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Expanding the Education Pathway to Undergraduate Engineering through Strategic Two-year and Four-year Institution Partnerships

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Abstract

To enhance the minority participation in undergraduate engineering, strategic partnerships with community colleges have been identified as an essential component in the U.S. STEM Education system with a total of 1,738 2-year institutions: 967 public, 100 non-profit and 671 private.[1] In 2012, there were over 20 million students enrolled in an academic institution across the United States with over 6 million being educated at a two-year public institution.[2] These public two-year institutions also have a large population of underrepresented minorities with approximately 34% of the total number of African Americans enrolled in an academic institution and 46% of the total number of Hispanics students enrolled in academic institutions.[3] In addition to expanding underrepresented minority participation through institutional partnerships with two-year public institutions, 33% of the total female population that was enrolled at an academic institution was enrolled in a two-year public institution.[3]

The state of Texas is positioned to be a key contributor to the overall increase in the both the number of STEM graduates and the increased number of underrepresented minorities graduating with a STEM degree, for four reasons: 1) Texas is ranked second in the nation as having the largest number of public community colleges[1], 2) Texas will experience the largest headcount growth of high school graduates over the next ten years with over 87,000 additional graduates by 2025[4], 3) As of 2010, Texas is one of five majority-minority states and 4) In fall 2014, Texas was noted as having the second highest estimated enrollment across the Nation with 1,442,610 students, second to California whose estimated fall 2014 enrollment was 2,497,958.[5]

In response to this anticipated growth and the increased demand for engineers, a co-enrollment Engineering Academy was successfully launched in fall 2013, through a strategic partnership between Texas A&M University Dwight Look College of Engineering and Blinn College-Bryan. The inaugural class consisted of 113 prospective engineering students. By 2014, after a full year of participation in the program, 21% of the participants successfully matriculated into their major of choice within the Look College. Forty-four percent remained in the program as co-enrolled students, taking courses at both institutions. Unfortunately, 35% of the participants were not retained in the program due to grades (19%), voluntarily opting out of the program (13%), or choosing to not return as a continuing student (3%).

A comparative review of the Engineering Academy against other engineering co-enrollment programs across the state of Texas will be discussed, as well as retention and matriculation data from both the fall 2013 and 2014 cohorts.

Introduction

Understanding methodologies to develop strategic STEM pathways to increase the number of students from underrepresented populations achieving STEM degrees is essential to meeting the need for approximately 1 million more STEM professionals over the next decade.[6] Community college students represent 42% of undergraduate enrollment and are historically over-represented in populations underrepresented in engineering.[7,8] Recruiting and retaining community college students is an important avenue to help meet the President's Council of Advisors on Science and Technology (PCAST) challenge.[7] The National Center for Education Statistics report on community college transfer students found that community college students who have declared a major and are actively enrolled in classes that will apply towards their degree are those most likely to successfully matriculate to and graduate from a four year program.[9] At the same time, collectively, students who start in the community college system face many challenges.[10] Over 90% of students enrolled in a community college expect to earn a bachelor's degree, yet less than 40% of students transfer to a four year institution within five years of their initial community college enrollment.[9] One of the factors that impedes students' progress, particularly in STEM is clear pathways and systemic support between the community colleges and the 4-year institutions.[11] A recent report by the National Research Council and National Academy of Engineering, "Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit" provides a guideline on how to develop a supportive STEM transfer ecosystem.[12]

In response to PCAST's recommendation for 1 million more STEM professionals in the next decade and the potential impact a large majority-minority institution can make for the state and the nation, a co-enrollment program was developed. At the onset of its development, the engineering co-enrollment program was founded on over a decade of experience gained through a strategic partnership between the general studies department at Texas A&M and Blinn College. This co-enrollment program, known as the Texas A&M Blinn Transfer Enrollment at A&M (TEAM) Program, now fourteen years (2001-2015) in existence, has enrolled a total of 8,122 students and graduated 2,846 in 112 different majors across the university. The number of graduates does not include the past four years of students admitted to the program (approximately, 3,900 students) which reflects their highest enrollment period.

The TEAM Program, serving as a launching pad for all majors across the university, has broadened the opportunity for students to achieve an economical education, taking core curriculum at both institutions, while deciding on their major of interest. In November 2014, this program was awarded one of the highest educational awards in the state for its exceptional contributions toward meeting one or more of the goals of *Closing the Gaps* by 2015. These goals include student participation, student success, academic excellence, and research.

Motivation

To enhance under-represented population participation in undergraduate engineering, strategic partnerships with community colleges have been identified as an essential component in the U.S. STEM Education system with a total of 1,738 2-year institutions: 967 public, 100 non-profit and 671 private.[1] In 2012, there were over 20 million students enrolled in an academic institution across the United States with over 6 million being educated at a two-year public institution.[2]

These public two-year institutions also have a large population of underrepresented minorities with approximately 34% of the total number of African Americans and 46% of the total number of Hispanics students enrolled in academic institutions.[3] In addition to expanding underrepresented minority participation through institutional partnerships, 33% of the total female population was enrolled in a two-year institution.[3]

The state of Texas is positioned to be a key contributor to the overall increase in the both the number of STEM graduates and the increased number of underrepresented minorities graduating with a STEM degree, for four reasons: 1) Texas is ranked second in the nation as having the largest number of public community colleges[1], 2) Texas will experience the largest headcount growth of high school graduates over the next ten years with over 87,000 additional graduates by 2025[4], 3) As of 2010, Texas is one of five majority-minority states and 4) In fall 2014, Texas was noted as having the second highest estimated enrollment across the Nation with 1,442,610 students, second to California whose estimated fall 2014 enrollment was 2,497,958.[5]

Another compelling argument for the state of Texas is shown in a 2010-2011 Snapshot report on mobility from the National Student Clearinghouse, Research Center (Figure 1). This report identified Texas as having the highest percent of students [78%] that have completed a 4-year degree after previously being enrolled in a 2-year institution. This is more than 30% higher than the U.S. overall [45%][13]

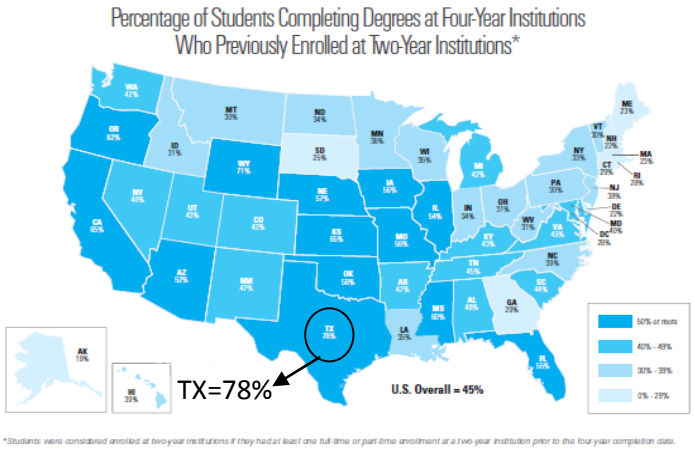

Figure 1. Percentage of students completing degrees at four-year institutions who previously enrolled at two-year institutions.[13]

A closer look at these graduates, as shown in figure 2, demonstrates that approximately 71% of students transferring from a two-year to four-year institution with an associate degree, graduated within four years of their transfer. Achieving an associate degree prior to transfer to a four-year institution resulted in a 17% higher rate of degree attainment than that of students who transferred prior to achieving their associate degree (54%).[14]

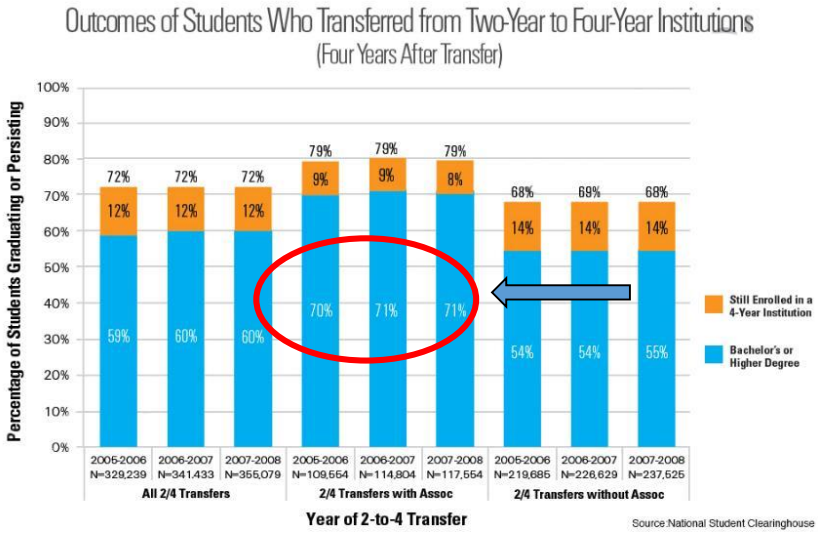

Figure 2. Outcomes of students who transferred from two-year to four-year institutions four years after transfer.[14]

Based on this comparison, it would appear that achieving an associate's degree is critical to achieving a bachelor's degree. But this is complicated for those wishing to achieve a STEM degree. For example, Blash reviewed the progress of engineering students in California community colleges and found that only 21% of engineering students who started at community colleges earned associate degrees and only 5% of these were in a major related to engineering. The majority of credits that these students took that transferred were in math rather than engineering.[11] Furthermore, Blash found that many students who started at a 2-year institution and matriculated in STEM at a four-year institution took a minimum number of classes at the initial two-year institution.[11] These results clearly identify critical issues that could be the result of inefficient or non-existent reverse transfer policies, poor curriculum alignment, and lack of transferable STEM courses related to the students major.

At the associate degree level ABET has accredited 96 applied science programs and engineering technology programs (ABET 2013). Compared to the 537 programs accredited at the bachelor's degree level, this leaves students seeking to go the community college route, approximately 50% of students in the US enrolled in undergraduate education, with far fewer choices when wanting to pursue a STEM degree(ABET 2013).[10] While many co-enrollment programs such as the PACE program between University of Texas at Austin and Austin Community College work to provide a seamless transfer for those in the School of Undergraduate Studies, for those wishing to pursue a technical degree, this transfer is more problematic and students find themselves behind.

There are other co-enrollment programs in the United States such as the one offered between Portland Community College (PCC) and seven different four-year institutions, however of these seven four-year institutions, Portland State University is the only one that has a reverse transfer agreement with PCC to provide associate degrees to eligible students and only Oregon Institute of Technology offers degrees in engineering, although the transfer path was still unclear. There are also several dual-enrollment programs for high school student to earn college credit and/or earn an associate degree by the time they graduate.

There are a few programs that encourage STEM students to transfer from a two-year to a four-year institution. For example, the Arizona State and Maricopa Community College Partnership is a two-year STEM program that encourages students to pursue an engineering curriculum however these 2-year students are co- enrolled into the University College and not the engineering college. Therefore they do not receive dedicated support or academic advising from the engineering college. Research from the National Center for Education statistics has demonstrated that community college transfer students most likely to earn a bachelor's degree are those students that are enrolled in their major and actively earning credits toward their major.[9] This would include receiving program of study planning from people who are experts in programs of study in engineering. Formalized opportunities to do this in engineering are limited, and there are currently none in the state of Texas. Therefore, transformational pathways directly leading to an engineering degree and supported by the college of engineering are needed to directly impact the number of students interested in attaining and achieving an engineering degree.

Program background and development

Over the last decade, Texas A&M has enrolled an average of 262 transfer students into the college of engineering through traditional transfer pathways. These students most likely received the majority of their support services, academic courses and advising from the two-year institution with no formal advising or support services from the Look College.

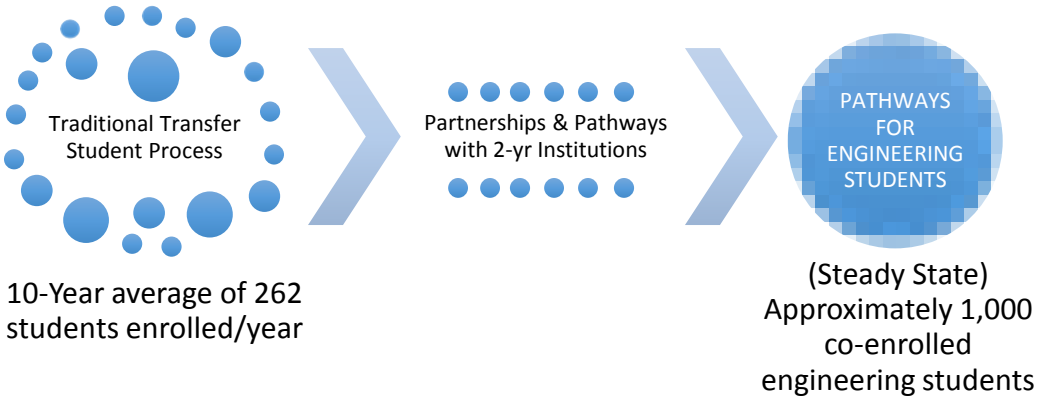

Figure 3. Simple schematic depicting traditional student transfer institutions with various types of courses and identifiable pathways and support for students interested in transferring from a two-year institution.

The Texas A&M Engineering Academy co-enrollment program developed in partnership with Blinn College, will streamline this process by developing supplemental engineering success courses, summer bridge programs, training programs for faculty and staff to support co-enrolled students, financial aid consortiums, curriculum alignment and reverse transfer agreements to lay the foundation needed to establish a seamless matriculation process.

The model begins with an identification of strategic partners prepared to challenge the existing

processes and policies that dictate the transfer framework in which all institutions abide. Blinn College ranks among the nation's leaders in transferring students to leading four-year universities and has received national recognition for its affordable educational excellence. Its district consists of four campuses serving over 13 counties, three workforce boards, and 47 Independent School Districts. They excel at partnering with its many local communities, including chambers of commerce, economic development boards, community education, dual credit agreements and training plans. Most importantly Blinn College educates students from over 1,500 zip codes with approximately 75% of the students coming from 238 different zip codes. In comparison, the average Texas community college serves 75% of its students from only 35-39 zip codes.

Immediately following the partnership agreement, administrative leaders, faculty and staff created committees to discuss boundaries and barriers for which the program resides. An immediate faculty training program was launched with Blinn College, providing faculty co-teaching opportunities for first year engineering courses offered through the college of engineering. Although these courses are retained by the Look College (offered and taught by Texas A&M engineering faculty). This training fostered a deep discussion and understanding of the competency gaps that could be filled through engineering success courses and summer bridge opportunities at Blinn College.

Admission process

The number of applications from talented students interested in achieving an engineering degree is four times greater than the enrollment capacity for Look College.[15] Therefore the engineering academy is offered to those talented students that would have received an offer for admission if the college of engineering had not reached its full capacity. These students receive an offer of admission inviting them to participate in the Engineering Academy Co-enrollment program along with information on the benefits, terms and conditions of the program. Academy students are also provided an admission guide and pre-enrollment checklists to guide them through the steps of securing their admission and enrollment to both institutions. Academy students can apply for early entry into engineering upon completion of one math, one science and one engineering course required for their preferred major and earning a minimum 3.5 Cumulative Grade Point Average (CGPA) at both institutions (calculated by Texas A&M). This option is available to Academy students as early as their second semester in the program. Academy students that do not choose the early entry option can continue taking courses at both institutions for the full two years of the program. Academy students that successfully complete the program with a minimum CGPA of 3.0 at both institutions (calculated by Texas A&M) at the end of the two-year program are guaranteed full admission to Texas A&M University, however, it does not guarantee admission to a particular academic college or major.

Enrollment and financial aid

Engineering Academy students must enroll for a minimum of twelve total credit hours each fall and spring semester. Three to five engineering credit hours will be taken at Texas A&M and the remaining course credits will be at Blinn College. Academy students may continue full-time enrollment over summer by taking up to six credit hours at both institutions. If a student drops

or withdraws from courses taken at the university and falls below one credit hour the student will be withdrawn from the university for that semester, thus forfeiting all student rights and privileges at the university for the remainder of the term.

Engineering Academy students can save up to $1500.00 per semester by paying partial tuition which is based on the number of credit hours taken at each institution. Through a financial aid consortium agreement, students can apply for financial aid at the university and be considered full-time students if the combined credit hours taken at both institutions equals twelve or more credit hours. The Academy students are eligible to apply for all scholarships at both institutions in addition to financial aid short-term and emergency tuition and fee loans offered through the university financial aid office.

Student learning community

Engineering Academy students begin taking their math, science and engineering courses as a cohort to help develop a community of engineering academic peers. These students are enrolled in tracks based on the results of their calculus readiness. However, all tracks, including pre-calculus, take engineering courses that were previously reserved only for students admitted directly to the college of engineering. Prior to this program the inability to take freshman level engineering courses prevented transfer students from continuing in sophomore level courses offered by the college and in most cases set transfer students back a full semester or more. Therefore, since Academy students are eligible to take these courses, they are able to progress in first year engineering courses and continue in sophomore level courses offered by the college.

Engineering Academy program metrics

The fall 2013 pilot program consisted of 113 Engineering Academy students with 81% male and 19% female, a gender division that is consistent with the national statistic in engineering. An interesting finding was that the diversity of the pilot program reflected the County in which the two-year institution served, regardless of the fact that the applicant pool for admission to the program came from several different counties across the state of Texas. For example, the diversity of the pilot program for Hispanics is 24%, however the African American and Asian population was minimally represented in the program with only 1% for each in comparison to 11.3% and 5.5%.[16] The remaining diversity of the pilot program consisted of 68% white, 4% Multi-racial, and 2% American Indian.

The Engineering Academy students were placed into two academic tracks. One track of ninety students were placed in a calculus track and the remaining twenty three students were placed in a pre-calculus track. At the completion of the fall 2013 semester approximately 77% of the students enrolled in the calculus and 78% of the students enrolled in the pre-calculus track, were retained.

After completion of the first year in the program, 44% of the participants were retained in the co-enrollment program and 21% successfully matriculated into an engineering discipline at the four-year institution. Unfortunately, 35% of the participants were not retained in the program due to grades (19%), voluntarily opting out of the program (13%) or choosing not to return as a

continuing student (3%). A semester-by-semester review of the first year student retention and matriculation by gender and ethnicity is shown in Table 1.

Recent data obtained at the end of the third semester reflected a total of 60 out of the original 113 students that were either retained (13.3%) or successfully matriculated (39.8%), demonstrating an overall program success of 53%. The remaining fifteen students in the program will continue to take courses at both institutions their final spring 2015 semester and will continue to apply for entry to a major.

Table 1. Fall 2013 cohort: First year retention and matriculation into the college of engineering by gender and ethnicity.

Fall 2013 Pilot Participant demographics				Program1st year[1] Retention(R) and Matriculation (M) by semester							
				1st Semester				2nd Semester			
				R	Pct.	M	Pct.	R	Pct.	M	Pct.
Ethnicity	Gender	*n*	Pct.	*n*	%	*n*	%	*n*	%	*n*	%
White	M	63	55.8	55	87.3			34	54.0	12	19.1
	F	14	12.4	9	64.3			4	28.6	4	28.6
Hispanic	M	21	18.6	14	66.7			9	42.9	3	14.3
	F	6	5.3	2	33.3			0	-	1	16.7
Multi-racial	M[1]	5	4.4	5	100			2	40.0	3	60.0
	F	0	-	0	-	No Matriculation at the end of 1st semester		0	-	0	-
American Indian	M	2	1.8	1	50.0			0	-	1	50.0
	F	0	-	0	-			0	-	0	-
Black	M	1	0.9	1	100			1	100	0	-
	F	0	-	0	-			0	-	0	-
Asian	M	0	-	0	-			0	-	0	-
	F	1	0.9	0	-			0	-	0	-
Total	M	92	81.4	76	82.6			46	50.0	19	20.1
	F	21	18.6	11	52.4			4	19.1	5	23.8
	All	113	100	87	77.0			50	44.3	24	21.2

[1]University data and research services (DARS) fall 2013 enrollment report (page 70) shows six multi-racial males enrolled in the engineering academy (114 students), however this student was not interested in pursuing engineering and was returned to the TEAM co-enrollment program.

In fall 2014, the Engineering Academy enrollment doubled from the original pilot program (113 students) to 227 Academy students. As shown in Table 2, the gender and diversity of the fall 2014 cohort is 82% male and 18% female with the diversity of Hispanics decreasing to 18%, African American increase to 2% and whites remained at 68%. Asian enrollment increased to 8%, Multi-racial decreased to 1%, while Hawaiian, international and unreported demographics were reported for the first time <1%. Preliminary data for fall 2014 academy students shows 93% retention. Of those 82% were males and 18% were females.

Table 2. Fall 2014 cohort: *Preliminary data*[1] for first semester retention and loss by gender and ethnicity.

Fall 2014 Engineering Academy Participant demographics				End of 1st semester (*Preliminary data*)[1] Retention(R) and Loss (L)			
				R	Pct.	L	Pct.
Ethnicity	Gender	*n*	%	*n*	%	*n*	%
White	M	128	56.4	117	91.4	11	8.6
	F	27	11.9	25	92.6	2	7.4
Hispanic	M	31	13.7	28	90.3	3	9.7
	F	9	4.0	9	100		
Multi-racial	M	3	1.3	3	100		
	F						
American Indian	M						
	F						
Black	M	4	1.8	4	100		
	F	1	0.4	1	100		
Asian	M	18	7.9	18	100		
	F	3	1.3	3	100		
Hawaii	M	1	0.4	1	100		
	F						
International	M	1	0.4			1	100
	F						
Not reported	M	1	0.4	1	100		
	F						
Total	M	187	82.4	172	92.0	15	8.0
	F	40	17.6	38	95.0	2	5.0
	All	227		210			

[1] Preliminary retention data presented in this table was obtained from the University data and research services (DARS) enrollment profile for spring 2015 and is noted as official twelfth class day, non-certified data.

Conclusion and Future Research

The compelling argument for Texas and its potential to impact the STEM workforce through strategic partnerships with 2-year institutions is statistically overwhelming and this partnership has provided a collaborative opportunity to identify and remove academic, administrative, and transfer barriers in-situ. As the engineering academy model is being created and refined through the research literature, the three main goals of the academies remain: 1) increase the participation and graduation of underrepresented groups interested in pursuing an engineering degree, 2) provide an immediate impact on the STEM workforce by minimizing the time to graduation through curriculum alignment between the two- and four- year institution, and 3) increase the number of awarded Associate degrees.

The authors plan to expand the engineering academy model across Texas, while continuing to contribute to the literature on the development of a vertical transformational program that would meet the goals of the engineering academies.

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