Comparing Effectiveness of Peer Mentoring for Direct Admit and College-Ready Freshmen

Dr. Teresa J. Cutright, The University of Akron

Dr. Cutright is a Professor of Civil Engineering at The University of Akron. She has a B.S., M.S., and Ph.D. in Chemical Engineering with emphasis on environmental remediation techniques with over 20 years of experience conducting site assessments, soil characterizations and treatability studies for a variety of environmental contaminants. In addition she also conducts education research via an EPA education grant and a NSF Scholarships for STEM education. Most recently she and her colleagues were awarded a NSF collaborative research grant to host workshops to broaden the participation of underrepresented minorities that in engineering.

Dr. Rebecca Kuntz Willits, The University of Akron

Rebecca Kuntz Willits is the Margaret F. Donovan Endowed Chair for Women in Engineering, a professor and interim department chair in the Department of Biomedical Engineering at The University of Akron and a member of the National Center for Regenerative Medicine at Case Western Reserve University. She obtained her undergraduate degree in chemical engineering at Tufts University, her MS in chemical engineering at Johns Hopkins University and her PhD in chemical engineering at Cornell University. Her current research interests are at the intersection of nerve regeneration, tissue engineering, and biomaterials, and are funded by the NSF and NIH. As an educator, she has received STEM-based funding from the National Science Foundation to support undergraduate research, STEM scholarships, and diversity.

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The University of Akron has had two National Science Foundation (NSF) funded science, technology, engineering and mathematics scholarship (S-STEM) programs. The cohort of the first S-STEM program (2010-2015) were students that were directly admitted to their selected discipline's department. The current NSF S-STEM cohort (2015-2020) is a mix of students who were either directly admitted to their major or college-ready students. The university classifies college-ready students as those who are ready for college but lack either a requisite high school GPA, ACT score or completion of a high school science or math course. Each program spanned five years with science disciplines typically graduating in four years and engineering students that participated in co-operative education graduating in five years. The final year of each S-STEM was used to provide peer mentoring in a pseudo-formal environment. In each, seniors who had already participated in the S-STEM program for four years mentored new freshmen for one year. This paper will describe demographics of each S-STEM cohort, the activities used during the peer mentoring, observable differences between direct admit and college-ready freshmen with respect to peer mentoring, and possible peer mentoring activities that can be implemented at other institutions.

Introduction

In 2018, 622,502 undergraduates enrolled in Bachelor of Science (BS) engineering programs in universities across the U.S. That same year women, African American, Hispanics, Native American and Hawaiian/Pacific Islanders earned 21.9%. 4.2%, 11.4%, 0.3% and 0.2% of the B.S. engineering degrees, respectively [1]. Women are often drawn to engineering disciplines where they can 'help' or give back [2], therefore, it was not surprising that women pursue environmental engineering (50.6%) and biomedical engineering (45.5%) more than the other disciplines [1]. Although the overall ASEE data indicated that the number of degrees awarded to underrepresented groups was higher than the previous year, the number of degrees for African Americans had decreased [3]. Retention of undergraduates in STEM programs has also been an issue. In 2009, 55% of students who started college with a declared STEM major either changed majors or left without earning a degree [4]. By 2018, only 53% of declared engineering majors obtained an engineering degree after six years [5]; with attrition being higher for underrepresented groups [6]. An in-depth literature review by Gesinger and Raman [7] reported the key factors of attrition in engineering disciplines to be classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interest and career goals, and race and gender. Social-psychological threat from stereotypes attributed to women and ethnic minorities exacerbate issues associated with classroom climate and self-efficacy [8], [9].

Significant efforts have been made to address retention in undergraduate engineering education. Research has found supplemental programs such as early research experiences, STEM learning communities, active learning in introductory courses, tutoring and mentoring to be effective to

varying degrees depending on the specific student's situation [5], [10] - [13]. Mentoring is not limited to faculty-student interactions. An early study by Good [14] indicated that freshmen needed networking with upperclassmen to ease the transition from high school to university. Clark et al. [15] attributed peer relationships as a key factor in the success of student satisfaction, integration and retention in higher education. Peer mentoring can build a community of support for the mentee (i.e., freshmen) while enhancing the teamwork, instruction and communication skills of the mentor (i.e., senior) [10]. When mentoring is from someone that is close in age and position, it can also provide encouragement and social support [11]. Social support from mentors and other women in STEM increased women's persistence in STEM [16]. This paper will describe demographics of each S-STEM cohort, the activities used during the peer mentoring, observable differences between direct admit and college-ready freshmen with respect to peer mentoring, and possible peer mentoring activities that can be implemented at other institutions

Selection Criteria

Two NSF grants used to provide scholarships to undergraduates pursuing STEM degrees were awarded to The University of Akron. The Scholarships for STEM (S-STEM) were awarded to the same cohort of students from the freshmen year until graduation. Scholarship recipients were selected based on the financial need, academic standing, and selection of a STEM discipline for their undergraduate degree. Care was taken to select students who met the aforementioned criteria and enabled the formation of a balanced team of engineering and non-engineering students. Students received their scholarship as long as the maintained continuous enrollment in courses leading toward a STEM degree, 3.0 GPA and actively participated in the one-credit course associated with the scholarship each semester. The course was used to enable more one-on-one interactions between students and faculty as well as with their teammates from different disciplines. Students who left the program (switched to a non-STEM major or no longer met academic requirements) were replaced with other STEM students who were already enrolled at The University of Akron. The replacements were made to maintain the cohort at the same academic level. Typically, students pursing a biology, chemistry, or mathematics degree graduate in four years, while students pursuing an engineering degree who participated in a co-op would require 5 years. Thus, after some of the original cohort graduated, there were sufficient funds to recruit new freshmen for the final academic year.

All of the students recruited during the 2010-2105 grant cycle were directly admitted to their selected discipline; with most being honors students. In addition, freshmen recruited to participate during the 2014-2105 year were all honors students. The student cohort during the 2015-2020 grant were a mix of students directly admitted to their selected department and college-ready students. The university classifies college-ready students as those who are ready for college but lack either a requisite high school GPA, ACT score or completion of a high school science or math course. Six freshmen were recruited to participate during the 2019-2020 year; five college-ready and one directly admitted.

Cohort Descriptions

The last year of the cohorts is described below, as that is the focus for peer mentoring.

First S-STEM Cohort 2010-2015

During the last academic year of the program (2014-2015) there were eight seniors (five male and five female) and eight new freshmen. Three of the freshmen (37.5%) were male and five (62.5%) female. Four of the seniors (50%) and three (37.5%) of the freshmen were from the Appalachia area (most poverty-stricken area in Ohio). The intended area of study for the S-STEM scholars was very diverse. Three were pursing biology, biochemistry, mathematics degrees from the College of Arts & Science. Five of the students were in the College of Engineering (two in Chemical Engineering, one Biomedical Engineering, one Civil Engineering and one Electrical Engineering). The disciplines of the freshmen matched the disciplines of the seniors. One of female freshmen left the program after one semester to pursue a non-STEM degree. The direct admit freshmen were specifically recruited from the pool that had already been admitted to the University and were qualified to be an Honor's student. The Honors qualification was used as these students would have the greatest potential for success at The University of Akron and Honor's scholarships to offset tuition costs.

Second S-STEM Cohort 2015-2020

The last academic year of the second S-STEM project started with 13 seniors spanning biomedical engineering (4), chemical engineering (5), civil engineering (3), and computer engineering (1). Five of the seniors were women and 8 were men. Of the 13 continuing students, 8 were directly admitted students while five were college-ready students. Two of the biomedical engineering 'senior' students graduated at the end of the fall semester.

Five new college-ready and one direct admit freshmen were recruited for the last year of the program. Three of the freshmen were male, three female, five Caucasian and one African American. One student was pursuing a biology degree, one electrical engineering, three civil engineering and one biomedical engineering.

Data collection and methods

Data was collected by external project evaluators and observations by the faculty mentor. A rubric was developed by the evaluators during the 2015-2020 project for the faculty mentor to rate each student's performance in the four areas identified as defining strong collaborative and mentoring skills throughout the fall and spring semesters.

Likert scale surveys where responders specify level of agreement to statements (strongly agree, agree, neither agree/disagree, disagree, strongly disagree) were administered and analyzed by project evaluators using descriptive statistics. A paired sample t-test was performed to determine if there was any significant change from pre to post assessments within group, with a p-value of .05. A two-sample t-test assuming unequal variance was used to compare the two groups.

Open ended survey questions were analyzed by performing a content analysis. Each response was entered into a computer software, then codes were assigned to the response inductively. The initial codes were later condensed into fewer codes based on program learning outcomes. Direct

quotations of responses that are provided in this document are verbatim to illustrate the responses by theme.

Class activities

A one credit class was used to provide interaction between the students, time for assignments and deliver course content. The first day, the faculty mentor gave an overview of the class expectations and peer mentoring. Next each student introduced themselves (discipline, hometown, high school size, Star Trek vs Empire Strikes Back and favorite food). Inclusion of movie preference and favorite food was used as an ice breaker. Details on hometown, high school size, and discipline were used to 'make connections' between the students. Seniors had also been instructed to include one piece of advice that they found most useful for college or that they wished they had known/paid attention to as freshmen (Table 1). First homework was assigned on the first day of classes. The partial listing of fall homework assignments in Table 2 were required to be completed by all students in both S-STEM projects. During the Fall semester seniors delivered 15-minute presentations, developed in conjunction with the faculty mentor, on the topics presented in Table 2. After the presentation, the non-presenting seniors augmented the topic by providing an example as to how they had benefited from or had used the topic either during their co-op or core class(es). The remainder of the class was spent on topics needed by the freshmen. The 'need' varied each week. At the start of the semester it entailed mentors helping mentees with studying (pre-calculus, calculus, or chemistry), navigating campus, and questions about transitioning to college. McCavit and Zellner [13] and Meyers et al. [17] also found that first year students to be more receptive about expectations of classes, using office hours, pace of classes, etc. from peers than from faculty. As the semester progressed, the majority of mentor-mentee discussions included completing the semester project.

Table 1. Seniors one thing I wished I had "known" or had "paid attention to" when I was a freshman

Student	Designation admission status as freshmen	Advice
Male	College-Ready	*Show up to class! No person/parent is forcing you to go. Easiest way to get the grade is to go to class.*
Male	Direct Admit	*I came from a small high school with small classes. Pace was very quick when I was a freshman. Do best to keep up so do not fall behind. One way is to use the planner (as homework one)*
Female	Direct Admit	*You will hear about tutoring. Did not need to study when in high school. First time I went to tutoring was awkward; but was very beneficial. Do not be afraid to go.*
Male	College-Ready	*Going to office hours might seem scary. Professors are people too. Use the resource. Professors are helpful and know what they covered in class so well prepared to help.*
Female	Direct Admit	*Do not be afraid to ask questions. Helps build relationship with professor, plus other students have the same question.*

Male	Direct Admit	*Upperclassmen are great resource. Can help with advice on books (purchase, pdf, rent, etc.)*
Female	College-Ready	*Don't take risks and do too much in a semester.*
Male	Direct Admit	*Manage time wisely. Do not wait til last minute to do things. Better to study gradually instead of last second.*
Male	Direct Admit	*Get as much co-op experience as possible.*
Female	College-Ready	*Always try to start assignment on day assigned–even if busy.*
Male	Direct Admit	*Hold onto lessons learned in class or advice from instructors, will use in co-op job*
Male	College-Ready	*Join design teams. Great way to meet others and learn other things*.
Female	Direct Admit	*Mentally step away from school if needed. If crying on math assignment, step away for a minute. If you manage your time well, taking time will be possible.*

Table 2 Activities for freshmen cohort, peer mentoring roles and homework assignments

Semester	Freshmen Activities	Peer Mentor Role
Fall 2019	Soft skills: study habits, time management, note taking, and communication.	"One thing advice" Example of how skill used in class or co-op.
	How to conduct a literature review.	Community building
	Select project topic.	Extra resource
	Start bibliography and draft of paper.	Technical source
	Identify how discipline can contribute to solving topic.	Community building
Spring 2020	Continue bibliography.	Community building
	Technical report.	Extra technical resource
	Poster presentation.	Practice audience
Common Homework	Thoroughly read syllabus for each class. Write down important dates for each class in calendar/planner.	Preparation for semester and time management
	Complete estimated time log of weekly activities. Include all activities (time in class, study, work, leisure, etc.).	Time management
	Specifically describe how to take notes. Does not mean which notes you took. Instead describe process of how you took notes.	Identification of style Effectiveness of process Reinforce need
	Describe how to actively/carefully listen to a lecture.	Self-identification of how spend time in class.

Four possible topics selected for year-long project: harmful algal blooms, water scarcity, antibiotic resistant bacteria in water, pesticides/pharmaceuticals in wastewater. Freshmen and seniors completed two bibliography entries on articles provided by the faculty mentor on each to

identify which topic they were most interested in. Permitting students to select their own group/topic that pertained to issues relevant to their home state had the added benefit of often increasing motivation [18], [19]. Most of the students self-selected into groups based on interest. Three of the seniors (college-ready admission status) switched to a second interest to provide resource for the freshmen interested in harmful algal blooms. As one of the freshmen noted,

> *"Having two seniors switch to a topic for my benefit helped show importance in what we were doing."*

Survey results

The final survey will be administered in May 2020. Comparison of the first and second cohort's final survey results will be discussed at the time of the presentation. It is important to note that 50% of the freshman from the 2010-2015 S-STEM project found peer mentoring from the seniors to be the most helpful aspect of their freshmen year.

Participants in the second mentoring program were given a survey with open-ended questions and a Likert scale (5 strongly agree, 4 agree, 3 neither agree/disagree, 2 disagree and 1 strongly agree) at the end of the Fall 2019 semester. Although the freshmen felt they were adequately using the mentors as a resource (4.4), the seniors were neutral. This could also be attributed to the senior outnumbering the freshmen. The one student that was not fully utilizing his mentor thought the "*class was a wonderful experience,"* but switched to a non-engineering major and told the faculty mentor that he did not want to "*get too close to my mentor.*"

Both the freshmen and seniors expressed a feeling of respect (Table 4). This was important as respect and honesty are the most desirable attributes in a mentor-mentee relationship [20]. The majority of the mentor-mentee occurred face-to face when in class. Any contact outside of class (20%) was predominantly via email or text. When asked what areas they felt had benefited most from the mentorship program, freshmen listed communication skills (80%), time management (40%), study skills (100%), personal attitude toward learning (80%), analytical problem solving (60%) and self-confidence (40%). Interestingly it was the female freshmen that indicated that their self-confidence had increased. Female freshmen from the first cohort had also reported "*interaction with seniors helped me feel more confident*." Self-confidence has been identified major factor in persistence of underrepresented groups [16], [21]. Students from underrepresented groups primarily derive their perceived competence from contact with classmates [6]. Thus, the psychological/emotional support from mentoring can increase self-confidence and professional identity [22]. Seniors also had moderately strong agreement (4.27±0.75) that peer mentoring was improving their ability to communicate. The same sentiment was provided by the first cohort.

> One first cohort senior said, "*Having to explain how to do a literature review to freshmen made me really think about how to do it.*"

Table 4. Results of mentor-mentee survey administered in Fall 2019 to 2015-2020 S-STEM cohort

Mentee	Statement	Score
Quality	My peer mentor & I enjoy high quality relationship	4.2±0.7
	I am effectively utilizing my peer mentor	4.4±0.8
	I am benefiting from the mentoring relationship	4.4±0.5
	My peer mentor is helping with the transition from high school	4.4±0.8
Learning	gaining better sense be successful/involved	4.4±0.5
	gaining new skills	4.4±0.8
	becoming more openminded/consider others' feelings/attitudes	4.4±0.8
	improving my ability to communicate effectively	4.4±0.5
Misc.	mentor is easy to talk to	4.6±0.5
	I respect my mentor	4.8±0.4
	feel my mentor respects me	4.6±0.5
Mentors		
Quality	mentee and I are enjoying a high-quality relationship	4.09±0.67
	mentee is effectively utilizing me	3.64±0.98
	both mentee & I are benefiting from experience	3.91±0.79
From being mentor	gaining better sense how to be successful	4.18±0.72
	gaining new skills	4.18±0.83
	becoming more open-minded/consider others' feelings/attitude	4.09±0.79
	improving my ability to communicate effectively	4.27±0.75
Misc.	easy to talk to mentee	4.55±0.66
	mentee & I respect each other	4.82±0.39
	felt well prepared	4.09±1.08

Faculty mentor observations across both cohorts

Direct admit freshmen from the first cohort depicted an 'air of confidence' that college-ready freshmen of the second cohort did not appear to have. This was particularly true at the start of fall semester. By the end of the fall semester, the college-ready comfort level in the class had increased to the point that they would ask questions of the seniors and faculty mentor without prompting. The direct admit freshmen reached this point before the college-ready freshmen.

In general, male freshmen were more confident of abilities than female students. An earlier study across multiple institutions found that female engineering undergraduates began studies with lower confidence in background knowledge and ability to succeed in engineering than their male counterparts [23]. However, female mentors can help mitigate the female freshmen students' anxiety about succeeding in engineering [24]. This is important as increasing a student's belief in their abilities is one of the key indicators in their ability to persist in engineering [25].

Two of the seniors from each S-STEM project were more proactive at getting their mentees to participate. In the first 2010-2015 cohort the most proactive (based on observations) was a

female civil engineering and female chemical engineering student. When asked why they were being proactive, both women indicated that when they were freshmen themselves, they did not realize importance of connecting with others, and they "*wanted to give back*" and make sure that new "*freshmen knew importance of interacting with mentors."* For the second 2015-2020 cohort, the most proactive was male direct admit student and male college-ready student. The male college-ready student indicated that:

> *"I like the addition of the peer mentorship aspect of this class. It was nice to have new faces and to be able to hopeful help new freshman to be prepared for their engineering curriculum."*

The male direct admit student enjoyed being a peer mentor so much that he is now considering academia as a career option and will start his graduate career in Fall 2020. Beltman and Schaeben [26] surveyed 858 mentors across multiple disciplines and found that mentors had sense of satisfaction and achievement in helping new students.

Conclusions

The peer mentoring was successful at helping engineering freshmen transition to college. College-ready freshmen were more reluctant to participate at the start of the semester than freshmen who had been directly admitted to their discipline. This was attributed to the students' high school GPA and being on track in the mathematics course. Overall, female mentors were beneficial at helping increase the confidence of female freshmen. In both project cohorts, freshmen were more willing to accept statements pertaining to value of program from peer mentors over the faculty mentor.

Providing face-to-face interaction within the class was essential in establishing initial connections. Other institutions would have to weigh the benefits to freshmen with adding another course to the curriculum. One possible option could be to have a 0-credit class for incoming freshmen so they could garner the benefits from peer mentoring without the addition cost. Although a few students (both freshmen and seniors) would have participated in the peer mentoring program without the scholarship, it was key factor for the majority of the students. A potential enticement for seniors could be a service project for Tau Beta Pi or another student organization.

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