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

BETUL BILGIN

ANTHONY E. FELDER

HOUSHANG DARABI

REZVAN NAZEMPOUR

SHANON RECKINGER

RENATA A. REVELO

DIDEM OZEVIN
University of Illinois at Chicago

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.

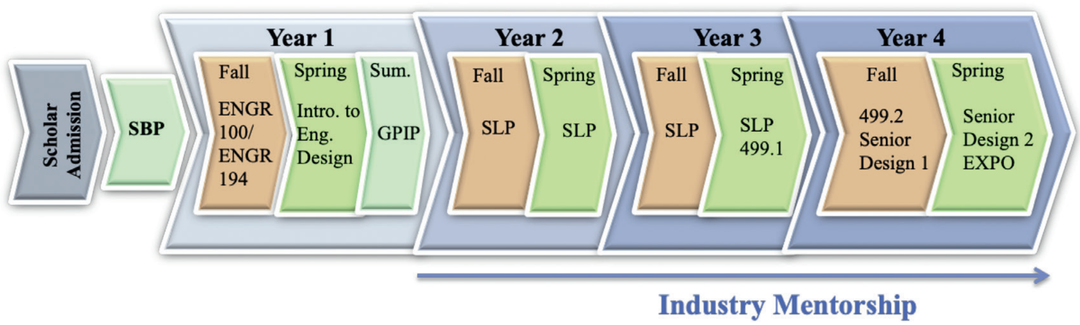

Figure 1. Structure of the S-STEM program at UIC. Scholars are admitted and matriculated through a summer bridge program (SBP). Students participate in special first-year classes (ENGR 100/ENGR 194, Intro. To Eng. Design) and research opportunities (GPIP) before a two-year service-learning project (SLP) and a capstone senior design class. Industry mentorship begins in the second year and extends through the student's senior year.

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

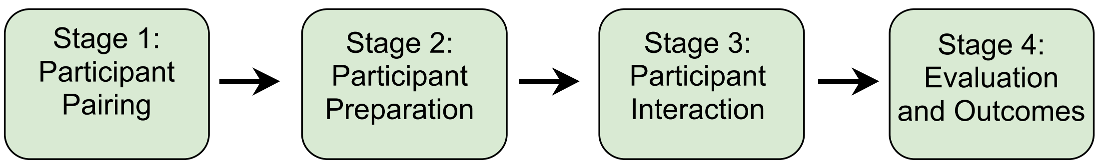

Figure 2. Four stages of effective mentorship.

Table 1. List of actions in each stage of the Industry Mentorship Program.

	Stage 1 (participant pairing)	Stage 2 (participant preparation)	Stage 3 (participant interaction)	Stage 4 (evaluation and outcomes)
Mentors	Complete Resume upload, Pairing Survey, Myers-Briggs Type Indicator survey	Mentor orientation	Progress Report approval	Mentors survey and workshop
Mentees	Complete Resume upload, Pairing Survey, Myers-Briggs Type Indicator survey	Mentee orientation	Complete Progress Report	Mentee survey and workshop

(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 inclusiveness 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.

Index item	Similarity Level	Mentee Questions	Alternative Phrasing for Mentors	Response format	Criteria for Scoring	Scoring Value
1	surface	Gender	NA	Free response, unrequired	Same response	+1*Ws
2	surface	Ethnicity	NA	Free response, unrequired	Same response	+1*Ws
3	surface	Have you attended a community college prior to UIC?	Did you attend a community college while a student?	Yes/No	Same response	+0.5*Ws
4	surface	What is your major of study?	What was your major of study?	Multiple choice	Same response	+1*Ws
5	deep	Select which of these extracurriculars you have participated in	NA	Checkbox	Same positive responses	+0.5*Wd
6	deep	As a student, what challenges have you experienced?	NA	Checkbox	Same positive responses	+1*Wd for each checkbox (max of +3 total)
7	deep	To what extent have you experienced imposter syndrome as an engineering student? Imposter syndrome: feeling inadequate or a sense of self-doubt despite having been successful.	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.	Likert, 0-5 ("not at all" and "an extreme amount", respectively)	The same response both being >2	+1*Wd
8	deep	What general professional skills do you want to strengthen before graduating? (i.e., what skills do you want to have prior to employment)	What are your general professional skills?	Checkbox	Same positive responses	+0.25*Wd for each checkbox (max of +2 total)
9	deep	How important is it for you to give back to your community using your engineering knowledge?	NA	Likert, 0-5 ("not important at all" and "extremely important", respectively)	The same response both being >2	+1*Wd
10	deep	How important is it that others (such as family and friends) recognize and acknowledge you as an engineer?	NA	Likert, 0-5 ("not important at all" and "extremely important", respectively)	The same response both being >2	+1*Wd

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 3. Computer Science similarities index algorithm scores for each mentor and mentee pair. Asterisks denote optimal pairings.

	Mentee						
Mentor	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	6.5	10.5*	6	8	10.5	9.5	10
2	4	8	4	7.5*	11	8	12.5
3	7.5	6.5	5.5	7.5	7.5	9.5*	9.5
4	4.5	7	6*	3	4.5	4	5
5	3.5	6	4.5	4	10.5	6.5	12*
6	5*	7	4.5	6	8	4	9.5
7	3.5	8.5	4.5	7	12.5*	8.5	10.5

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.

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AUTHORS

Betul Bilgin is a Clinical Associate Professor of the Chemical Engineering Department at the University of Illinois at Chicago (UIC). Betul received her M.S. degree in Biomedical Engineering from the University of Minnesota and her Ph.D. in Chemical Engineering from Michigan State University. Betul's interests include engineering education, team-based learning, and biotechnology.

Anthony E. Felder is a Clinical Assistant Professor in the Richard and Loan Hill Department of Biomedical Engineering at the University of Illinois at Chicago (UIC). Anthony received his Ph.D. in Bioengineering from UIC. Anthony's interests include engineering education, retinal oxygenation, and the development of novel ophthalmic medical devices.

Houshang Darabi is a Professor of Industrial and Systems Engineering in the Department of Mechanical and Industrial Engineering (MIE) at the University of Illinois at Chicago (UIC). His research group uses Big Data, process mining, data mining, Operations Research, high performance computing, and visualization techniques to achieve its research and educational goals.

Rezvan Nazempour is a graduate research assistant at the University of Illinois at Chicago. She is completing her Ph.D. in Industrial Engineering and operations research at the Mechanical and Industrial Engineering Department. She received her BSIE and MSIE from Iran University of Science and Technology (IUST) and Alzahra University, respectively. Her research interests include educational data mining, graph mining, and machine learning.

Shanon Reckinger is a Clinical Associate Professor in the Computer Science Department at the University of Illinois Chicago (UIC). Shanon received her MS and PhD in the area of Computational Fluid Dynamics from the University of Colorado at Boulder in 2010 and 2011, respectively, and her MS in Computer Science from Stanford University in 2018. Shanon's research interests include computational fluid dynamics and computing education.

Renata A. Revelo earned the B.S., M.S. in electrical and computer engineering, and Ph.D. in education organization and leadership in 2007, 2009, and 2015 respectively from the University of Illinois at Urbana-Champaign. She is currently a Clinical Associate Professor of Electrical and Computer Engineering at the University of Illinois at Chicago. Her research interests include engineering identity development, the culture of engineering, social and critical consciousness in engineering, and success of underrepresented students in engineering.

Didem Ozevin is a professor in the Department of Civil, Materials and Environmental Engineering at the University of Illinois at Chicago (UIC). Didem received her Ph.D. in Civil Engineering from Lehigh University. Didem's interests include engineering education, nondestructive evaluation of materials and structures.