An Integrated Program for Recruitment, Retention, and Graduation of Academically Talented Low-Income Engineering Students

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Dr. Houshang Darabi is an Associate Professor of Industrial and Systems Engineering in the Department of Mechanical and Industrial Engineering (MIE) at the University of Illinois at Chicago (UIC). Dr. Darabi has been the Director of Undergraduate Studies in the Department of MIE since 2007. He has also served on the College of Engineering (COE) Educational Policy Committee since 2007. Dr. Darabi is the recipient of multiple teaching and advising awards including the UIC Award for Excellence in Teaching (2017), COE Excellence in Teaching Award (2008, 2014), UIC Teaching Recognitions Award (2011), and the COE Best Advisor Award (2009, 2010, 2013). Dr. Darabi has been the Technical Chair for the UIC Annual Engineering Expo for the past 7 years. The Annual Engineering Expo is a COE's flagship event where all senior students showcase their Design projects and products. More than 700 participants from public, industry and academia attend this event annually. Dr. Darabi is an ABET IDEAL Scholar and has led the MIE Department ABET team in two successful accreditations (2008 and 2014) of Mechanical Engineering and Industrial Engineering programs. Dr. Darabi has been the lead developer of several educational software systems as well as the author of multiple educational reports and papers. Dr. Darabi's research group uses Big Data, process mining, data mining, Operations Research, high performance computing, and visualization techniques to achieve its research and educational goals. Dr. Darabi's research has been funded by multiple federal and corporate sponsors including the National Science Foundation, and National Institute of Standards and Technology.

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Dr. Peter C Nelson, University of Illinois at Chicago

Peter Nelson was appointed Dean of the University of Illinois at Chicago's (UIC) College of Engineering in July of 2008. Prior to assuming his deanship, Professor Nelson was head of the UIC Department of Computer Science. In 1991, Professor Nelson founded UIC's Artificial Intelligence Laboratory, which specializes in applied intelligence systems projects in fields such as transportation, mobile health, manufacturing, bioinformatics and e-mail spam countermeasures. Professor Nelson has published over 80 scientific peer reviewed papers and has been the principal investigator on over $40 million in research grants and contracts on issues of importance such as computer-enhanced transportation systems, manufacturing, design optimization and bioinformatics. These projects have been funded by organizations such as the National Institutes of Health, the National Science Foundation, the National Academy of Sciences, the U.S. Department of Transportation and Motorola. In 1994-95, his laboratory, sponsored by the Illinois Department of Transportation, developed the first real-time traffic congestion map on the World Wide Web, which now receives over 100 million hits per year.

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Betul Bilgin is Clinical Assistant Professor of Chemical Engineering (CHE) at the University of Illinois at Chicago (UIC) and has been teaching the Senior Design I and II courses for 6 years and Introduction to Thermodynamics for two years. Since her appointment in 2014 she has been exploring active learning, peer instruction, team-based, hands-on, application-based techniques in her classes to fully engage her students. She was selected as a UIC Teaching Scholar for Spring 2017, named as an American Institute of Chemical Engineers (AIChE) "35 under 35" winner in the education category for 2017 and named as American Society for Engineering Education (ASEE) "20 under 40" awardee for 2018.

Dr. Yeow Siow, The University of Illinois at Chicago

Dr. Yeow Siow has over fifteen years of combined experience as an engineering educator and practitioner. He received his B.S., M.S., and Ph.D. from Michigan Technological University where he began his teaching career. He then joined Navistar's thermal-fluids system group as a senior engineer, and later brought his real-world expertise back into the classroom at Purdue University Calumet. He is currently a Clinical Associate Professor at the University of Illinois at Chicago where he enjoys success in teaching and education research.

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Abstract

This paper provides detailed information for a poster that will be presented in the National Science Foundation (NSF) Grantees Poster Session during the 2020 ASEE Annual Conference & Exposition. The poster describes the progress and the state of an NSF Scholarships in Science, Technology, Engineering, and Math (S-STEM) project. The objectives of this project are to 1) enhance student learning by providing access to extra- and co-curricular experiences, 2) create a positive student experience through mentorship, and 3) ensure successful student placement in the STEM workforce or graduate school. S-STEM Scholars supported by this program receive financial, academic, professional, and social development via various evidence-based activities integrated throughout their four-year undergraduate degrees beginning during the summer prior to starting at the University.

The paper describes the characteristics (demographics, high school GPA, ACT/SAT scores, etc.) of the Scholars supported by the S-STEM grant. The paper also provides information about the completed tasks of the project to date. The completed tasks include a system for recruiting academically talented and economically disadvantaged students, a Summer Bridge Program (SBP), a first semester introductory engineering course, and a system to recruit and maintain faculty mentors. The ongoing tasks include the execution of a service learning project course and a system for recruiting industry mentors. This paper reports detailed assessment and evaluation data about different project tasks and the academic success metrics of the Scholars. It also lists a set of recommendations based on the lessons learned in this S-STEM project.

Introduction to the Scholarship

Although there are a lot of remarkable organizational and personal efforts and significant financial investment in recruiting low income engineering students, the number of these talented students and professionals is considerably low [1] [2]. As a research-intensive, urban, and Minority Serving Institution, the six-year graduation rate in the College of Engineering at the University of Illinois at Chicago of academically talented, low-income students is 38% lower than that of academically talented, high-income students. To address the issue of low retention and graduation rates of academically talented low-income students, any strategy should consider this.

The S-STEM program at the University of Illinois at Chicago began in 2017; the duration of the grant that currently sustains the S-STEM project is five years. The objectives of this project are to 1) enhance student learning by providing access to extra- and co-curricular experiences, 2) create a positive student experience through mentorship, and 3) ensure successful student placement in the STEM workforce or graduate school. Different evidence-based activities are implemented

throughout the Scholars' four-year degrees to support them financially, academically, professionally, and socially.

This paper summarizes the completed tasks of the project in the 30 months since its inception and summarizes the activities projected for the remainder of the project.

S-STEM Scholars First and Second Cohorts

Eighteen students were recruited, interviewed, and selected in the first half of 2018 as the first Cohort of S-STEM Scholars. The second Cohort of S-STEM Scholars included 13 students, all of whom were recruited, interviewed, and selected by the end of spring semester of 2019 and before starting the second Summer Bridge Program (SBP). S-STEM Scholars from both Cohorts received financial assistance, based on their individual need, in addition to the support program provided.

Tables 1 and 2 show the degree major, gender, and race information of the first and second Cohorts of the Scholars.

Table 1. Scholars' majors

Major		BioE	ChE	CME	ECE	CS	IE	ME	Total
Number of Scholars	Cohort I	1	2	3	2	4	1	4	17**
	Cohort II	1	1	1	1	7	0	2	13
	Total	2	3	4	3	11	1	6	30

* BioE: Bioengineering, ChE: Chemical Eng., CME: Civil & Materials Eng., ECE: Electrical & Computer Eng., CS: Computer Science, IE: Industrial Eng., ME: Mechanical Eng.
** Originally, there were 18 Scholars recruited for the first Cohort but one of them dropped out of the University after the first year.

Table 2. Scholars' general information

Information		Gender		First Generation (NCES)	Race				
		F	M		Hispanic	African American	Asian	American Indian	White
Number of Scholars	Cohort I	7	10	7	7	2	3	2	3
	Cohort II	5	8	3	0	1	5	0	7
	Total	12	18	10	7	3	8	2	10

As Tables 1 and 2 show, the S-STEM Scholars represent the majority of the engineering majors in the College of Engineering. Out of 30 Scholars, 12 are female and 18 are male. In total, 10 students are first-generation college students and 3 of the students identify as Black/African American and 7 as Hispanic.

Progress and State of the Scholarship

In this section, we report the progress of the project nearly 30 months after its inception. There are various activities that have been designed for the Scholars. In the remaining subsections, we

discuss the feedback and lessons learned from the completed tasks. Additionally, we describe the progress of the ongoing tasks.

Feedback and Lessons Learned from the Completed Tasks

S-STEM Scholars Eligibility and Selection - Second Cohort. Citizenship, academic talent, and financial need are the main criteria for the selection of the Scholars. After the Scholars were pre-selected, they had an in-person interview with the Award Committee members. A specific metric called Selection Index (SI) has been developed by the University Administration for admissions, which represents the predicted first semester GPA. We described this metric in Darabi et al[3].

Table 3 shows the average high school GPA and SI for both cohorts of the Scholars.

Table 3. Scholars' high school GPA and SI score

Cohort/Metric	Number of Scholars	Average High School GPA (out of 4.00)	Average SI Score (out of 4.00)
Cohort I	17	3.749	3.324
Cohort II	13	3.916	3.777
Total	30	3.821	3.520

For Cohort II of the Scholars, students had to be U.S. citizens or permanent residents and be eligible for the Federal Pell Grant, which were similar to the first Cohort selection criteria. Moreover, their SIs should be within a target range for recruitment. A list of students admitted to the University who met these criteria were contacted in March of 2019 and 36 of them were interviewed by the Award Committee, later in the spring semester. The goal of the interviews was to examine the motivation and maturity of each candidate. After each interview, the Award Committee members scored each candidate based on assessment criteria such as motivation and leadership, potential to succeed in engineering, being goal-oriented, etc. The committee then discussed scores for each student. Finally, 14 students were offered scholarships based on the committee's input and 13 of them accepted the offer.

Second Summer Bridge Program - Second Cohort. The Summer Bridge Program (SBP) consists of a one-week, residential, and immersive experience designed to prepare S-STEM students transitioning into college and sustaining success throughout their undergraduate years [4]. There are four main categories that SBP focuses on including lectures, workshops, field trips, and hands-on. The goal of these activities was to help to ensure Scholars' academic success, to provide peer and faculty mentorship, to establish professional goals, to foster community involvement, and to provide emotional support. Five types of assessment were employed to evaluate the SBP components. These include both qualitative and quantitative methodologies, in addition to formative and summative assessments.

Data collected from these evaluations showed that an "Industry Expert Panel", which was implemented for the first time in SBP for Cohort II, was the most popular and informative session for the Scholars. During this session, they learned about the industry, the job process, and how to

make connections for a successful career in the future. The assessment results also helped us identify any SBP components that needed attention such as extending the duration of CAD/3D printing hands-on activity, converting some modules from seminar-style to self-paced, and allowing Scholars to revisit the "Learning Your Educational System" material. We intend to use the evaluation results and lessons learned from the SBP executions to build a sustainable Summer Bridge Program for all first-year engineering students.

Mentorship Program. During the SBP, each Scholar was paired with a student ambassador. For Cohort II, S-STEM Scholars from Cohort I serve as ambassadors.

To ensure that all Scholars have access to resources and feel supported, each Scholar was also assigned to a faculty mentor. We implemented the mentoring program structure for Cohort I in 2019 and we continue the mentoring sessions for all 30 Scholars. Moreover, during the monthly investigator meetings, the team discusses the results of their mentoring sessions and strategies to strengthen the mentoring program.

Introductory Engineering Course (ENGR 194). ENGR 194 was offered for the first time in Fall 2018 for Cohort I. After analyzing the evaluation results, the investigators decided to apply several modifications including removing math focused study group and redesigning the" Entrepreneurship Challenge" module. After the revisions, the course was offered to Cohort II in Fall 2019. To evaluate our performance of ENGR 194 in Fall 2019, we also created a comprehensive survey at the end of the semester. Based on the results, the investigators discussed each component of the course and coordinated course improvement. The effectiveness of the course will be reported in a separate paper.

Guaranteed Paid Internship Program. In Summer of 2019, Cohort I participated in the Guaranteed Paid Internship Program (GPIP). GPIP is a novel, ongoing program in the College of Engineering that guarantees qualified, academically talented students a paid internship or research opportunity as long as they commit to returning to the College the following fall semester.

Sixteen out of 17 of the Cohort I Scholars completed GPIP in academic research laboratories inside or outside of the University of Illinois at Chicago, technology companies, or makerspace. Our assessment showed that, during GPIP, the Scholars acquired various engineering and research skills, and learned how to tackle real-world engineering problems in industrial setting.

Progress of the Ongoing Tasks

Execution of a Service Learning Project Course (ENGR 294). In Fall 2019, Cohort I Scholars attended a Service Learning Project (SLP) course which was implemented for the first time at the University. This course creates an opportunity for students to engage with their local community and provides students with a sense of pride and belonging through their efforts. Following the service learning model, the course also has a reflection component to allow Scholars to deeply

connect with themselves and the community. During the last session of the course, Scholars presented a summary of their service learning project proposals to their fellow Scholars, peers, and faculty. Cohort I Scholars will continue to work on the SLP and enroll in the SLP course for three more semesters, until Spring 2021.

Recruiting Industry Mentors. The College of Engineering Industrial Advisory Board has guaranteed to provide all S-STEM Scholars with industry mentors. These mentors come from diverse backgrounds, which will help in their engineering identity development.

Cohort I Scholars are gradually being assigned to industry mentors. As of early spring 2019, 9 out of 17 Scholars were introduced to their industry mentors. These mentors will help the Scholars transition from academia to the professional world. They will assist Scholars in obtaining internships or jobs. They will also offer a valuable insight into what skills are in demand in the workforce and will provide guidance to Scholars on ways to build these skills.

Generation of Knowledge

The results of the implementation of an introductory course (ENGR 194) for first-semester engineering Scholars and its impact on retention improvement and academic success have been analyzed, and a report on the findings submitted to an education conference. Moreover, we have conducted engineering identity focused interviews with Cohort I Scholars and the results have been disseminated by R.A.Revelo et al [5].

Conclusions

As of the submission of this paper, we have recruited 30 Scholars. The diversity of both S-STEM Scholar Cohorts combined is reflective of the student diversity on campus and college demographics. We offered various evidence-based activities such as the Summer Bridge Program, mentorship program, an introductory engineering course (ENGR 194), and a service learning project course (ENGR 294). These activities provided financial, academic, professional, and social support to S-STEM Scholars.

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