...
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(Patton and Bondi 2015). Surface-level characteristics include gender, race, ethnicity, and major of study, whereas deep-level characteristics include attitudes, interests, goals, experiences, and values. The balance and consideration between surface- and deep-level characteristics is designed to deliver effective mentorship through trust and authentic engagements (Blake-Beard et al. 2011).

Both mentors and mentees completed surveys regarding surface- and deep-level characteristics. To quantify mentor-mentee pairing, a similarities index algorithm is used to quantify a matching score. A matching score is generated for all mentor-mentee combinations based on scoring criteria and multiplicative weights. The weight of surface- and deep-level questions are +1 and +2, respectively. A summary of questions, response format, criteria for scoring, and scoring methodology is provided in Table 2. Questions which addressed engineering identity, self-worth, and background were preliminarily more heavily weighted than personal hobby or interest. The maximum possible score is 15.5.

Mentor-mentee pairing is performed by optimizing the sum of total matching scores using the “assignment problem” algorithm (Hillier 2012) solved with R. To supplement pairing, participants complete an abridged Myers-Briggs Type Indicator (MBTI) (La Perle 2013) and share resumes.

Stage 2: Participant Preparation

Orientations are provided to both mentor and mentee as inspired by similar programs ("CIMER" n.d.), Nucleus Learning of Mentorship ("STEM Mentor Training — Nucleus Network" n.d.), and Branchaw et al (Branchaw, Butz, and Smith 2020). Orientation materials for both include mentorship philosophy, IM program purpose/structure, and expectations (communication, professionalism, timeliness, goals). Mentor orientation also includes background literature, appropriate methods, equity and inclusive-ness training, and methods for culturally responsive mentorship. After orientation, both groups should attend an introductory banquet where they first meet and the pairing logic is discussed.

Stage 3: Participant Interaction

We provide tools and framework for mentor-mentee interactions to establish an effective relationship (Pritchard and Grant 2015); (Washington and Cox 2016). Mentors and mentees together define meeting logistics, frequency (minimum of once per semester), goals, and overall mentorship expectations. Progress reports are also included to provide a granular reflection of each meeting and document the following: date, meeting theme, reflection from the meeting (long response), action items, and tracking of mastery for up to 10 specific skills. Notably, skills tracking occurs longitudinally.

Stage 4: Evaluation and Outcomes

The efficacy of mentor-mentee pairing and longitudinal mentorship is determined by the program faculty. To facilitate assessments, the research assistant conducts annual interviews and
### Table 2. Questions to assess surface- and deep-level similarities between industrial mentors and student mentees. Response formats, criteria for scoring, and scoring values are provided.Ws and Wd are surface- and deep-level weights with values of +1 and +2, respectively. Questions were inspired by contemporary literature, program faculty, and feedback from industry mentors. All questions were reviewed by both the program faculty and an external program evaluator.

<table>
<thead>
<tr>
<th>Index</th>
<th>Similarity Level</th>
<th>Mentee Questions</th>
<th>Alternative Phrasing for Mentors</th>
<th>Response format</th>
<th>Criteria for Scoring</th>
<th>Scoring Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>surface</td>
<td>Gender</td>
<td>NA</td>
<td>Free response, unrequired</td>
<td>Same response</td>
<td>+1*Ws</td>
</tr>
<tr>
<td>2</td>
<td>surface</td>
<td>Ethnicity</td>
<td>NA</td>
<td>Free response, unrequired</td>
<td>Same response</td>
<td>+1*Ws</td>
</tr>
<tr>
<td>3</td>
<td>surface</td>
<td>Have you attended a community college prior to UIC?</td>
<td>Did you attend a community college while a student?</td>
<td>Yes/No</td>
<td>Same response</td>
<td>+0.5*Ws</td>
</tr>
<tr>
<td>4</td>
<td>surface</td>
<td>What is your major of study?</td>
<td>What was your major of study?</td>
<td>Multiple choice</td>
<td>Same response</td>
<td>+1*Ws</td>
</tr>
<tr>
<td>5</td>
<td>deep</td>
<td>Select which of these extracurriculars you have participated in</td>
<td>NA</td>
<td>Checkbox</td>
<td>Same positive responses</td>
<td>+0.5*Wd</td>
</tr>
<tr>
<td>6</td>
<td>deep</td>
<td>As a student, what challenges have you experienced?</td>
<td>NA</td>
<td>Checkbox</td>
<td>Same positive responses</td>
<td>+1*Wd for each checkbox (max of +3 total)</td>
</tr>
<tr>
<td>7</td>
<td>deep</td>
<td>To what extent have you experienced imposter syndrome as an engineering student?</td>
<td>To what extent did you experience imposter syndrome as an engineering student? Imposter syndrome: feeling inadequate or a sense of self-doubt despite having been successful.</td>
<td>Likert, 0-5 (“not at all” and “an extreme amount”, respectively)</td>
<td>The same response both being &gt;2</td>
<td>+1*Wd</td>
</tr>
<tr>
<td>8</td>
<td>deep</td>
<td>What general professional skills do you want to strengthen before graduating? (i.e., what skills do you want to have prior to employment)</td>
<td>What are your general professional skills?</td>
<td>Checkbox</td>
<td>Same positive responses</td>
<td>+0.25*Wd for each checkbox (max of +2 total)</td>
</tr>
<tr>
<td>9</td>
<td>deep</td>
<td>How important is it for you to give back to your community using your engineering knowledge?</td>
<td>NA</td>
<td>Likert, 0-5 (“not important at all” and “extremely important”, respectively)</td>
<td>The same response both being &gt;2</td>
<td>+1*Wd</td>
</tr>
<tr>
<td>10</td>
<td>deep</td>
<td>How important is it that others (such as family and friends) recognize and acknowledge you as an engineer?</td>
<td>NA</td>
<td>Likert, 0-5 (“not important at all” and “extremely important”, respectively)</td>
<td>The same response both being &gt;2</td>
<td>+1*Wd</td>
</tr>
</tbody>
</table>
surveys with mentors, mentees, and faculty advisors separately to evaluate outcomes from various perspectives. De-identified data is then analyzed to determine results related to graduation, post-graduation placement, engineering identity, skills development, program implementation, and mentorship dynamics.

**PRELIMINARY RESULTS**

In the UIC S-STEM program, there are three cohorts. Here we report on stage 1 of one Cohort. Participants were surveyed and results were coded for the similarities index algorithm. In this Cohort, most students were from the computer science major (7/11) and the algorithm was only applied to them with seven potential computer science mentors. Mentors’ motivation to participate in the program was related to altruism, communication and leadership training, and professional advancement. There were limited student participants from other majors and so mentor-mentee pairing was performed manually on a departmental basis. Matching scores for the computer science students are shown in Table 3. The max matching score was 12.5, the minimum was 3, and the average was 7.13±2.60. Though a minimum value for standard deviation was not declared, the variability of scores enables our methodology to obtain optimal mentor-mentee pairing. The optimal pairings are shown in Table 3 with an asterisk. Paired participants are currently in stage 3. To frame the stage 3 interactions, we suggested the following topics: skills development, career options, networking, site visits, job shadowing, and conflict resolution. From ongoing faculty mentorship with these students, mentees of this cohort reported that their interactions with mentors have been very helpful.

<table>
<thead>
<tr>
<th>Mentee</th>
<th>Mentor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.5</td>
<td>10.5*</td>
<td>6</td>
<td>8</td>
<td>10.5</td>
<td>9.5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>7.5*</td>
<td>11</td>
<td>8</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>7.5</td>
<td>6.5</td>
<td>5.5</td>
<td>7.5</td>
<td>7.5</td>
<td>9.5*</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.5</td>
<td>7</td>
<td>6*</td>
<td>3</td>
<td>4.5</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.5</td>
<td>6</td>
<td>4.5</td>
<td>4</td>
<td>10.5</td>
<td>6.5</td>
<td>12*</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5*</td>
<td>7</td>
<td>4.5</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3.5</td>
<td>8.5</td>
<td>4.5</td>
<td>7</td>
<td>12.5*</td>
<td>8.5</td>
<td>10.5</td>
<td></td>
</tr>
</tbody>
</table>

*Table 3. Computer Science similarities index algorithm scores for each mentor and mentee pair. Asterisks denote optimal pairings.*
In general, we encountered practical challenges during implementation, including identifying enough unique mentors, compliance with the program structure, and administrative organization.

**NEXT STEPS**

Future work includes the validation of the similarities' algorithm and relative weighting of questions through a comparison of outcomes between cohorts. Furthermore, the effect of a longitudinal mentorship framework will be evaluated on Stage 4 outcomes. Programmatic changes for the future include the use of individual development plans in Stage 3, expansion of the program within the College of Engineering to include students outside the S-STEM program, and utilizing the collective alumni base as a source for mentors.

**REFERENCES**


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