

A STEM Transfer and Retention Program at Texas A&M International University

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Abstract

This paper presents a program funded by the Department of Education aimed at transferring and retaining highly motivated Hispanic students into our new Bachelors of Science in System Engineering Program at Texas A&M International University (TAMIU) in Laredo, Texas. TAMIU's interest is not only in recruiting engineering students from both local high schools and the local community college, but also in retaining them so they graduate. The program consists of an articulation agreement between the local community college and the university to streamline the transfer of students receiving Associates in Arts degree and includes a set of summer engineering workshops aimed at retaining the college students so they eventually transfer into our program.

1. Introduction

This ongoing program is designed to improve the recruitment and retention of highly motivated Hispanic and other minority students into our Systems Engineering program at TAMIU. This program is part of a grant from the US Department of Education, Minority Science and Engineering Improvement Program (MSEIP) titled "STEM Minority Outreach and Recruitment Enhancement (STEM-MORE)" under award number: P120A110067 and is designed to increase the number of Hispanic and minority students attaining Science, Technology, Engineering, and Mathematics (STEM) degrees. This paper addresses the Transfer and Retention Program (TRP) which is part of this overall program.

1.2 Background Information

TAMIU is the only four-year institution located within a 150-mile radius of Laredo, Texas. The university student body comprises of 90% Hispanic students of which most are economically disadvantaged and are under prepared when entering the university. The City of Laredo sits on the boarder of Mexico and has a much lower per capita income when compared to both the state and national average. Data from the U.S. Census Bureau 2010 and the 2005-2009 American Community Survey 5-Year Estimates shows that the City of Laredo has the following characteristics:

- The Hispanic population is 94%
- The per capita income is \$13,941 compared to \$27,041 nationally.
- The percent of residents living at or below the poverty income level is 29% compare to 14% nationally.
- Over 22.5% of the population has less than a 9th grade education compared to 6.4% nationally.
- Only 12.8% hold a Bachelor's degree compared to 17.4% nationally.
- Only 5% hold a master's or higher degree compared to 10.1% nationally.

TAMIU has seen an average enrollment increase of 10% annually over the past five years. In the fall 2010 TAMIU had 85% undergraduates, 91% Hispanic, 60% female, 72% economically disadvantaged (Pell Grant recipients), and 45% first-generation students. Furthermore the students graduating from K-12 are generally less prepared for higher education than the national average, we believe due to the economic situation most are in and the fact that almost half are first-generation, (the first in their family to attend higher education). For these same reasons, we believe, TAMIU also has a high number of students that do not complete the program and never earn their Bachelor's degree.

This presents a challenge in motivating our current and future students to remain with their engineering goals and graduate from our Systems Engineering or Pre-engineering programs.

1.3 The Challenge

We have found significant challenges in educating our students including:

- A high percentage of STEM students are suspended for failing to meet the standards for good academic standing at the end of their first academic year (these students also lose their eligibility for financial aid)
- A high percentage of students experiencing difficulty comprehending the academic language of their STEM courses and
- Failure to comply with institutional academic requirements for graduation is high, particularly among STEM students.

The challenge of the university is to recruit new students and retain our existing students. The piece of this challenge the TRP addresses is to retain our engineering students.

1.4 Related Work

At the University of Texas, Pan American, they have an approach that includes several activities¹. First they implemented an enhanced student service program which includes STEM advising and mentoring and a student assistant program specifically for Calculus I. It includes a curriculum reform program where they develop courses using the Challenged Based Instruction (CBI) method². This method is a form of inductive learning³ designed to increase the student's involvement and motivation in a course by challenging them to seek the course material. The third activity includes faculty development seminars and workshops on teaching using the CBI method. Finally the last activity is a dual enrolment program with South Texas College, a local college. In contrast, our approach is much simpler albeit perhaps not as effective. It only involves a summer engineering workshop for students and an articulation agreement with the local community college. Our faculty participated in the CBI workshop that was offered by the University of Texas, Pan American program however that is not part of the activities described in this paper. Their results are mostly not yet available.

At Cañada College in Redwood City California, the Summer Engineering Institute⁴ is a program very similar to the one presented here that includes two-week summer engineering workshops held on the campus of San Francisco State University and taught by the faculty from both institutions. It is aimed at underrepresented and educationally disadvantaged students pursuing STEM careers. The workshop introduces students to the engineering educational system and the profession, is designed to recruit students into the engineering fields, increase awareness of the resources and skills needed for success, and to increase the student's knowledge of the

engineering topics. Their program was also funded by the US Department of Education, Minority Science and Engineering Improvement Program (MSEIP).

At San Jose State University they offered a 10 day residual summer transition program called EXCEED: Excellence in Your Engineering Education⁵ designed to improve retention and graduation rates. The program included workshops on writing and math to prepare the students for their first year of classes, a campus resource hunt to familiarize the students to the university resources available to them such as counseling services, health services, time management and career resources and finally industry tours and guest lectures to expose the students to the engineering fields. The participants also worked in small teams on a community based service learning project to build a project. The projects did not require any prior engineering knowledge. In comparison to our work, our workshops are intended for first year students that have completed the Foundations of Engineering I course and have some knowledge of engineering. Our workshops are only focused on motivating the students to remain in engineering. The projects in our past two workshops have been more advanced and did require some expertise in engineering. Our program does not aim to support the students in writing or math. In addition for the students transferring from college, the workshops aim at getting them familiar with the university resources in engineering including getting to know the faculty.

The following program offered at the University of South Alabama is not aimed at the underrepresented student population but only at retention in STEM for the general student population. The program called Freshman Research Experience in Engineering⁶ (FREE) includes a two-week workshop in which the students work on a project on either robotics or composite materials. They claim an increase in the student's critical thinking skills. In comparison to our program, our program is specifically aimed at the underrepresented group particularly the Hispanic population. Furthermore we generally accept all of our existing students that completed the Foundations of Engineering I course regardless of GPA while the FREE program aims specifically at the high achieving pre-college students. They select students with high ACT, GPA scores. Our rationale is that the high performing student will benefit the least from the workshop.

The last program in our literature review is at our own university, TAMU. The Summer Transfer Engineering Workshop⁷ (STEW) is a two-week residential workshop held at the Dwight Look College of Engineering at Texas A&M University in College Station, Texas. It is designed to increase the number of minority students in engineering. The workshop includes information sessions, field trips, laboratory tours, and design projects. This program is similar to the one presented here and actually involves the same students. This makes assessment difficult as both programs are influencing the same student population concurrently.

1.5 Details of the Program

The TRP program consists of two parts. The first is an articulation agreement with the local community college, Laredo Community College (LCC) and the second is a set of engineering summer workshops.

The articulation agreement is to streamline the transfer of students earning an Associates in Arts degree from LCC and transferring to TAMU so that the students can transfer all of their courses into their Bachelor's degree program.

The workshops are to keep the motivation of the transferring students high so they do not change their minds before entering our program and to facilitate this transfer by familiarizing them to our faculty, facilities and program.

2. The Articulation Agreement with Laredo Community College

This articulation agreement which is not yet complete, will allow the engineering students from LCC to transfer into our Systems Engineering Program without losing any credits. The benefit of this program to TAMIU is to increase the number of students transferring from LCC to TAMIU as opposed to other universities. LCC also benefits by increasing the number of students that attend LCC first before transferring as opposed to attending TAMIU directly after high school for all 5 years. To TAMIU this may represent a loss of students enrolled in their general education courses for the first 2 years however the program should increase the number of student enrolled in the discipline specific engineering courses. Currently our Systems Engineering Program is in need of students to fill the engineering courses offered. Students benefit by having an option of attending LCC first then transferring to TAMIU without the loss of any course as opposed to attending TAMIU for all 5 years or transferring but losing some courses. This LCC/TAMIU option represents a cost saving to the students as LCC has lower tuition rates. LCC is also better equipped to handle the poorly prepared students entering their program.

The agreement involves the matching of courses between LCC and TAMIU so that LCC's engineering courses can be used in place of those offered at TAMIU. To facilitate this process, it was agreed by both institutions that any course required by TAMIU but not available at LCC would be offered at TAMIU for LCC students. These courses may include Foundations of Engineering I and II, Engineering Graphics, Statics and Dynamics, and Electrical Engineering Principles. LCC will count these courses towards their degree requirements. In exchange LCC may offer courses primarily used by TAMIU students and allow TAMIU students to take the courses at LCC and have it count towards their TAMIU degree. This agreement will give both institutions and their students flexibility. Furthermore there are some engineering courses that neither institution can fill in the summer with only their students but will have sufficient students if both institutions agree and offer credit for this course regardless where it's offered. Due to LCC going through state mandated changes in their core requirements, the agreement is not yet complete. Much progress has been made so far however.

3. The Summer Engineering Workshops

Each year of the grant a two week summer engineering workshop is offered. The target participants are LCC engineering students that are thinking about transferring into our Systems Engineering Program. The goal is to motivate these students so they do not change their minds and transfer to another school or another program within TAMIU. However because the articulation agreement is not yet in place the first two workshops were offered to TAMIU students who have completed their first year in the Systems Engineering or the Pre-engineering programs. The goal for the TAMIU students was to motivate them into staying with the program and lower the number of student that do not follow through and change majors or just drop out of the program.

3.1 General Workshop Details

The workshops are two weeks in duration of full day activities. The first two workshops were offered during the summer of 2012 and 2013. The next one will be offered in the summer of 2014. For the first two workshops the students received a stipend of \$1000.00 to attend. The students worked in small groups to acquire many skills related to their success in the STEM fields and engineering, in particular. Skills they learned include teamwork, research, procurement of materials, problem solving and career planning. While working on mathematics and engineering related projects they also got familiar with TAMIU's faculty, students, equipment and other resources available to them. The workshops were enhanced by the supervision, guidance and mentoring by our engineering and mathematics faculty. Each team was assigned a department faculty that oversaw the progress of the project and gave them advice and support. The faculty was paid for their participation. During the last day of the workshop every team presented their project (see Figure 1 and Figure 2). Each presentation included a demonstration of the project.



Figure 1: Student presentation. The project consisted of an electric generator powered by a bicycle used to power a light bulb.

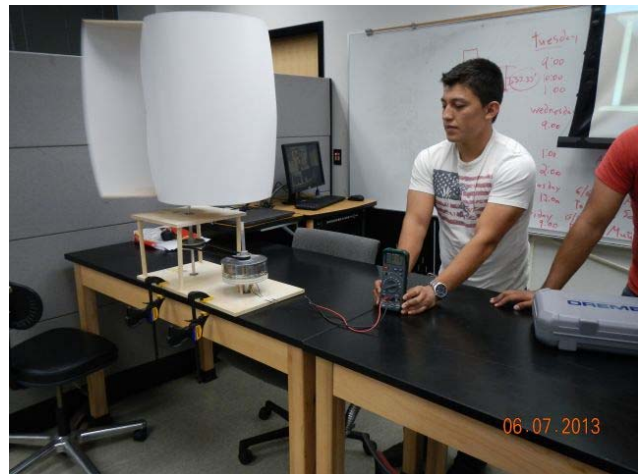


Figure 2: Student presentation. The project consisted of an electric generator powered by a wind mill. Both the generator and the wind mill were created by the students.

3.2 Details of the 2012 Workshop

A total of 16 applications were submitted of which we accepted all 16 of them. All were Hispanic and all were from TAMIU. As the agreement between LCC and TAMIU was not yet in place, it was difficult to recruit LCC students this time around. Some of the student's characteristics are shown in Table 1 below.

Table 1: 2012 Student characteristics.

| | |
|------------------------|-------------|
| Percent Hispanic | 100% |
| Average GPA | 2.92 / 4.00 |
| Average credits earned | 43 |
| Percent TAMIU students | 100% |

In Figure 3 the breakdown of the 2012 participants is shown.

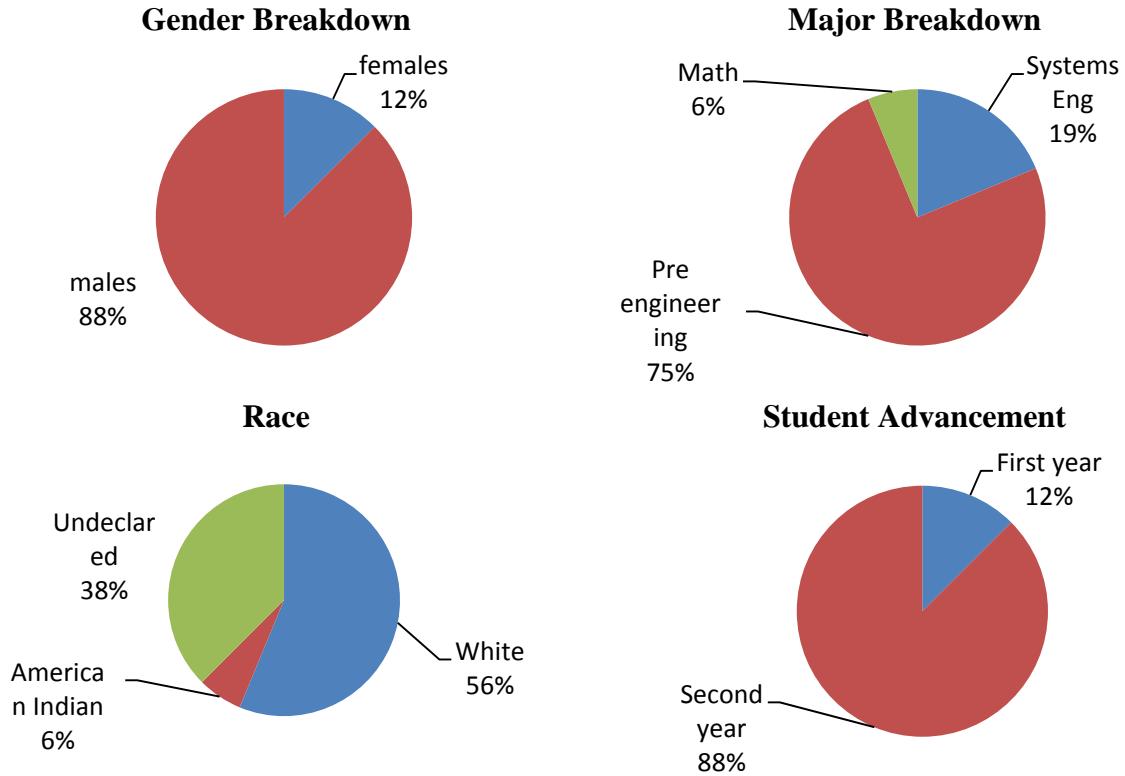


Figure 3: Breakdown of the 2012 participants.

The workshop was offered from June 18 through June 29, 2012 from 9:00 am to 4:00 pm excluding weekends. The time was divided among group projects, invited speakers and field trips. The schedule is shown in Table 2.

Table 2: The schedule for the 2012 workshop.

| Day/Date | Time Slots | |
|---------------------------|--|---|
| | 9:00 A.M. – 12:00 P.M. | 1:00 P.M. – 4:00 P.M. |
| Monday 6/18 | Welcome & Introduction | Project proposal |
| | Meet with mentors | |
| Tuesday 6/19 | Work on project Dr. Bachnak | Work on project |
| Wednesday 6/20 | Work on project | Work on project |
| Thursday 6/21 | Work on project | Morales - Machine Shop & ACE Machine Shop Visit |
| Friday 6/22 | Work on project | Airport Control Tower FAA Mr. Lopez (956) 724-5481 |
| Monday 6/25 | Work on project | Work on project |
| Tuesday 6/26 | Work on project | Work on project |
| Wednesday 6/27 | Work on project | Work on project CEC Engineering Jeff Puig |
| Thursday 6/28 | Benjamin Hinojosa & Adrian Uresti AEP Project demonstrations and presentations | Project demonstrations and presentations |
| Friday 6/29 | Water Plant Tour Toni Moreno Jefferson Water Plant | Project Submittal & Awards |

The students worked in small groups on engineering project of their choice approved by the instructor. There were 3 faculty advisors assigned to the individual groups to guide them and provide support as needed. At the end of the workshop each group presented their project to the rest of the students.

We invited four speakers that were local engineers and they talked about how they studied and later worked to get to where they are now and they gave a description of their daily work. For our field trips we visited 4 local engineering based companies. Each one provided a look at the engineering infrastructure in Laredo and each included a presentation from the local engineers working at the location we visited.

3.3 Details of the 2013 Workshop

A total of 22 applications were submitted of which we accepted all but only 18 of them participated. Of the 18 participants, 17 were Hispanic and 1 was African-American. All were from TAMIU as the agreement between TAMIU and LCC was not yet in place. The workshop

was offered during the weeks of May 20 through May 24 and June 3 through June 7, 2013 from 9:00 am to 4:00 pm. The time was divided among group projects, invited speakers and field trips. Some of the student's characteristics are shown in Table 3 below.

Table 3: 2013 student characteristics.

| | |
|------------------------|--------------|
| Percent Hispanic | 94% |
| Average GPA | 3.275 / 4.00 |
| Percent TAMIU students | 100% |

The breakdown of the 2013 participants is shown in Figure 4.

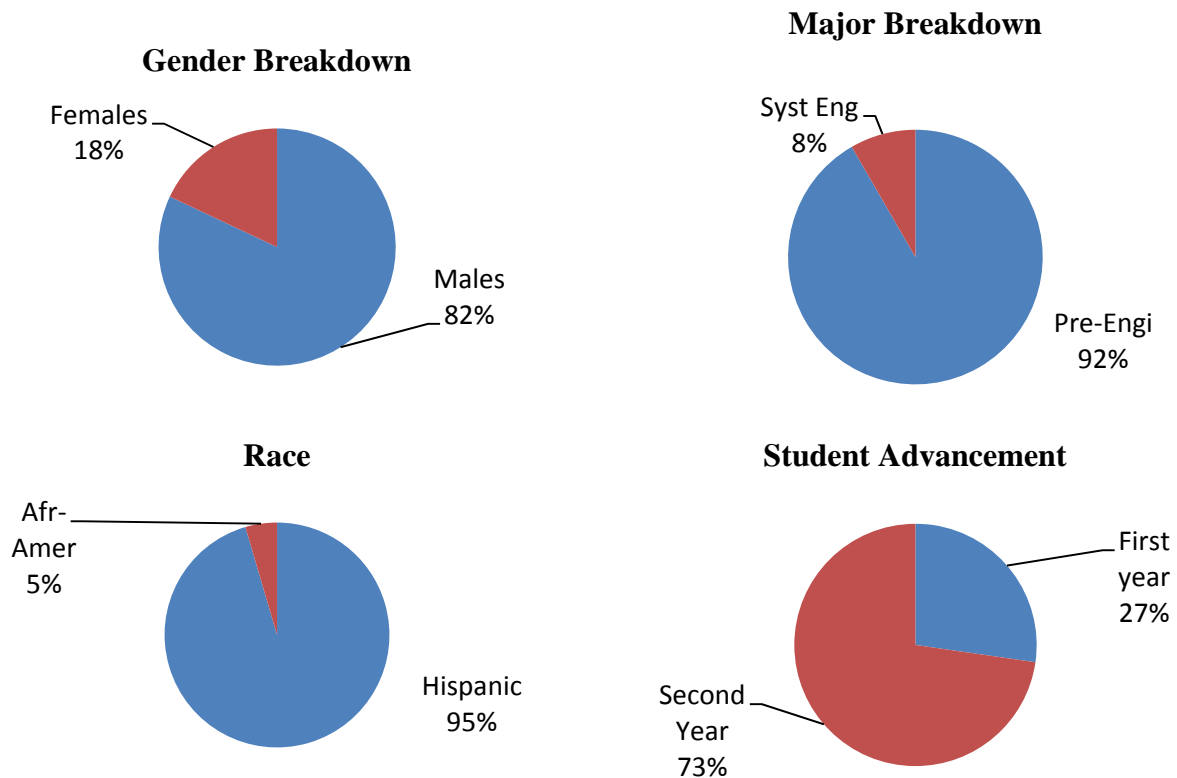


Figure 4: The breakdown of the 2013 participants.

The schedule for the 2013 workshop is shown in Table 4.

Table 4: The 2013 workshop schedule

| Day/Date | Time Slots | |
|--------------------------|--|---|
| | 9:00 A.M. – 12:00 P.M. | 1:00 P.M. – 4:00 P.M. |
| Monday 5/20 | Welcome & Introduction | Project proposal |
| | Meet with mentors | |
| Tuesday 5/21 | Work on project Dr. Bachnak | Work on project |
| Wednesday 5/22 | Work on project | Rosa Trevino, PE Retired TxDOT Engineer |
| Thursday 5/23 | Ricardo Villarreal, PE Engineer at Howland Engineering | Work on project |
| Friday 5/24 | Work on project | Adrian Uresti, PE AEP Engineering |
| Monday 6/3 | Work on project | Work on project |
| Tuesday 6/4 | Luis Ramirez, PE Retired TxDOT District Engineer & Henry Mejia Blue Top Companies | Luis Portilla Plant Manager Rheem Plant |
| Wednesday 6/5 | Water Plant Tour Jefferson Water Plant | Laredo's Airport Control Tower & Prolamsa, Inc Tubing manufacturer |
| Thursday 6/6 | Toyota Mfg Plant San Antonio | Southwest Research San Antonio |
| Friday 6/7 | Edgar Munoz, PE Terracon Labs | Project Submittal & Awards |

The students worked in small groups on engineering projects of their choice approved by the instructor. At the end of the workshop each group presented their project to the rest of the students.

We invited 7 speakers that were local engineers from Laredo, Texas and Nuevo Laredo, Mexico and they talked about how they studied and later worked to get to where they are now and they gave a description of their daily work. All the speakers invited the students for further conversation and possible plant visits in the future.

3.4 The Projects

The students were allowed to select their project and team members. They were required to produce a proposal of the project including all materials needed to complete it and a schedule with a description of what each member will do. Once their project got approved they started the procurement of their material. This included shopping for the best price and availability and producing justification for the purchase. If it was equipment they needed then they needed to

provide justification of the purchase of that equipment which includes a rationale for not using available equipment. Some of the projects are listed below.

- Connect-4 artificial intelligence game playing program where the user plays the game against the computer.
- The assembly of a small robot kit and interface with an Arduino board for its control.
- A bicycle powered power generator.
- Learn how to use our new CNC controlled milling machine using AutoCAD.
- A Lego MindStorm robot controller by a Raspberry Pi microcontroller board.
- A wake up light that increases the light intensity over time to simulate the sun rising in the morning controlled by a Raspberry Pi microcontroller board.
- A wind powered power generator.
- A hydrogen powered model car.

3.5 The Speakers and Field Trips

A major challenge of our engineering program is the limited opportunities available in Laredo for our graduates. To address this issue we added local prominent engineering speakers to talk to the students about life as an engineer in Laredo. Regional fieldtrips were also included to expose the students to the different types engineering industries that exist in Laredo as well as in nearby Nuevo Laredo, Mexico.

The speakers were selected to have a good representation of the types of engineering positions most likely to be available to the students when they graduate. The speakers are also engineers that have similar characteristics of the student. The speakers typically had a Bachelor's degree from a regional university near Laredo. Figure 5 and Figure 6 shows invited speakers, both are licensed professional engineers. In Figure 7 Mr. Wes Barbarena talks about the engineering involved in this water treatment plant. Figure 8 shows a local surveyor team giving the participants a demonstration of measuring the distance between two locations on campus. In Figure 9 the students are visiting a soil testing facility. The students really liked the visit to the local airport's control tower, (see Figure 10). Figure 11 and Figure 12 shows field trips to the Toyota Plant and to Southwest Research Institute both in San Antonio, Texas.



Figure 5: Mr. Adrian Uresti, a local engineer talks about his experience as an engineer working in Laredo.



Figure 6: Mr. Ricardo Villarreal, PE, a local engineer talks about his experience as an engineer working in Laredo.



Figure 7: Mr. Wes Barbarena explains how the water is treated at the Jefferson Water Plant in Laredo.



Figure 8: A demonstration given by Blue Top Surveyors on the use of surveying technology.



Figure 9: Terracon Labs



Figure 10: Laredo International Airport Control Tower



Figure 11: Toyota Plant in San Antonio, Texas



Figure 12: Southwest Research Institute, San Antonio, Texas

3.6 The Assessment of the Workshops

The success of this workshop was measured by using a survey and by collecting retention data. The survey results shows an average response of 4.69 / 5.0 in 2012 and 4.63 / 5.0 in 2013 in all of the questions related to their experience where 0 is disappointing and 5 is wonderful (see Figure 13). In particular, the survey shows an average response of 4.9 / 5.0 in 2012 and 4.8 / 5.0 in 2013 for the workshop's ability to encourage the students to continue to work towards a STEM degree.

The student's comments on the surveys indicate that the majority of the participants prefer that the instructor assign the projects rather than leaving it up to the students to find a suitable project. They also indicated their desire to spend more time on the projects.

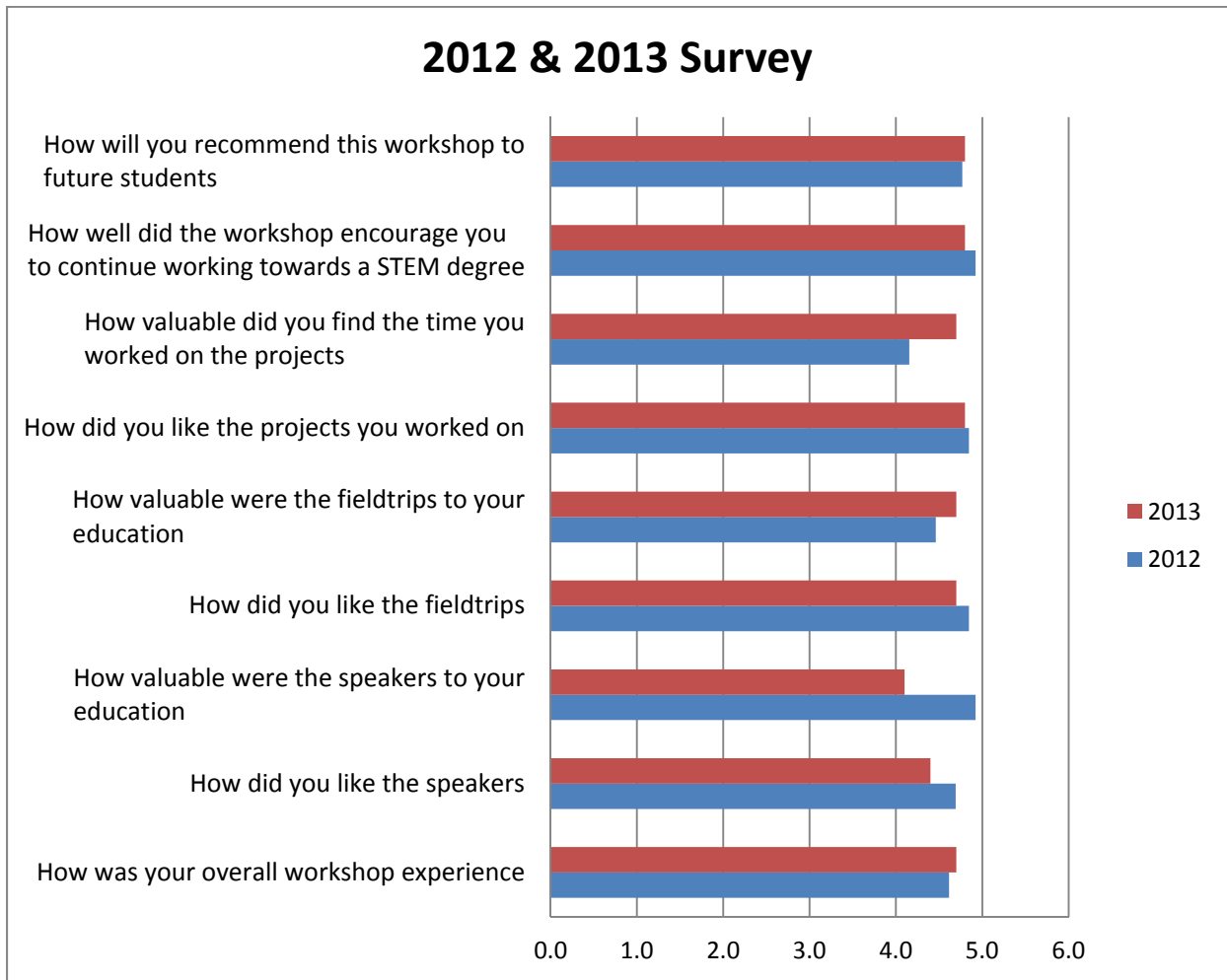


Figure 13: Survey results for the 2012 and 2013 workshops.

The retention rate for all STEM majors offered by the university from 2002 to 2009 is presented in Table 5 and shows an average of 52.41% of all first time, full time freshman students who began as STEM major continued with a STEM major after their first year. We do not have engineering specific retention data for those years but from Table 8 we can see that engineering

student population makes up 27% of the total STEM student population in 2012. From Table 6 the retention rate for engineering which includes pre-engineering and systems engineering was 87.4 for 2011 and 76.36 in 2012. We believe it was higher than the average for all STEM majors because we had and still have several retention programs in place such as the STEW¹⁵ program. The effects of these programs can be seen in the recruitment rates for 2012 and 2013, see Table 8. In comparison the retention rate for the participants of the workshop is 91% average for 2012 and 2013, see Table 7. Fortunately we have 1 year overlap, 2012, between the engineering students and the workshop participants. In 2012 the retention rate for all engineering students was 76.36%, Table 6, while the retention rate for all students who participated in the workshop for that same year is 87.5, Table 7. Since the participants of the workshop were all engineering students except for 1, the 76.36% statistic includes the students that produced the 87.5% statistic. Therefore the retention rate for all of the engineering students who did not participate in the workshop must be less so that the average comes out to be 76.36%. From Table 7 and Table 8 we can see that about 7% of the total engineering student population participated in the workshop. We cannot use the 7% to compute the retention rate for all non-participants because this number is computed using the total number of engineering students which includes 3rd and 4th year students as well. These retention rates are not included in the 2nd year retention rates in Table 6.

So in summary in 2012 about 7%, Table 7 and Table 8, of the total engineering student population participated in the workshop and produced a retention rate of 87.5%, Table 7, while the retention rate for all engineering students including those who participated in the workshop was only 76%, Table 6. Another way to see the result is to just consider averages. The average retention rate for the participants of the workshop is 91%, Table 7, for all engineering students is 77%, Table 6, and for all STEM majors is 52%, Table 5.

Table 5: 2nd year retention rates for all STEM majors.

| Year | 2nd year retention rate in percent |
|-------------|--|
| 2002 | 57.1 |
| 2003 | 53.3 |
| 2004 | 68.1 |
| 2005 | 52 |
| 2006 | 34.3 |
| 2007 | 49.5 |
| 2008 | 50.4 |
| 2009 | 54.6 |
| Average | 52.4125 |

Table 6: 2nd year retention rates for engineering majors as of 10/2013. The weighted mean uses the number student in each program in each year.

| Year | Pre-Engineering | Systems Engineering | Weighted Mean |
|------|-----------------|---------------------|---------------|
| 2011 | 65.52 | 100 | 87.40 |
| 2012 | 79.59 | 70.59 | 76.36 |
| | | Average | 77.24 |

Table 7: Retention data for the workshop participants as of 2/2014.

| | 2012 | 2013 | Average |
|--------------------------------------|------|------|---------|
| Number of Participants | 16 | 18 | 17 |
| Number of Systems Engineering Majors | 3 | 1 | 2 |
| Number of Pre-engineering | 12 | 17 | 14.5 |
| Number of Math | 1 | 0 | 0.5 |
| 1st year | 2 | 5 | 3.5 |
| 2nd year | 14 | 13 | 13.5 |
| Switched Majors | 1 | 1 | 1 |
| Quit School | 1 | 0 | 0.5 |
| Retention Rate | 87.5 | 94.4 | 90.95 |

Table 8: Enrolment data for Systems Engineering and Pre-Engineering.

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|-----------------------------------|------|------|------|------|------|------|
| Systems Engineering | 5 | 10 | 55 | 68 | 86 | 114 |
| Pre Engineering | 33 | 44 | 117 | 114 | 154 | 190 |
| Total Engineering | 38 | 54 | 172 | 182 | 240 | 304 |
| Total STEM | | | | 814 | 884 | |
| % increase in Engineering Total | | 42% | 219% | 6% | 32% | 27% |
| % increase in Systems Engineering | | 100% | 450% | 24% | 26% | 33% |
| % increase in Pre-Engineering | | 33% | 166% | -3% | 35% | 23% |

4.0 Conclusion

In this paper we presented a transfer and retention agreement between LCC and TAMIU and a set of workshops for first year minority engineering students that have completed the Foundations of Engineering I course. The workshops were offered during the summers of 2012 and 2013. The survey results indicate the workshop was well received and the participants

indicated that the workshop encouraged them to remain in a STEM field. The statistical analyses indicate that the participants of the workshop had a retention rate of 87.5% compared to the retention rate of 76% for all engineering students during the same year.

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