Effect of Organizational Change on Student Retention and Engagement

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Effect of organizational changes on student retention and engagement

Abstract

Engineering and computer science disciplines remain substantially under-represented in Hispanic, African American and women students. Relative to the population demographics reflecting approximately 50% women, 60% white non Hispanic/Latinx, 13% African American, 19% Hispanic and 1.3% Native American, engineering demographics reflect under-representation. While recent trends reflect significant gains, women remain under-represented in engineering. Based on the ASEE EDMS system, in 2022, women earned 25% of engineering degrees and under-represented students (URM=African American, Hispanic, native American and Pacific islanders) earned 21% of degrees. From a first time in college enrollment in a university perspective, URM freshmen accounted for 27% of all freshmen enrollment. Within that the African American student population was at 6% and Hispanic at 13%. The gap between freshmen enrollment at the Universities and higher percentages at graduation reflects the trend that URM students are entering the University experience beyond the freshmen level making the transfer student engagement and retention a key need. In this paper we explore systematic organizational change in communicating the degree pathways to a graduation in engineering and engaging students sequentially from enrollment through graduation. We explore these in the pre-pandemic, post-pandemic, new HSI designation macro changes in the University. The results indicate that students are benefitted from having administrators, faculty and full-time staff work synergistically to communicate information that can be accessed by students without needing an appointment/commute and to grow a students pathway to lifelong learning through research is best enabled through student-student direct engagement.

Introduction

The need for the Engineering and Computer Science graduates in the workforce is high.[1] National STEM occupation growth is projected to surpass growth in all other occupations. [2,3] Nearly all STEM jobs require some type of post-secondary credential. Belser et al. [4], probed the effect of harnessing career trajectory to alleviate retention challenges in freshmen and sophomore years of an engineering degree. They modelled variables such as race and gender, SAT score and math readiness on retention stats. While nationally, trends in high school graduation for college enrollment project contractions, Texas is among the handful of states that will see an increase in the number of high school graduates in the next 15 years. Those increases will reflect a more diverse student body with 75% of the high school graduates being non-White. [5] Institutions will need to focus on serving students that have historically been underserved and marginalized within higher education. The cost of education has been identified as a significant contributor to challenges with broadening participation of all demographics in the engineering workforce.

The career and job market trends have driven increased efforts to grow science and engineering interest in schools. Positive trends in enrollment are reflective of the growth of STEM and STEAM academies, growth of middle and high school camps, outreach activities by non-profits and universities [6]. Efforts at the community colleges and universities include tutoring, diversity

offices within engineering with supplementary support for under-represented students to navigate the colleges. There is however a considerable difference in engineering enrollment demographics when comparing urban and college town, high endowment and minimal endowment university offerings. As states cut funding to public universities, two trends have emerged. First the cost to a student for a degree attainment decreases as a growing dual credit in school to community college to university pathway has developed [7]. Second, universities are growing research activity with a combination of temporary (adjunct), non-tenure instructors, tenured research faculty. From the ASEE-EDMS data, in 2022, non tenure track full time and part time instruction accounted for 24% of the instructional staff. The general correlation between non-tuition revenue and resource availability has led to increase deference to the Carnegie research rankings for universities emerging from being teaching focused.[8]

The University of North Texas metrics of performance over the 2003-2023 period are reflective of growing science and engineering value in urban areas. A new college of engineering was created in 2013 with Materials Science, Computer Science and Engineering Technology forming the founding departments. New non-doctoral granting departments of Mechanical and Energy Engineering and Electrical Engineering were subsequently created with provision of doctoral granting across the majors enabled by 2015. In 2017 a new department of biomedical engineering was added. The University attained the highly research active doctoral degree public university R1 status in 2015 and maintained it in 2018 and 2022. While many R1 schools will have a high ranking for science and engineering, at UNT this has not correlated. Resources for academic support in terms of tutoring are centrally offered with a ratio of approximately one tutor for 250 students for less than 10% of freshmen and sophomore classes. In 2020, the University was designated a HSI with a 28% Hispanic enrollment. The University of North Texas in 2015 had 11, 1.42, 8 and 23% African American, American Indian, Pacific Islander, Hispanic students respectively. In contrast the college of engineering had 15, 1.51,7.25 and 23% African American, American Indian, Pacific Islander, Hispanic students respectively. This reflects that the college demographic mirrors the University with a higher fraction of African American students.

In this paper we outline organizational change efforts to impact student retention that require low financial investments paired to increased student engagement systems enabled by an NSF-HSI grant. The sequential macro changes and the organizational change we have executed are outlined in Table 1.

Table 1: Macro-change and organizational change for student recruitment and engagement

Year	College Environmental Conditions	Organizational efforts
2003-2014	New college, 2 doctoral degrees R2 Carnegie Status	Student enrollment in engineering and computer science based on interest/no application of SAT/ACT score criteria. Retention rate of <40% associated with inability to meet pre-requisites, GPA leading to suspension, probation
2015	R1 Carnegie, all programs have doctoral granting ability.	Students not able to enroll in Calculus 1 not enrolled in the college
2018	All students with engineering interest enter the college	Students not able to enroll in Calculus 1 enrolled in the college in a pre-major program within the college
2019	Pre-pandemic year	Pass/No Pass grading options for Spring 2020 semester. Transfer partnership initiated with community colleges
2021	Post-pandemic year, proactive program for under-represented students DEEN launched and integrated with deans office direct supervision.	Return to pre-pandemic teaching modes. Add pre-calculus degree plans. Student cohorts formed with emails inviting students to events to connect to SHPE, SWE, NSBE from associate dean
2022	Continued management of DEEN	Student cohorts formed with emails inviting students to events to connect to SHPE, SWE, NSBE signed by students and emailed from associate deans office
2023	Transition to student organization oversight for students.	Student cohorts formed with emails inviting students to events to connect to SHPE, SWE, NSBE and emailed by students to students

Math readiness organizational change

At UNT, all 8 long semester (fall/spring) degree plans in engineering and computer science required enrollment in Calculus 1. Calculus has been the focus of much of the interventions with significant benefits evident through use of spatial visualization[9], Wright Math [10] interventions among others. Nearly all engineering universities provide a math placement test to students prior to enrollment should they not meet requirements for enrollment in the first calculus course via the Advanced Placement (AP) exams or International Baccalaureate (IB) or dual credit transfer. Students are immediately offered interventions such as math tutoring etc. Concerns have arisen that by utilizing success in math as the means of assigning interventions, a student begins their engineering and computer science journey with a deficit framing [11]. We utilized a series of changes by using a combination of organizational and human interventions. In Table 2, we provide the demographics of the cohort starting in a series of fall semesters. Students

enter the college as first time in college (FTIC) or transfer students. Students who begin in Calculus 1 or higher are denoted as math ready (MR) and will meet pre-requisites for enrollment in courses following a prescribed path to graduation. Students are non-MR if they will be required to enroll in courses such as pre-calculus, algebra or below. Retention of students 6 years after the starting semester is reported in Table 3. Retention will reference either enrollment or graduation.

As a baseline, in 2015, 766 exhibited interest in engineering. 536 students enrolled in Calculus 1 while 230 were not enrolled in math 230. The impact of being advised outside engineering was that 6% had graduated or were enrolled in a 4 year degree 5 years later. In comparison, students enrolled in the college of engineering had a 44% rate of retention overall. The Hispanic and under-represented minority populations exhibited a similar rate of retention. That is race as a parameter did not have an additional impact on graduation/retention. Within this broad umbrella however, under-represented Hispanic women demonstrate a lower rate of retention with a 33-35% retention rate. Recalling that in 2015, students who were non-MR were advised outside the college, we infer that if students are advised outside engineering and are not MR, the path to engineering is a hurdle. An initial interest in engineering, not only resulted in a complete lack of retention but complete exit from college was evident with a 9-12% retention rate and complete exit of all women who were not math ready.

Between 2016 and 2017 a set of courses were provided to students who enrolled in engineering outside the college. Retention rate of under-represented students and women continued to be in in the 10-15% range. In 2018, a new program of pre-majors was created with all students who exhibited interest in engineering being placed into engineering. Students were provided a set of courses integrated into the degree plan. Once they completed the set of courses and were able to enroll in linear algebra or differential equations, the students were moved into the major. The impact on retention of both math ready and not math ready students increased to 55-60%. The retention rate of women who were math ready was significantly lower (49%). The analysis reveals that the lowest retention rate occurs for non-Math ready students who transferred into engineering from a community college. Further exacerbation of the situation (38% retention) occurs when gender is considered. Women transferring from a community college have the lowest retention when non-MR (38%).

In 2019, a formal collaboration with the area community colleges was created and a concurrent enrollment program was initiated. The impact on transfer retention rates was significant for students who transferred into engineering able to enroll in calculus 1 and higher. The improvement was across race and gender with a significant improvement (67%) for Hispanic women. We note that 2019 new cohorts enrolling in the college experienced the pandemic midway through Spring 2020 and had adjusted grading to accommodate for unplanned online teaching.

The 2020 cohort entered in with the online/virtual environment for the first semester. Here there was a return to low retention rates for transfer students who entered without being able to enroll in calculus with an accentuation for women on this negative result. Table 2 shows that enrollment of women was significantly affected for transfer students who were non-Math ready

for Fall 2020. Further for FTIC students, the 2020 cohort that reflected students who had high school online, math readiness was affected with a larger group of students enrolling as non-MR. This trend persists through Fall 2021.

In 2021, a formal NSF-HSI grant Establishing a Journey of Inclusion, Identity and Intersectionality through Guided Pathways to Enhance Latinx Success in Engineering and Computer Science was initiated in collaboration with a community college North Central Texas College (NCTC). Cohorts were formed and a peer mentoring program launched. In addition to the guided pathways providing options for students to graduate with a start in pre-calculus, numerous events were organized to invite students to connect as a cohort. While the invite list exceeded 600, attendance for all events was in the single digits. Despite the low attendance, it is to be noted that retention rates for both math ready and non-math ready groups was maintained. The group at risk remained the intersectional group of women and under-represented populations.

In 2022, noting a greater number of students entering with placement in algebra, an additional pathway to graduation was created beginning with algebra. Cohorts were reformed for Fall 2022 entrants and emails were sent from the deans office staff adding the students to the signature. The attendance at the 5 events over fall 2022 averaged at 19 students per event.

In 2023, the students across the college received emails directly from students using more informal approaches such as tabling, discord, Instagram, linked in facebook. The attendance grew with 110 students averaging attendance.

The inference to be drawn from these initiatives is that

a. Information of flexible pathways to graduation without identifying the student as belong to non-math ready (pre-major) or major was an effective means of transforming retention for students.
b. An active engagement with the community college leading to pragmatic dual enrollment rather than sequential attainment of an associates degree preceding initiation of college degree plans improves retention
c. Communication to students for increased connection with under-represented students is aided when students work directly with students supported by staff over reach out by full time staff.

Table 2: Demographics of students 2015-2022

			All	URM	Hispanic-a	All-womer	URM-Women	Hispanic-Women
	Math ready	FTIC	336	122	91	54	91	91
		TRANSFER	200	73	45	24	7	15
		MR-total	536	195	136	78	98	106
	Not math ready	FTIC	117	49	27	18	11	6
		Transfer	113	42	21	11	4	2
		non-MR to	230	91	48	29	15	8
2015		Total	766	286	184	107	113	114
	Math ready	FTIC	295	125	92	57	27	19
		TRANSFER	173	65	38	24	7	4
		MR-total	468	190	130	81	34	23
	Not math ready	FTIC	322	202	129	71	48	28
		Transfer	163	68	41	24	14	8
		non-MR to	485	270	170	95	62	36
2018		Total	953	460	300	176	96	59
	Math ready	FTIC	309	114	85	65	23	15
		TRANSFER	163	56	33	30	16	9
		MR-total	472	170	118	95	39	24
	Not math ready	FTIC	329	216	127	59	41	22
		Transfer	162	74	41	26	13	6
		non-MR to	491	290	168	85	54	28
2019		Total	963	460	286	180	93	52
	Math ready	FTIC	272	110	75	53	26	18
		TRANSFER	217	98	72	25	11	9
		MR-total	489	208	147	78	37	27
	Not math ready	FTIC	345	223	168	70	44	27
		Transfer	103	53	30	13	5	2
		non-MR to	448	276	198	83	49	29
2020		Total	937	484	345	161	86	56
	Math ready	FTIC	206	76	50	42	20	14
		TRANSFER	201	92	59	42	25	14
		MR-total	407	168	109	84	45	28
	Not math ready	FTIC	457	291	151	85	59	27
		Transfer	96	51	27	20	13	8
		non-MR to	553	342	178	105	72	35
2021		Total	960	510	287	189	117	63

Table 3: Retention over the 2015-2021 years

			Retained-All	Retained-URM	Retained-Hispanic	Retained-All-Women	Retained-URM-Women	Retained-Hispanic-Women
	Math ready	FTIC	53%	52%	59%	49%	59%	53%
		TRANSFER	30%	29%	55%	54%	57%	75%
		MR-total	44%	43%	58%	51%	59%	56%
	Not math read	FTIC	9%	8%	58%	58%	58%	57%
		Transfer	3%	5%	32%	38%	29%	38%
		non-MR to	6%	7%	47%	50%	50%	52%
2015		Total	33%	31%	54%	52%	54%	54%
	Math ready	FTIC	60%	56%	59%	49%	59%	53%
		TRANSFER	60%	57%	55%	54%	57%	75%
		MR-total	60%	56%	58%	51%	59%	57%
	Not math read	FTIC	53%	54%	58%	58%	58%	57%
		Transfer	45%	35%	32%	38%	29%	38%
		non-MR to	50%	0%	52%	53%	52%	53%
2018		Total	55%	52%	54%	52%	54%	54%
	Math ready	FTIC	71%	65%	65%	75%	70%	73%
		TRANSFER	66%	70%	67%	60%	63%	44%
		MR-total	69%	66%	65%	71%	91%	
	Not math read	FTIC	49%	47%	42%	59%	56%	45%
		Transfer	54%	49%	56%	58%	46%	67%
		non-MR to	60%	54%	53%	65%	59%	56%
2019		Total	60%	59%		65%	97%	56%
	Math ready	FTIC	71%	70%	71%	75%	77%	83%
		TRANSFER	63%	66%	68%	72%	73%	67%
		MR-total	67%	68%	69%	74%	96%	78%
	Not math read	FTIC	52%	52%	54%	63%	61%	63%
		Transfer	52%	45%	43%	38%	0%	0%
		non-MR to	64%	50%	23%	59%	6%	59%
2020		Total	60%	58%	59%	66%	64%	68%
	Math ready	FTIC	74%	76%	80%	83%	90%	86%
		TRANSFER	68%	66%	71%	67%	64%	86%
		MR-total	71%	71%	75%	75%	76%	86%
	Not math read	FTIC	57%	54%	51%	66%	64%	52%
		Transfer	57%	59%	44%	65%	62%	50%
		non-MR to	57%	55%	50%	66%	64%	51%
2021		Total	63%	60%	60%	70%	68%	67%

Fostering Belonging: Student engagement in first and second year of entry into engineering

Figure 1 shows the efforts to grow belonging embracing the engineering identity. We utilize the Goodwin et al. [12] framework of engineering identity. The original framework for identity incorporates personal, social, and engineering identity. In our implementation efforts, we focus on social (race, ethnicity, gender) and engineering identity. The connection in all these three is reinforced through four frames. As outlined by Goodwin et al. Interest in engineering represents the first stage for a student which is expressed in our system by applying to the college. UNT places all students who express an interest in engineering into the college once they meet the initial admission criteria. Competence is the second step of identity development which is achieved through building of knowledge and skills. This is accomplished in curriculum as well

as in a formal peer mentoring program which encourages all students who enter the college of engineering to work with a student who is a junior or senior student with a 3.4 and above grade point average with a matching race/ethnicity/gender. The third step is validation of competence through *performance* of activity to showcase their knowledge revealing abilities to themselves and others. The final stage of identity development is validation of engineering ability through *recognition* which is provided by either an instructor or through dissemination opportunities or awards.

Our efforts began with a grassroots program called Diversity and Excellence in Engineering Night in 2016 that grew into a formal network. An industry advisory board with representatives of the Society of Hispanic Engineers, National Society of Black Engineers and Society of Women Engineers provides key guidance to the program goals. Reviewing their experience with students from UNT conducting internships in the DFW metroplex from the UNT College of Engineering, the advisory group recommended a focused effort on increasing self confidence, communication and workplace readiness of our students. Their observation was matched by the engineering education research which shows that the first generation student has disadvantages in knowing professional expectations for advancement . Thus DEEN was organized to

1. Connect a student to a peer role model student and industry mentor when they start in engineering
2. Build a cohort of community college students to welcome new transfer students
3. Provide students a research experience with faculty
4. Provide students an opportunity to lead, organize and manage an outreach event to communicate to high school students on their decision to become engineers.

The college initially managed the efforts for DEEN as outlined in Table 1. However, a few factors emerged that transitioned the efforts to the component student organizations. First, the students at UNT typically work on campus or off campus concurrent to their academic workload compacting their time for student organizations. Second, the University grew campus wide initiatives for students by race and gender. This led the students to have additional leadership/reporting offices that overloaded their schedules. The advisory board initiated increased engagement directly with SHPE and NSBE while the college worked on removing barriers for events, career and mentoring opportunities.

Industry mentoring was conducted through an initial speed networking event, panel with industry and alumni and increased participation in regular monthly organization meetings. Mentors were encouraged to cover four points. First what technology area I work in. Second is the degree I received and areas that I utilize from my degree. Third, areas that I learnt after graduation and options for certificates or professional networks. Fourth, a prompt for the student to work with them on to build communication skills.

All student leaders, each year expressed a desire to grow interest in engineering for under-represented populations. Thus the engineering identity model was implemented through outreach programming to future populations.

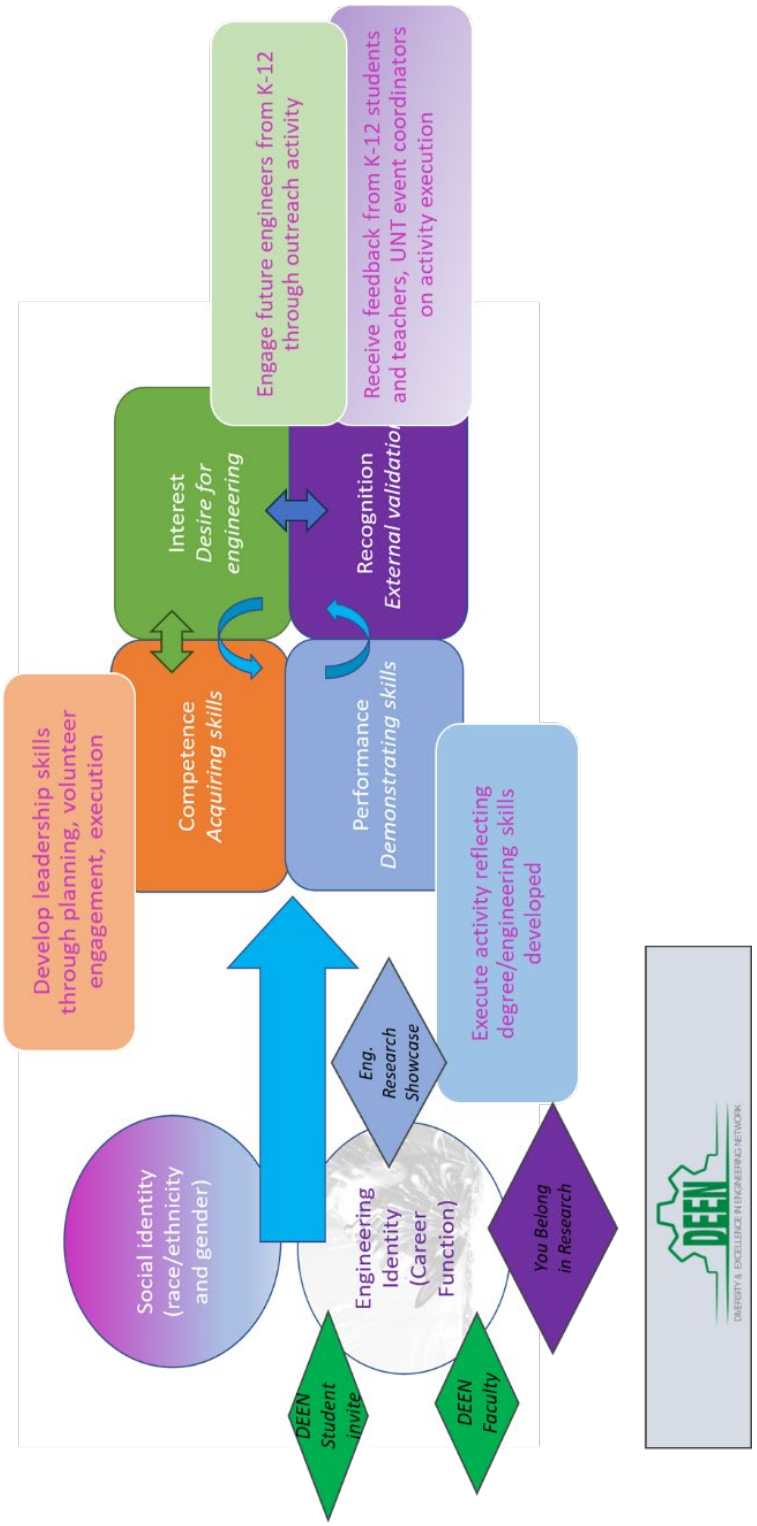

Figure 1: Original Godwin model of engineering identity and modified actions from DEEN.

The impact of the program on retention and graduation are dramatic. First the impact of the first year student and industry peer mentoring segment. Prior to the program, 83% of women left the college in the first year. After the program, the number of women leaving engineering dropped to 40%. Among the under-represented student populations, prior to the program, 64% of students left engineering and after the roll out, 41% left engineering.

When conducting the outreach, all engineering students reflected that the experience of leading and organizing an engineering activity paired to communicating to their younger self (in a high schooler) made them all grow in confidence in being an engineering. In transferring the engineering concepts to the high schoolers, 46% indicated that doing an engineering project with an engineering student led to a higher interest in a degree in engineering and computer science.

To grow engineering identity with technologies of the future paired to low time availability of students outside of work/academic responsibilities, we enhanced opportunities for students to engage with faculty. One area of concern in addressing social and engineering identity is that faculty do not reflect the demographics of the students as shown in Figure 2. The faculty advisor for SHPE led the implementation of the DEEN-Faculty engagement program.

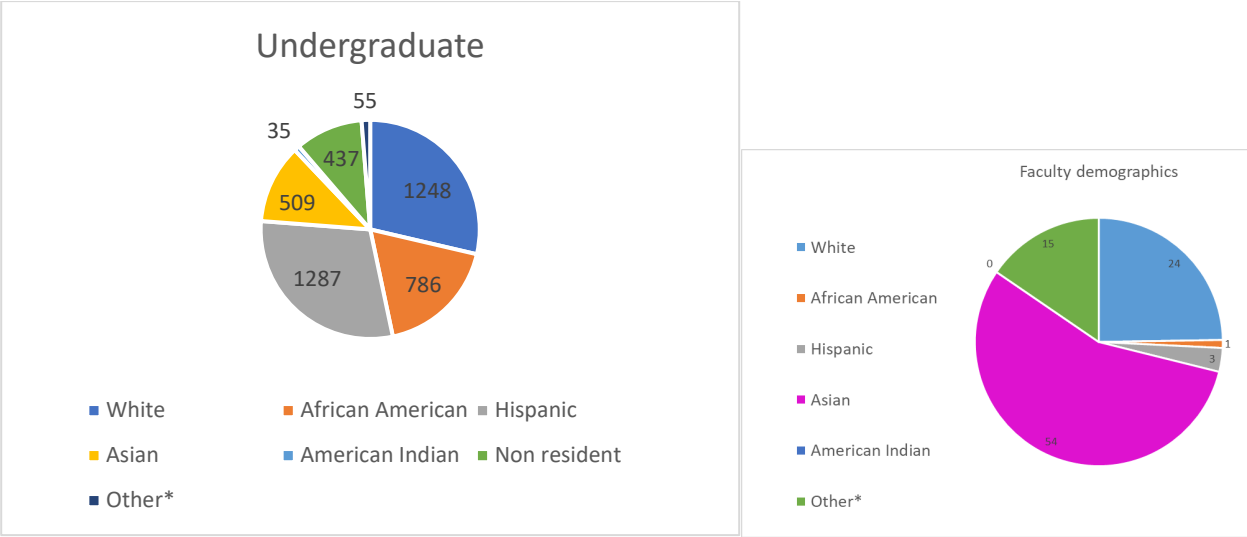

Figure 2: Student and faculty demographic variation reflects a need for enhanced advocacy approaches

Faculty provided invitations to students to visit the laboratory (Figure 3). Two effective modifications emerged. When provided by advisors, college associate deans and faculty, there were no students who responded to the invitation. Both individual emails or group emails provided no distinction, Subsequently 4 under-represented students were employed to reach students. They sent group and follow up individual e-mails. A higher interest resulted. Of 44 students who were contacted individually, 12 signed up to visit faculty. The student mentor provided the questions that students raised as did the faculty. Questions to the faculty centered on

the technical and research field while questions to the student were personal/financial/ communication based.

Figure 3: Faculty invitations sent to under-represented students

Conclusions

This paper explored the efficacy of different modes of delivery. In the series of programs that highlight modes of growing transfer student pathways, [13],[14], human engagement has been emphasized. Our explorations indicated that in urban environments, options for enrollment with or without math readiness result in a low cost highly efficient means of student retention. Math readiness in the community college is recommended and ideal but even at the University level, the growing enrollment of freshmen from high schools into algebra or below reflects a need to make math starting points an optional set of information than a means to deny the *interest* aspect of engineering identity. Secondly, our efforts in student engagement reflect that students are the optimal means of engaging students. That is the full time administrative and staff mentoring the peer mentors to directly engage with students offers an ideal engagement with students. Third, without a gender or race match, the utilization of students to recruit students into research and pairing research grants with recruiting/retention initiatives offers a positive mode of broadening participation.

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