Bridging the Gap: Two-Year Colleges at the Crossroads between High Schools and Universities in STEM Education

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Abstract

Bureau of Labor Statistics (BLS) indicates that demand for engineers will continue to show a steady growth during the 2014-2024 period and expects greater-than-average growth from several individual engineering fields with rates ranging from 23.1% for biomedical engineers to 5.3% for mechanical engineers. The increasing employment of engineers in service industries, research and development, and consulting is expected to generate most of the employment growth.

A high level of achievement in Science, Technology, Engineering, and Mathematics (STEM) education is essential if the U.S. is to maintain a leading role in space science, aeronautics, cybersecurity, and technology in general. At the same time, too many students are graduating high school without the skills needed to succeed in college. Almost 50% of high school graduates did not have any kind of college readiness coursework. In 2015, high school graduation rates reached upward of 82% in the United States, but a study of outcomes revealed that only about ten percent of them were actually are ready for college. Two-year colleges have the means to step in and facilitate the transition of students between high school and university studies.

The paper will present some initiatives that can be started in high schools and continued at the two-year college level to create a continuous flow of successful students into STEM fields at the university level. These initiatives are just one example of multiple efforts directed at building a unified approach for attracting, training, and retaining students in STEM fields and to articulate a seamless transition for a continuum of education that will fortify technical education for the new decade.

Starting the Post-Secondary Education

In 2012, Community College Week reported data released by the President's Council of Advisors on Science and Technology which suggested that if the U.S. is to remain a STEM leader, the country must produce one million more STEM graduates than current projected rates.

The Atlantic reports that according to a 2011 STEM report from the Center on Education and the Workforce at Georgetown University, 92% of STEM workers will need post-secondary

education by 2018. Around 35% of that number will require training at the community college level, while another 65% will need baccalaureate degrees. Every government agency and many private industry sources are predicting a significant increase of demand for qualified American scientists, engineers, and technicians, (STEM) professionals [1], so it is important to explore all available resources to not only attract and retain students, but to properly prepare them to succeed in these fields. The reason why this is becoming a real problem is because global competition in education is becoming stronger and stronger every year.

The National Science Foundation in a 2015 Survey of Graduate Students and Post-doctorates in science and engineering found that from 2008 to 2013, STEM graduate students in the U.S. who were U.S. citizens or permanent residents rose by 3.1%. Of these, 25.8% were Hispanic, and 7.8% were African-American.

As a result in 2015, there were only 18 education systems with higher average science literacy scores for 15-year-olds than the United States, 14 with higher reading literacy scores, and 36 with higher mathematics literacy scores [2]. This translates to a large number of students leaving high schools unprepared to meet the requirements of post-secondary education [3]. This reality is particularly harmful for STEM education where math and science courses are the foundation. According to a 2016 report from the Center for American Progress [4], somewhere between 40 to 60% of first-year college students now require remedial courses in math, English, or both - meaning that millions of students across the country are trapped in classes that only cover content they should have learned in high school. Data from 911 two- and four-year colleges revealed that 96 percent of schools enrolled students who required remediation in the 2014-15 academic year, the most comprehensive recent numbers. At least 209 schools placed more than half of incoming students in at least one remedial course. These courses do not count toward any degree; they are just prerequisites for enrollment in college credit earning courses. That adds years to the graduation time with unnecessary additional costs for classes, and for many students with limited resources, this means dropping out of college without a degree.

This problem has been recognized for many years and numerous programs around the country have been initiated with various degrees of success [5] - [7]. High schools and Two-year colleges started to implement new initiatives that are meant to remediate the achievement gap and prepare students to be ready for true post-secondary education.

Initiatives at the High School Level

High schools have the advantage and the opportunity to address this problem before the issue starts. The primary conundrum has been repeatedly demonstrated that more than literacy skills or positive student behaviors, math skills are the number one predictor of academic success in higher education. The more students develop a solid foundation in math, the more they experience a boost in skills and confidence needed to persist through more challenging problems encountered in STEM education.

Different student groups differentiated by ethnicity, gender, and level of poverty are affected by these challenges differently. Hispanic and African American ethnicities experience a higher achievement gap compared with other groups. These students have a particularly high achievement gap compared with students from other groups as they have disproportionately more challenges including poverty and learning the English language. The lack of access to high-quality math content, instruction and experiences only widens the achievement gap.

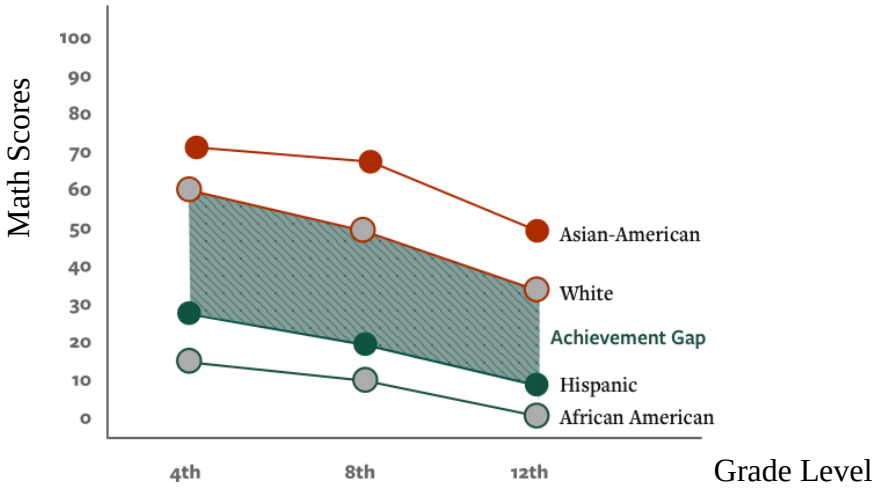

Figure 1 - *National Math Scores 2015*
(National Center for Education Statistics)

One way to address these challenges is the help received from many different federal agencies that have STEM- and STEAM-related grant programs for K–12 schools. In fact, STEM- and STEAM-focused grant opportunities are available from the Department of Education, Defense, Labor, and Agriculture, as well as other federal grant providers like the EPA and NSF.

Many grant funding initiatives for K–12 STEM and STEAM, particularly from the National Science Foundation (NSF), focus on making connections between institutions and resources

outside the school itself. The goal is to help students expand their horizons and sense of what is possible through STEM and STEAM in the future. They also give to the entire educational community access to a broader range of instructional tools and curriculum development that otherwise a school district might not be able to provide alone.

An important initiative meant to help students improve their high school learning outcomes was the introduction of dual credit and Advanced Placement (AP) courses. Recent studies have shown that students who participate in dual-enrollment programs are more likely to go on to obtain a college degree [8] – [10]. In addition to earning college credit, these courses offer high school students several benefits:

- They provide a smoother transition between high school and college
- They offer first-hand exposure to college-level work while still in high school
- The students taking these courses have a chance to complete their bachelor's degree faster
- These classes provide access to a variety of higher education resources
- They offer students an opportunity to begin their freshman year of college with college credits while they also earn credits toward high school graduation
- Cost savings experienced by taking classes in high school for college credit can be calculated exponentially
- Exposure to rigor, higher-order thinking skills, project-based learning, and group or team work are just a few advantages that prepare younger students for the intricacies of post-secondary education
- Higher expectations for quicker learning, research skills, and analysis create a more robust skill set for students
- Differentiate transcripts and provide an educational résumé that is more marketable to provide a competitive advantage over other students

Initiatives at the Community College Level

Being a large part of the post-secondary education, the community colleges can play a vital role in addressing the remediation problem. Remediation education is most common at community

colleges. More than two-thirds of the students are estimated to be enrolled in remedial education based on the placement test that found their math or English language skills to be beneath the requested level. Community colleges present some unique advantages over four year institutions to prepare students for a STEM education at the post-secondary level. At a time of increasing higher education costs, they present a more affordable alternative to four year institutions. With their small size classes, community colleges provide an environment with a more personalized approach, at the foundational level of college education. They are more adaptable to the student's needs and generally more in tune with their communities. The availability of remedial courses makes community colleges a fertile ground to explore better options for students with underdeveloped abilities [11] – [13]. Two-year colleges also often offer a less expensive way for the undecided students to explore a variety of STEM courses where they can discover the career that best suits their interests and prepare them to continue their studies toward a bachelor degree [14] – [16].

Our college decided to explore all the options available to address these needs by generating multiple initiatives. The results confirmed that the recruitment, retention, and graduation rates from STEM programs can be improved with initiatives that can be replicated everywhere. Since there is no magic bullet solution, every generation of students presenting different kind of challenges, we have to adapt our methods to every situation with slightly different approaches so we consider our work a continuous "work in progress".

The first initiative, in 2002, was to start a massive recruitment campaign in local high schools. The engineering faculty and students participated in every career related event and college night recruitment meetings in every high school in our area for the following three years. Throughout all this campaign, the importance of raising students' performance in math and science was strongly emphasized. In the same year a summer bridge program named The Early Development of General Engineering (EDGE) program was initiated with the help of an NSF discretionary grant. The evolution of the EDGE program has been presented in a series of ASEE papers that demonstrated the power of sustained outreach activities [17] - [24]. The EDGE program had a strong Math component that helped participating students alleviate the need for remedial math courses.

The next major initiative was also started in 2002, when our college joined NASA's Community

College Aerospace Scholars Program. The program exposes students to projects simulating NASA activities in which students have to complete several modules and projects online and have them evaluated by NASA engineers. Then those students go to NASA's Johnson Space Center for three days. There they learn scientific concepts, get experience with the way that engineers invent and solve problems together, and learn how the aerospace industry works. This program was an important element in our efforts to attract and retain students in our STEM programs. In 2012 NASA recognized our ten years of continuous participation in the program.

Another major initiative was the opening of the one and only MESA (Math, Engineering, and Science Achievements) Center in Texas at our college in 2007. The importance of the MESA programs in higher education was emphasized in numerous papers including our own ASEE paper published in 2013 [25]. The MESA Center offered a place where STEM students could congregate to form study groups, get help from tutors, work on projects, and support each other. The student chapters of professional organizations such as, Latinos in Science and Engineering (MAES), Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), Society of Women Engineers (SWE) and Society of Physics Students (SPS) have helped students create extended social support networks. The MESA Center was the focal point of another powerful initiative that was started in 2010 at our college. That was the year when we developed the first undergraduate research program on our premises with initial support from the NASA CIPAIR grant from 2009. As a result of this initiative alone over 175 students have been directly involved in 41 undergraduate research projects at our college and four papers have been presented at different ASEE conferences [26] – [29].

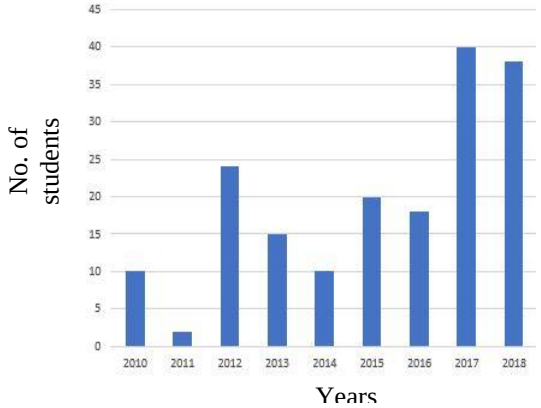

Figure 2 – San Antonio College (SAC) Students in Undergraduate Research Projects at SAC

At the same time, the engineering faculty initiated a strong mentoring program [30] that culminated with a National Award for Excellence in Teaching from NISOD and a Presidential Award for Excellence in Science, Math, and Engineering Mentoring for one of our faculty. The mentoring ideas were promoted at students levels too, creating a network of support and involvement between the novice students and the ones more advanced in their studies.

Among the most notable initiatives that our college took to address the math problem is to offer more math refresher courses to help students achieve higher math levels at an accelerated rate. For the last three years we provided math refresher courses during summers and throughout the semesters. The math refresher courses are based on the University of Texas at Austin's Dana Center Math Pathways (DCMP) [31] model which is an accelerated remedial model that allows students to work through the different math levels at their own individual pace. This competency-based model has been very successful assisting students to progress to college level math much faster.

Another initiative is to increase flexibility to increase assistance to students needing math remedial courses. For this purpose two new math labs have been added to provide extra 130 computers and two existing labs have been refurbished adding 126 stations. All these new stations are provided to increase access to our computer assisted ALEKS program. **A**ssessment and **LE**arning in **K**nowledge **S**paces (ALEKS) [32] is a new Web-based, artificially intelligent assessment and learning system successfully used by our Math Department to help students improve their math performance. A very important result of these added resources is an increased ability to provide extended tutoring to students when needed by allowing for math faculty to work with small groups of students to review their progress and provide extra tutoring for their successful completion. A new initiative started last year was to challenge students to complete all the developmental math courses in one semester. This is a particularly difficult initiative, since most of the students take other courses at the same time and have to navigate extra requirements from jobs and family obligations. As a result of all our efforts last fall semester, 1,588 students registered for our math refresher courses and 82.7% completed them. In the spring semester 506 students registered for math refresher courses and 84.7% completed them. Of all students that completed our math refresher courses last year, all of them placed at least one level above the initial placement, 30% two levels, 12% three levels, and 3% placed in Math 1314 – College Algebra.

The results of all of these initiatives started showing up without delays. In 2001 our college had only 164 students with a declared major in engineering. By 2016 we reached 698 students making our program the fifth largest in our college. During the same period, engineering graduates have gone from one or two a year to fifty in 2015-2016. SAC is a Hispanic-Serving Institution, and during the last 13 years over 65% of SAC engineering students have been underrepresented minority students.

A 2015 performance survey of SAC engineering students transferring to University of Texas at San Antonio (UTSA, the primary four-year program attended by SAC transfers) showed the positive effects of our initiatives. In the third and fourth years of engineering studies, students who completed their first two years at San Antonio College were twice as likely to have a GPA between 3 and 4 as those who started directly at UTSA. SAC students were also half as likely as the UTSA "natives" to have GPA's in the lowest quartile.

Conclusions and Future Plans

It is hard to determine which of these initiatives have had the most effect on the success experienced by our program. One thing is for sure. Enthusiasm and passion is the key to any initiative attempted. The faculty must have enthusiasm and passion for the engineering profession, enthusiasm for passing the torch to the next generation, enthusiasm in upholding the highest professional standards, and enthusiasm in believing in the unlimited potential of their students! With the goal in mind our team decided to hire as faculty only engineers with a proven track of industry experience that have passion and enthusiasm of teaching engineering the way is done out there in the real world so our graduating students will be "industry ready". This decision was made based on the fact that from all the engineering graduates with a bachelor degree less than 10% continue their studies to a master's degree or higher [33] and eventually end up working in research. The rest are entering the challenging and competitive world of real world industry with many of them having been trained mostly by professors that had only an academic background. Going from Bachelor, to Master's, Ph.D. and continue directly to a research career mostly in an academic setting does not provide the unique experience gained in industry where the practicing engineer bears the direct responsibility for all the decisions leading to the product or process created to address the specific customer requirements. With our background we were able to adjust and adapt

our program to fit the needs of our students using only the available resources, just like in our past practice.

Instead of entering higher education under a deficit model with remedial coursework needed, students may enter ahead of schedule when high schools and two-year community colleges work together to provide the skills that students need. Providing a more focused mathematical foundation for students who need help at both levels will create an environment that is more conducive to finish university coursework at the expected or even an accelerated pace (with dual credit and AP courses). Future recommendations include studying math programs at the high school and two-year college levels that provide the ability to close achievement gaps, especially those experienced by minority students.

Our Math Department plans to continue to offer math refresher courses and increase available tutoring. In the mean time we plan to monitor the new initiative from the Charles A. Dana Center at The University of Texas at Austin called Launch Years. This initiative looks specifically to address the barriers that keep many students–especially first-generation college students and those from low-income families–from progressing in their math courses between their junior year of high school and their junior year of college. Launch Years aims to rethink current structures, policies, and practices that shape the mathematics experiences students have in those years, because those years are critical in preparing students for entry into college and guiding them through higher education pathways to degree attainment.

We expect that our audience will gain from our paper new ideas about how to improve their programs and successfully address the specific needs presented by their students. Since different areas of our country have noticeable differences between various groups of students the engineering faculty should adopt, adapt, or develop new methods suitable to the specific needs of each of those groups.

Our students' success exemplifies what is possible when support is available and they are motivated to apply themselves fully to their studies and the multiple opportunities that exist in our community college program. The future of the program at San Antonio College will continue on an upward and positive trajectory where there will be more opportunities for students to get motivated to pursue careers in a STEM field.

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