



## **A View From The High School/Two Year College Partnership Interface: Our Best Practices Employed In Engineering And Technology Education**

### **Mr. Dave Galley, Collin College**

Dave Galley (MSEE, MBA, BSEE) serves as the Director of Engineering for Collin College. Recently, based on his work and that of the Collin College faculty in STEM education, the Collin College Engineering and Technology Department won the coveted 2014 Tech Titans of the Future University Level Award from the DFW Metroplex Technology Business Council (MTBC). In addition, through his work in higher education, he was selected to receive the prestigious 2014 "Wylie Way" award. He has presented an NSF workshop on and authored a variety of papers/presentations in the critical field of student pipeline success in STEM education. Galley is the Collin College co-PI for the Dallas STEM Gateways Collaborative NSF STEP Grant led by the University of Texas at Dallas. Finally, Galley sits on the STEM Advisory Board of the MTBC. Prior to joining Collin College, Galley was a Senior Engineering Fellow, a Senior Scientist and a Senior Manager in the semiconductor industry working for companies such as ATMEL, Raytheon Corporate and Harris Semiconductor. He brings more than twenty-five years of Silicon Valley based industrial technology experience to his role in the education space. He has authored numerous technical publications/presentations in semiconductor engineering and plasma processing. His current interests focus on the recruitment, retention and success of STEM pipeline students from high school through the university and into the workplace.

### **Mrs. Gena S Martin, Collin College**

Gena Martin (MBA, BBA) serves in the Engineering and Technology Department at Collin College. Recently, based on her work and that of the Collin College faculty in STEM education, specifically in the area of Technical Dual Credit, the Collin College Engineering and Technology Department won the coveted 2014 Tech Titans of the Future University Level Award from the DFW Metroplex Technology Business Council (MTBC). After her time at Baylor University, Martin's education career began in secondary education. Since 2007, she has focused on the critical interface between higher education and secondary education. In 2011, she joined Collin College as the Career and Technical Education Coordinator specifically working with technical dual credit students. Recently, after working closely with the department, she joined the Engineering and Technology Department of Collin College assisting students on the high school level, on the college level, and in industry who plan to pursue STEM degrees. Further, through her work with industry on the MTBC STEM Advisory Board, she coordinates key industrial connections for the department. Her current interests focus on the recruitment, retention and success of STEM pipeline students from high school through the university and into the workplace.

### **Dr. Jeannie Christine Stone, Wylie Independent School District**

Dr. Jeannie Stone began her career in Dallas ISD as a middle school English teacher in 1989. Prior to assuming her current role as Assistant Superintendent for Curriculum and Instruction in Wylie ISD, Dr. Stone served as a high school teacher, high school assistant principal, high school principal, and other administrative positions. This is her 25th year in public education.

Dr. Stone believes in the importance of individualized learning for every student, and she is committed to creating meaningful pathways for all students to ensure their success both while in school and beyond. She is passionate about developing best practices to create greatness in every public school classroom.

### **Ms. Becky Hunt, Allen Independent School District**

Becky Hunt (MEd in Administration, BS in Education) serves as the Director of Career & Technical Education, for Allen Independent School District. Recently based on her work guiding the Career & Technical Education (CTE) programs a new advanced engineering program is offered at Allen High School. She coordinates a CTE advisory committee made up of business partners, who provide guidance to program improvement. The advisory committee is evolving into a dynamic team that listens to new trends in industry and the workforce. Hunt has over 25 years in education. Prior to joining Allen ISD, she was the



CTE Director, for a large school district in Texas. In 2007, she was the Outstanding CTE Administrator, in Texas. From 2008-2011, she served on the board for the Career & Technology Administrators of Texas. She has designed and implemented CTE programs in high wage and high demand areas. Her current interests focus on high school engineering programs, marketing strategies that attract younger girls into engineering careers, innovative engineering programs, building a vertical curriculum, and providing seamless transitions for students from high school through the university and into the workplace.

#### **Jean Laswell, Rockwall Independent School District**

Jean Laswell (MACTE, BBA) serves as a Coordinator for Career Technical Education (CTE), STEM and Robotics for Rockwall Independent School District (RISD). Recently, based on her work in education, Rockwall ISD was selected to participate in the DFW Metroplex Technology Business Council STEM initiatives. Laswell serves as a member of the Board of Directors for two organizations: the Career-Technical Educators of North Texas and Interlink, Inc., a regional nonprofit alliance bridging the gap between business, education and government to develop a quality workforce with a globally competitive advantage. In her role as RISD CTE Coordinator, Laswell is responsible for STEM programs including curriculum development, educator professional learning, dual credit, student recruitment, and collaboration with business and industry through the Rockwall ISD Career Education Advisory Board. Recently, Laswell has presented at state and national conferences including the Career-Technical Association of Texas, the National Career Clusters Institute, and the National Science Teachers Association. Prior to her work in education administration, Laswell was a secondary educator teaching STEM courses in computer science, robotics and engineering and was selected as a 2011 Teacher-of-the-Year. Laswell also brings more than 20 years of experience in business, including extensive work as a marketing research consultant for STEM-related businesses and organizations. Her current interests focus on curriculum and instructional design to grow the STEM pipeline through recruitment, retention and placement from high school to post-secondary and career.

#### **Ms. Lynn Mortensen, Retired Raytheon Company**

Lynn Mortensen (BSCS) serves the North Texas community promoting STEM education through her participation as a member of the Metroplex Technology Business Council STEM Talent Team, the University of Texas at Dallas Jonsson School of Engineering Industry Advisory Council, the University of Texas at Arlington Engineering School Board of Advisors, and Collin College Convergence Technology Business Leadership Team. Mortensen is currently following her passion as a STEM advocate and volunteer after spending 30 plus years in the aerospace and defense industry. She started her career as a Computer Scientist with a degree from California State Polytechnic University Pomona. She retired from the Raytheon Company in 2013 having held many positions within the company in program management, product development and engineering management including vice president of engineering of a \$3B business segment. During her career, Mortensen was the recipient of several awards including the Malcom R. Currie Innovation Award and Raytheon Womens Network Woman to Watch Award. In 2011, she was selected as a Women Worth Watching in Technology from the Diversity Journal. As a member of the Dallas Society of Women Engineers Outreach Committee and an active volunteer at FIRST and BEST robotics, she continues to share her experiences with the next generation of engineers in the hope of increasing the number and diversity of engineers for the future.

#### **Dr. John W. Sibert, The University of Texas at Dallas**

John Sibert obtained his B.S. degree in chemistry from the University of South Florida and Ph.D. from the University of Texas at Austin under the direction of Professor Jonathan Sessler. He was then awarded a National Institutes of Health Post-Doctoral Fellowship with Professor Brian Hoffman at Northwestern University. He is currently an associate professor of chemistry at The University of Texas at Dallas with research interests that lie in the area of molecular architecture, designing and building new molecules for applications that span from medicine to environmental science to advanced new materials. He is an author, inventor and award-winning teacher with an educational emphasis on engaging learners in innovative methods centered around curiosity and discovery. He co-wrote UT-Dallas' campus-wide education plan



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titled "Gateways to Excellence in Math and Science (GEMS)" and has appeared as a science advisor for ABC and CBS News. He is a member and the president-elect of the UT System Academy of Distinguished Teachers.

# A View From The High School/Two Year College Partnership Interface: Our Best Practices Employed In Engineering And Technology Education

Dave Galley<sup>1</sup> and Gena Martin<sup>1</sup>,  
Jeannie Stone<sup>2</sup>, Becky Hunt<sup>3</sup>, Jean Laswell<sup>4</sup>,  
Lynn Mortensen<sup>5</sup> and John Sibert<sup>6</sup>

1- Collin College, 2- Wylie ISD, 3- Allen ISD, 4- Rockwall ISD, 5- Formerly, Raytheon Corporation, 6- University of Texas at Dallas

## Abstract

Collin College, three Independent School Districts (ISDs) in North Dallas and the University of Texas at Dallas have established a partnership to significantly increase the students engaged in Science, Technology, Engineering, and Mathematics (STEM) with the ultimate goal of having these students join the STEM workforce after a two-year degree, a 2 (AS) + 2 (BS) pathway or a four-year degree. Building upon previous cooperation among these institutions, Best Practice methods have been identified and are being implemented to bring about a cultural change that will lead to a sustained increase in the production of STEM-trained graduates needed by local high-tech businesses. In order to expand the diameter of the STEM pipeline, new non-traditional student populations must be recruited, encouraged and not traditionally “weeded-out.” Our research and Best Practices center on two specific populations: females and non-top 15% students that are considering whether college is part of their pathway to the workforce. Our work builds upon a very successful five year NSF STEM Talent Expansion Program (STEP) grant in which curriculum alignment and clean college/university articulations were accomplished. In this work, we present the results of concerted efforts across the high school/two-year college interface that have resulted in clear flowcharted articulated pathways for students to successfully navigate. Best Practices are presented showing an engaged robotics club that supports ASEE national competitions/STEM robotics outreach camps and the utilization of unique two-year college student chapters of professional organizations such as the Society of Women Engineers and the Information Systems Security Association. As the end goal is to produce students with relevant skill sets and technical certifications for local industry, strategies that result in “industry engagement in the classroom” are critical. Through interaction with local business councils and college industrial advisory boards with members who are engaged across the “interface,” the relevance of the technical education offered is assured. In conclusion, our presentation highlights unique approaches that attempt to encourage students and minimize the hurdles confronted by a potential STEM student.

## Introduction

It has been realized and well documented that the “gathering storm” has come<sup>1</sup> and in order to weather it and in order to re-establish the manufacturing and technology base of the United States, we need “One Million Additional STEM College Graduates” over the next decade<sup>2</sup>. Currently, we graduate about 300,000 STEM discipline graduates per year<sup>2</sup>. We will need to graduate an extra 100,000 STEM students in each of the next ten years to meet the projected need<sup>2</sup>. In this paper, our partnership describes a number of Best Practices that we have adopted with excellent results to date. The context of our presentation is the interface between the high school and the two-year college. We must provide cleanly articulated pathways from high school

to two-year to four-year institutions in the traditional 2 + 2 format for Bachelor's Degree students. Simultaneously, we must provide successful pathways for students that exit the pipeline for employment after their two-year AAS degree. Strategies need to be in place to help them succeed in the two-year workforce college experience. The use of co-op experiences and hands-on lab education to provide the engagement that they require is critical. Therefore, the interface between the high school and the two-year college becomes a critical zone where Best Practices must be discovered, invented and disseminated for national implementation in order to meet the challenge posed by the aforementioned requirement of one million additional graduates<sup>3,4,5</sup>. As discussed by the President's Council of Advisors on Science and Technology (PCAST) in their 2012 report<sup>2</sup>, the fastest way to generate graduates and attain our goal is through different methods of teaching, supporting and retaining students. Finding ways to engage them and help them to persist is critical to attainment of our goal<sup>6</sup>. In the following discussion, our partnership offers a number of Best Practices that help to generate and maintain students early in the pipeline, engage institutions to common purposes for the good of the students, create clear articulated pathways in order to build the trust of students and parents, and work with industrial stakeholders as they are realizing that they can no longer take a passive role simply waiting for students to exit the pipeline.

### **Beginning To Build The STEM Pipeline**

Increasing the number of students in the STEM pipeline really means increasing the number of students entering the pipeline and retaining those that have entered. Traditional thinking has been to encourage students that are good in Math to give STEM fields a try. During the trial period, students are weeded out. Those that "can't make it" in fields like engineering are encouraged to seek other fields of study like Business or Accounting. Our approach has been to challenge all parts of this stereotypic process. In order to facilitate our planning and to have a clear vision of all of the inputs, outputs and feedback loops in our specific pipeline, a pipeline graphic was constructed and serves as the model for our partnership as well as this paper (see Figure 1). The graphic allows one to see the components of the effort. In the case of the high school/two-year college interface, one sees that curricular alignment is a key with clear articulation. The college inputs Technical Dual Credit classes into the high school to make sure that the curriculum alignment loop is closed successfully. As shown on the chart, trusted articulation pathways must be aligned in terms of curriculum between the two-year and four-year institutions. Importantly, industry's needs in terms of workers output from the pipeline must be accounted for through engagement in many ways with all three institutional levels. Finally, the financial implications of pathway choice for the student must be clearly conveyed to the student and parents. As the risk of pursuing a pathway through the two-year institution is lowered through clean articulation and barrier removal, the student can take advantage of the cost structure difference. In the case of our partnership, the cost of one course at the four-year university (~ \$2,165) is roughly equivalent to the tuition cost of two entire years (~20 courses at \$2340) at the two-year college. This fact alone can determine whether a student can attend college, must work during college, and/or exit a bachelor's program with a reasonable debt load.

# The High School/Two-Year College Partnership Interface In Perspective

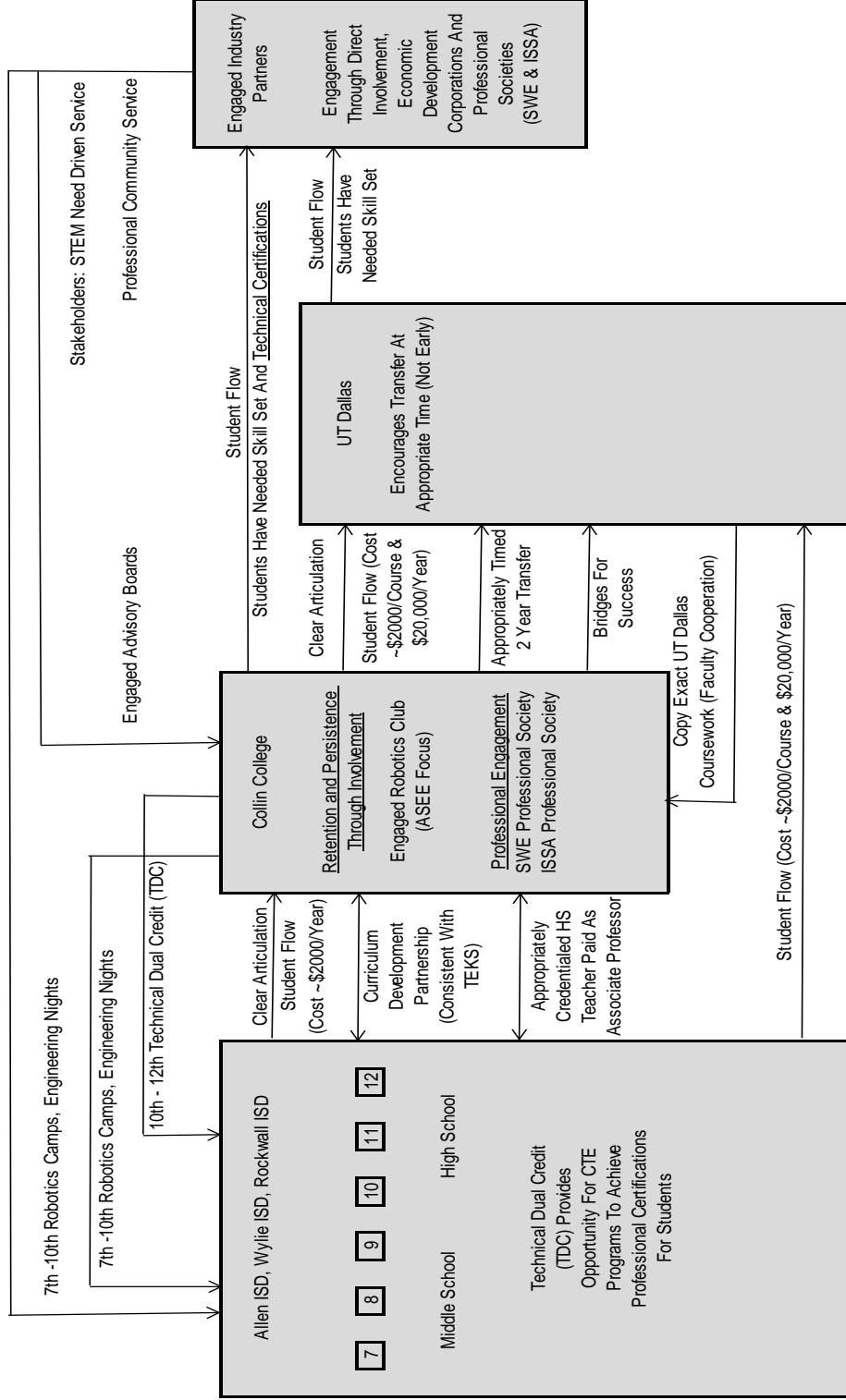


Figure 1-The STEM Pipeline: The High School/Two Year College Partnership in Perspective

As we are in need of more graduates exiting the pipeline, we must consider how to increase the pipeline's diameter. In particular, if we are to truly increase the diameter of the STEM pipeline, we must reach out to and successfully engage two specific populations: females and non-top 15% students. Through the unique structure of the relationship between two-year institutions and independent school districts (ISDs), the two-year institution is in a unique position to contribute to the successful engagement of these two critical populations. The engagement of the latter population can be accomplished through encouragement to "try STEM fields and college," hands-on outreach programs and Technical Dual Credit (TDC) while in high school. In the case of the former population, our robotics camp research shows that boys need "confirmation" to continue strongly in engineering, whereas girls need "confirmation" after "affirmation" and "visualization." Based on the above finding, we believe that the approaches to encourage middle school boys to proceed towards STEM careers and the approaches to encourage middle school girls to proceed towards STEM careers must have some similar elements and yet be necessarily different.

A study that shows the difference between boys and girls was done very early in our collaborative project. Collin College asked questions of Allen ISD students that were judged to be "good" in 7<sup>th</sup> and 8<sup>th</sup> grade math by test scores and teachers. The simple study was completed using responses from 38 boys and 36 girls. The boys thought they were "good enough" to be in engineering. The girls thought that they "needed improvement" to be in engineering. These "thoughts" ran counter to the actual test scores. The girls' test scores were actually on average 7% better than the boys' test scores with a similar test score range between the populations.

While this finding is not unique, it does show that when boys attend an outreach event, they are looking for "confirmation" that they can perform the task at hand. As we have confirmed as a Best Practice through our robotics camps, outreach to girls must have additional components that address the need for "affirmation" and "visualization." We have found that having female engineers from industry speak to the girls and "mentor" them during the camp experience creates a much richer and more successful camp experience for them.

Best Practice outreach to increase the number of female students in the pipeline, based on the perceptions described above, can take many forms. One of the most successful forums that we found is the "Girls Night Out with Female Engineers." This concept was started in partnership with Allen High School. The ISD identified the top 150 math scoring 8<sup>th</sup> grade female students in their middle school pipeline. These girls and their parents were invited to the high school one evening to participate in a special event featuring eight female engineers from local industry. These ladies each had unique journeys to share and stories to tell regarding their educational experience and how their corporate careers unfolded. The engineers were from local Fortune 500 companies such as Cisco, Raytheon, and Texas Instruments. Each was given seven minutes to describe to the girls their unique journey. Then, the floor was opened for questions. The girls particularly liked the questions session. Questions ranged from how to work with male engineers to how to network with women. In addition, the girls got confirmation that, based on the experience of the engineers participating, one could have a good engineering job and raise a family. Unfortunately, many of the parents had not supported this view of engineering careers being flexible. This forum proved to be a watershed moment for many of the parents as one of them confessed that before the event she was very proud of her daughter's math scores and was feeling that her daughter would therefore make a great accountant. After the discussion

(“affirmation”) and the panel presentation (“visualization”), the participating girls knew that there were STEM careers open to them and that those STEM careers would not by definition preclude other goals that they may have in life.

While the selection of these top math students may skew the data towards the “positive” in terms of math, science and personally knowing an engineer, the data are nonetheless encouraging. As shown in Figure 2, while some of the students don’t like math, they understand that they are good at it and want to take higher level math. Given the hands-on nature of middle school science, we see that the girls report liking science and being good at it. While there is a fall-off in interest in engineering, the numbers are still encouraging, in particular, in terms of those wanting to take a college class in engineering at the high school level. Finally, 100% found the discussion interesting and 96% said that the presentation made them want to be an engineer. Before the event, less than half (48%) of the girls knew a female engineer (note that this is a high number in comparison to the general public which may be correlated in some way to the math scores achieved by the participants). After the event, all of the girls had affirmed that they could be an engineer and had visualized eight very successful women in engineering.

<b>Allen Girls Night Out With Female Engineers</b>	Strongly Agree	Agree	Disagree	Strongly Disagree
<b>1. I like Math.</b>	34%	45%	17%	3%
<b>2. I am good at Math.</b>	59%	38%	3%	
<b>3. I plan to take advanced Math classes at Allen High School.</b>	76%	24%		
<b>4. I like Science.</b>	55%	41%	3%	
<b>5. I am good at Science.</b>	59%	41%		
<b>6. I plan to take advanced Science classes at Allen High School.</b>	75%	25%		
<b>7. I like Engineering.</b>	29%	46%	25%	
<b>8. I am good at Engineering.</b>	24%	55%	21%	
<b>9. I plan to take Engineering classes at Allen High School.</b>	29%	54%	18%	
<b>10. I am interested in taking a <i>college level</i> Engineering class while at AHS.</b>	22%	44%	30%	4%
<b>11. I found the panel discussion interesting.</b>	68%	32%		
<b>12. The presentation made me want to be an Engineer.</b>	36%	60%	4%	
	YES	NO		
<b>19. Did you know any engineers before tonight?</b>	76%	24%		
<b>20. Did you know any <i>female engineers</i> before tonight?</b>	48%	52%		

Figure 2- Selected Results From Allen High School “Girls Night with Female Engineers”

### **High School Technical Dual Credit Course Work**

A critical Best Practice which feeds the STEM pipeline is Technical Dual Credit (TDC). A dual credit course is a college level class taken typically by a junior or senior in high school where the student earns both college and high school credit for the course. Technical Dual Credit at Collin College refers to a dual credit course in the area of Engineering or Technology. In the Fall of 2010, Collin College began offering its first Technical Dual Credit course, Introduction to Engineering, at one high school in only one school district (Allen ISD). At that time, Collin



College had achieved a large academic dual credit presence in our service area by offering courses such as English, History and Social Studies. The Introduction to Engineering course was the first of its kind outside of the academic dual credit course offerings at Collin College. Since then, the Technical Dual Credit program has expanded to include three partner school districts Allen ISD, Wylie ISD, and Rockwall ISD, multiple high schools within the districts and a variety of courses in the areas of Engineering and Technology. As shown in Figure 3, the number of students engaged by the Collin College’s Engineering Department over the past four years has grown from 36 students in the 2010/2011 school year to 219 students for the 2013/2014 school year. This growth can be attributed to several Best Practices.

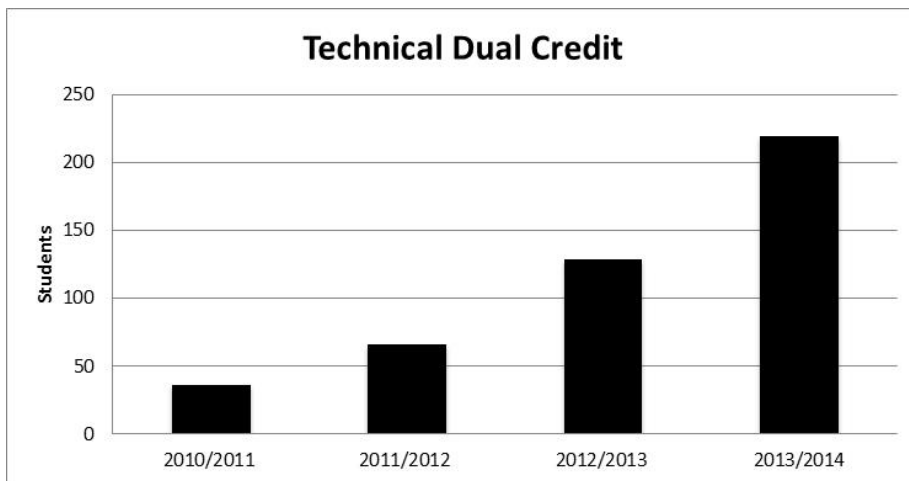


Figure 3- The Growth Of Technical Dual Credit At Collin College

Students electing in their junior or senior year to take a Technical Dual Credit class, are choosing to start college early. It is a unique student who is not only ready for this challenge, but is also interested in the areas of Engineering and Technology. A 2011 study of dual credit students across our state found that 56% of students are female and 44% are male<sup>7</sup>. The students surveyed participated in various types of dual credit, with only 10-11% in Career or Technical Dual Credit<sup>7</sup>. The data obtained from the Technical Dual Credit students at Collin College over the last four academic years shows that the majority of the participants are male (85%). The data from Collin College also shows that of all the students who participated in a Technical Dual Credit class, 56% of those students took only Technical Dual Credit classes and did not take academic dual credit courses. This finding is critical to Best Practice recruiting. Further, it suggests that when high school students are offered the opportunity to take a college level course outside of the traditional academic dual credit offerings, in areas such as Engineering and Technology, students who might not have previously chosen to take a college class for dual credit are choosing to take a Technical Dual Credit course. More specifically, the data shows that 59% of the male students and 37% of the female students that enrolled in a Technical Dual Credit course chose only to take Technical Dual Credit course(s) during high school. These findings significantly show that by offering Technical Dual Credit courses a population outside of the traditional dual credit constituency is impacted. As these students represent a new collegiate STEM pipeline population, Best Practice recruiting must be engaged to find and cultivate these students that are outside of the traditional academic dual credit constituency.

Students benefit greatly from taking dual credit courses while in high school<sup>8</sup>. A student can experience the rigor of a college course while still in high school and high schools are able to offer a variety of courses that previously were unavailable to their students. By offering Technical Dual Credit courses at area high schools, students become aware of concepts and careers within the area of engineering and technology that they may not have been aware of without the coursework. By taking these courses, students are exposed to content, rigor and opportunities that are not necessarily available in high schools. As Figures 4 through 6 show from a study of our Technical Dual Credit students, there can be very positive impacts from Technical Dual Credit coursework in terms of filling the STEM pipeline.

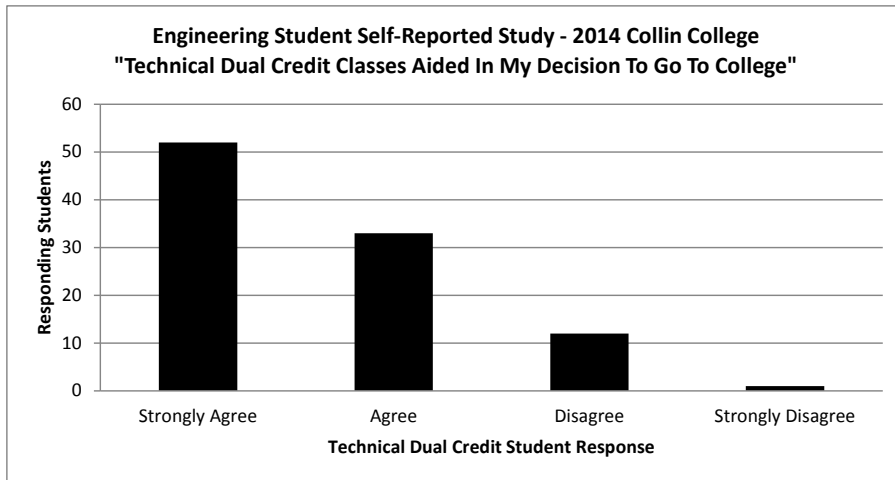


Figure 4- The Impact Of Technical Dual Credit Upon Students In Terms Of College Attendance

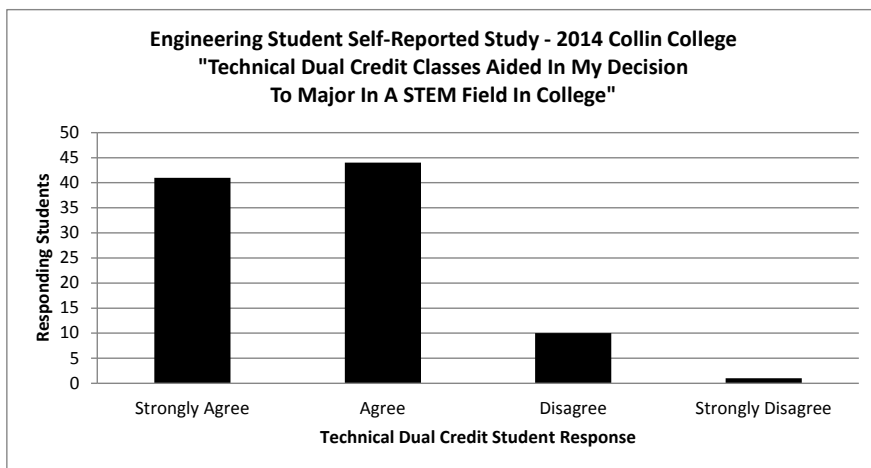


Figure 5- The Impact Of Technical Dual Credit Upon Students In Terms Of Choosing STEM

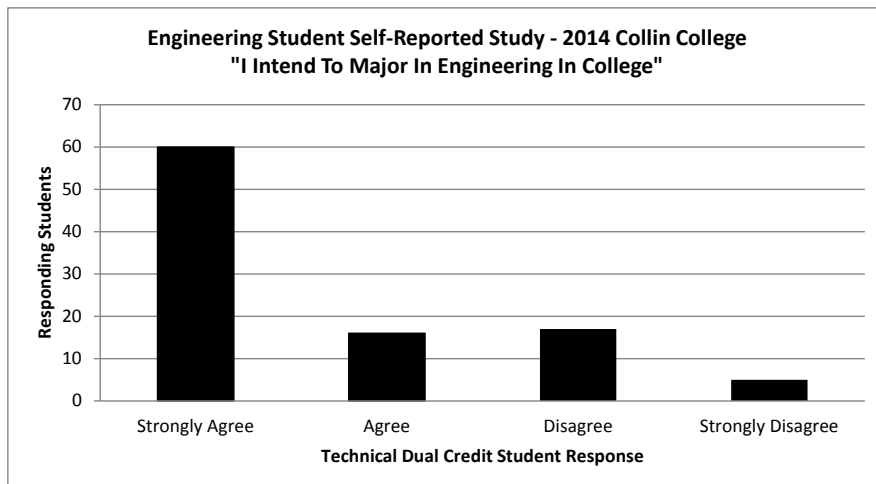


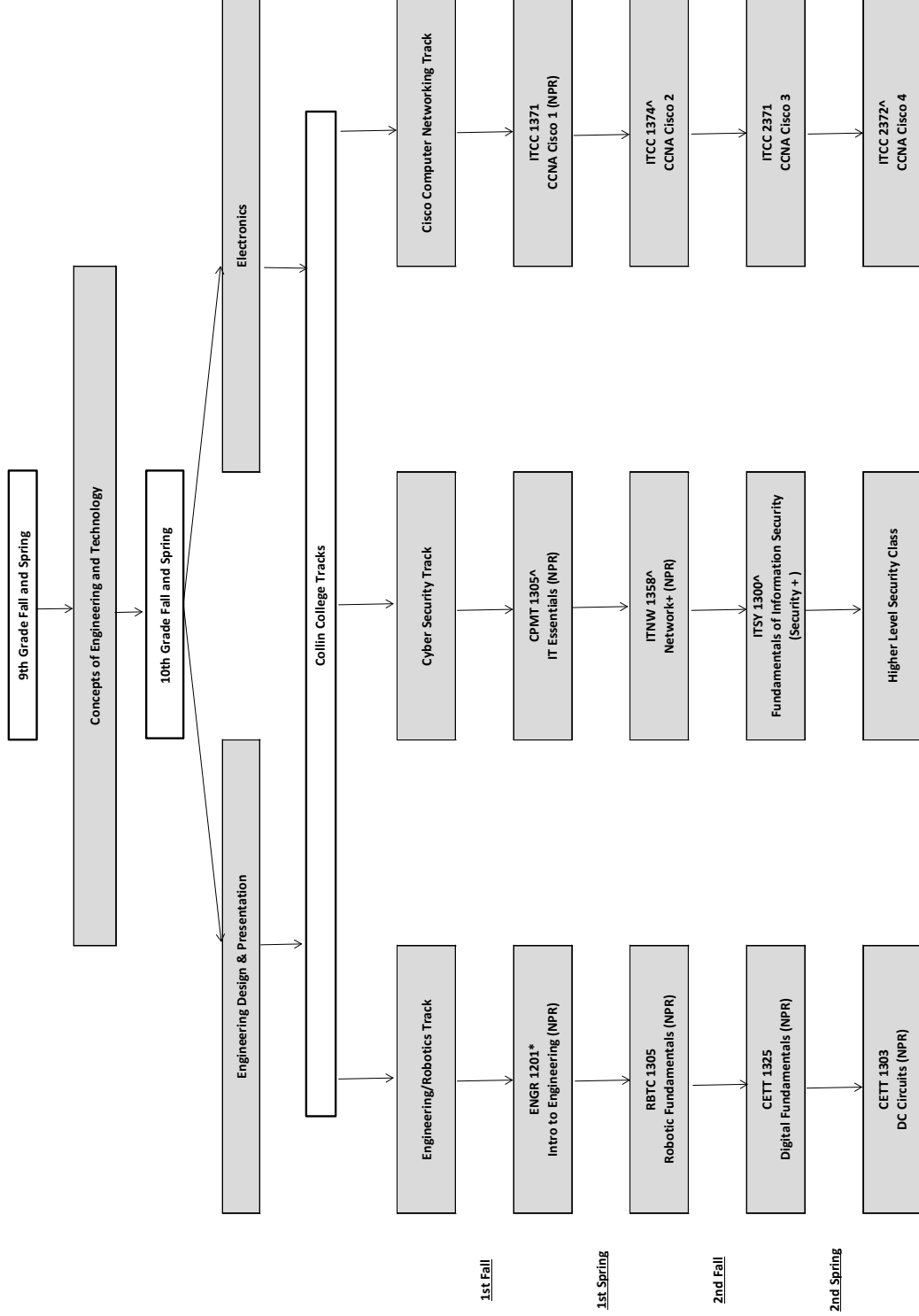
Figure 6- The Impact Of Technical Dual Credit Upon Students In Terms Of Choice Of Major

A direct pathway is created from the high school to the community college and on to the four year institution by offering Technical Dual Credit courses in local school districts. The school districts that Collin College has partnered with to offer Technical Dual Credit have started developing high school curriculum in grades 9 and 10 to take the pathway all the way through the high school experience directly into an associate’s degree program. Figure 7 shows the complete high school pathway created by Wylie ISD, a partner ISD of Collin College. In addition, Wylie ISD has used Technical Dual Credit with Collin College as the catalyst to develop an engineering specific curriculum that starts in the freshman year of high school. As a Best Practice, in order to create this engineering curriculum, the school district partnered with Collin College, UT Dallas and area business leaders to develop relevant content for grades 9 and 10 to support students who are pursuing a pathway into an engineering or technology degree. These classes did not exist within this school district prior to Collin College partnering with them to offer Technical Dual Credit. Further, in order to create a seamless communication path for students and stakeholders in the high school, we have determined that a Best Practice is to hire acceptably credentialed high school teachers as adjunct faculty and have them teach at least one course. This practice provides about ~\$3800 per course (i.e. effectively “coach’s extra pay”). Lastly, Technical Dual Credit courses from the AAS degree programs allow students to achieve meaningful industry professional certifications (e.g. A+, Network+, Security +, Cisco CCNA) which is a major metric for CTE educational programs.

**Outreach To Pre-College STEM Students**

It has been well established in STEM education literature and confirmed in our geographic area that STEM outreach is best facilitated by the establishment of targeted STEM curriculum for pre-college students and, specifically, through the use of robotics as a way of engaging students in engineering and computer science. The department’s Robotics Camp that engages students who are considering entering the STEM pipeline has a number of Best Practices. These targeted curriculum camps focus on robotics and programming fundamentals as a way to “hook” as many students considering STEM educational pathways as possible.

Wylie ISD Technical Dual Credit STEM Pathways Offered By Collin College For 11th And 12th Grade Students



\*Academic Transfer Course

^Certification Third Party Exam Available

NPR=No Pre Requisite needed (Algebra 2 > 85 grade in course assumed pre req for all technical dual credit classes)

Figure 7- Complete High School and Technical Dual Credit Pathways Example

In order to establish a formidable robotics presence that could facilitate robotics competition support, robotics camps, and represent Collin College at robotics competitions (e.g. the American Society of Engineering Educators (ASEE) Annual Robotics Competition), it was decided that Collin College needed to facilitate a student organization, the “Collin Robotics Club,” to function as an Engineering Department STEM Outreach Emissary. The concept of total immersion of a student organization into all facets of the outreach effort has had challenges. Finding the right students and playing off each student’s strengths, while realizing that once a student is identified he or she will only be with the program for a year or two, is a substantial challenge that requires unique and specific Best Practices by an institution. Three Best Practices that we have established and believe are critical to the continuity of the student based effort involve:

- 1/ the development of a constant Robotics Club recruiting plan that targets freshman level entry courses (i.e. Calculus 1 and 2, University Physics 1, and Introduction to Engineering)
- 2/ rewarding the strongest participating outreach students with the ability to be on the travelling team that attends the annual ASEE Robotics Competition
- 3/ using paid part-time student assistants to manage the logistics of running the club.

An additional Best Practice revolves around the specific support of high school robotics competitions (e.g. FIRST and BEST). It is a critical function of the Robotics Club and is used to promote Collin College Engineering Department in a variety of ways (e.g. by encouraging high school students to consider taking Technical Dual Credit coursework, by encouraging local corporate in-kind support of Collin College functions). At these competitions, Collin Robotics Club advisors, as well as the students, perform duties as runners, judges, advisors and mentors to potential STEM pathway students participating in the various competitions throughout our geographic service area.

### **The Collin College Robotics Camp Model**

A formidable Best Practice that has been developed by the Engineering Department is the Collin College Robotics Camp Model. It has been designed to support 30 - 40 students per camp from the local area. In the three day event, the students learn about robotic electrical functions, mechanical functions, sensor functions and LabView programming. While the curriculum design changes for each camp, the format of the camp does not change. During the camp, STEM middle/high school students, Collin Robotics Club members and professors are engaged in fruitful learning. Camp participants pay only \$79 for 3 days of camp participation (compared to the going rate of \$429 for 4 days in our service area). On the last day of each camp, parents are invited to see what the students have completed in terms of robotics. We consider this lunch to be a Best Practice. After a provided lunch, the parents and students participate in a discussion of STEM pathways at Collin College which can result in clear articulated pathways to UT Dallas partner. This model has never failed (through numerous camps) to be heralded by parents as a great use of time that fosters discussions with their camper that may not have occurred otherwise. We find that parents of 7<sup>th</sup> to 9<sup>th</sup> grade campers are just coming to terms with the notion of college, from expenses to what major that their student wants to pursue. As parents, they are grappling with whether they think the major is appropriate. We try to indicate to them that this is not their decision. At this point in their student’s life experience, their role is to help facilitate the student’s choices. The parents have indicated that this discussion allows them to consider many

things including college expense for the two pathways: two-year institution then four-year institution versus four-year institution, college major including the many interdisciplinary areas for robotics, the concept of girls in STEM education, and the appropriateness of two-year terminal degrees for math challenged students. We indicate that these math challenged students can still be in engineering starting as engineering technicians. Parental engagement and support of students wanting to pursue STEM is critical. In particular, we find that parents of girls, as well as the girls themselves, need to be able to “visualize” (i.e. see themselves in an engineering role). During the discussion, the cost of exact transferable coursework is discussed. Everyone weighs the financial benefit of taking a single course at our four year university partner for the in-state cost of \$2,165 versus taking an entire 30 credit year for \$1,170 at Collin College (see Figure 1). The lunch discussion is meant to be as “intrusive” as possible without crossing the line.

### **The Collin College “All Girls Mentoring” Robotics Camp Model**

After interviewing many girls that have attended our robotics camps and after speaking with numerous practicing female engineers, we have recognized the critical need for girls not only to “confirm,” but “affirm” and “visualize” themselves in the engineering pathway. Our Best Practice conclusion is that girls can get all three needs fulfilled at an “All Girls Mentoring” Robotics Camp. Therefore, we have developed this second camp model which has been piloted twice and has proven to be a tremendous success. By model, the camp is restricted to girls. Playing off our successful mixed gender camp model, it runs for the same three days with the parental lunch and STEM college discussion. While robotics is still the vehicle to confirm to the campers that they can be successful in a STEM field, the videos shown at the camp are changed to be more “helpful to society”<sup>8</sup> and female engineers from local industry speak to the girls as the camp opens each day and at lunch time. Therefore, the girls are exposed to six professional engineers that affirm for them through the stories of their personal journeys to becoming an engineer that each of the campers can do it as well. Additionally, through the talk that each engineer gives and, then, the mentoring that each offers during the balance of the day with the robotics effort, each camper is able to visualize themselves in the role of an engineer. At the end of the camp, each of the speaking engineer’s personal contact information is given to each camper for further communication if she or her family wishes to contact the practicing engineer. After the first camp, we had a number of campers reach out to one of the speakers to help them work through the discussion of majoring in engineering with hesitant family members. It is our belief that this desire for follow-up only further confirms the value of the model and approach. From the data in Figure 8, one can see the enthusiasm generated by the camp model. A full 90% of the campers showed an interest in attending Collin College. A complete 100% found the speakers of value and every camper reported learning from the speakers. Wonderfully, 69% reported that they were inclined to reach out to one or more speakers after their camp experience.

Through our approaches and efforts to build STEM student engagement, we have challenged all parts of the stereotypic “weeding out” process. By using Best Practices to encourage both male and female students, noting that boys simply need “confirmation” to continue strongly in engineering, whereas girls need “confirmation” after “affirmation” and “visualization,” the data and experience of our partnership can be considered to be actionable intelligence that others may leverage to the benefit of STEM students nationwide.

All Girls Camp Survey	Yes	Somewhat	No
6. After attending the camp are you interested in attending Collin College in Robotics or a STEM field?	76%	14%	10%
7. Did you enjoy the female engineers that spoke at the camp?	61%	39%	0%
8. Did you learn from the speakers about their journey?	50%	50%	0%
9. Do you plan to contact the speakers after the camp?	38%	31%	31%

Figure 8- “All Girls Mentoring” Robotics Camp Survey

### **Ensuring Student And Parent Confidence In The STEM Pipeline: Building Bridges**

Ensuring that students and parents can see the pathway to student success by following the STEM pipeline created by Collin College and our partners through the emphasis of math classes early in the middle school and high school experience, the appropriate choice of high school coursework, the taking of Technical Dual Credit classes, and a clear articulation pathway from the two-year institution to the four-year institution is critical to the student following the STEM pipeline as laid out. While there are many measures by which the created STEM pipeline can be viewed, it starts with the student being able to identify early in the process that he or she wants to pursue a STEM career. Whether this is done through engineering nights, science fairs, robotics camps or another means, an early decision is critical. This fact is why our partnership has put a premium on the previously mentioned activities. The parental support of the STEM student’s special needs, particularly if the student wants to pursue engineering, is absolutely critical. In our geographic area, there are not enough slots in STEM related camps for the number of students that need these experiences (we counted about 27 camps, averaging 30 slots, each summer for more than 200,000 students desiring the experience). Based on supply and demand, the cost of the camps that are run is high. Therefore, the quality of the camp can be a make or break for the potential STEM student. Realizing this factor, the partnership fully supports Collin College in running the parental lunch discussing STEM pathways and the importance of taking Math early at the end of each camp. While it is possible to take the time to remediate undeveloped math skills, it is time consuming and usually holds an engineering student back by an academic year. This can be financially challenging. Far worse, it can create a situation where a potential student gives up and pursues another field rather than enduring the wait for their math skills to catch-up.

After the student and parent make the decision that the student will successfully pursue a STEM related field in college, the choice of pathway is non-trivial. It is at this juncture that course relevance and articulation becomes important. Having concluded this, our partnership decided very early in the set of priorities to engage Industrial Advisory Boards at the two-year institutions to provide for relevant Associates level coursework and support in the area of middle school and high school industry relevant STEM programs. Another critical priority involves clear articulation to the receiving four-year institution<sup>9,10</sup>. Again, as a top initial priority for our partnership, the establishment of aligned curriculum, specific articulation by degree program, the teaching of lower division UT Dallas “copy exact” coursework at the two-year institutions and quarterly meetings between advising teams from Collin College and UT Dallas were viewed as critical to a clear STEM pathway for students. We consider achieving this clarity to be a Best Practice due to the fact that both the student and parent must “trust” the pathway in order to engage and follow the pathway. While cost is important, the ability to see the “mainstreaming”

of the pipeline pathway is critical in order to develop the “trust” required to follow the pathway. Our partnership has seen this first hand as Collin College’s engineering department which was failing seven years ago has been restored from decline and has had substantial growth due to a focus on student and parent confidence (see Figure 9). The same new found confidence in the STEM pipeline built by the partnership caused a dramatic increase in the number of students starting at Collin College with the goal of transferring to UT Dallas<sup>11</sup> (see Figure 10).

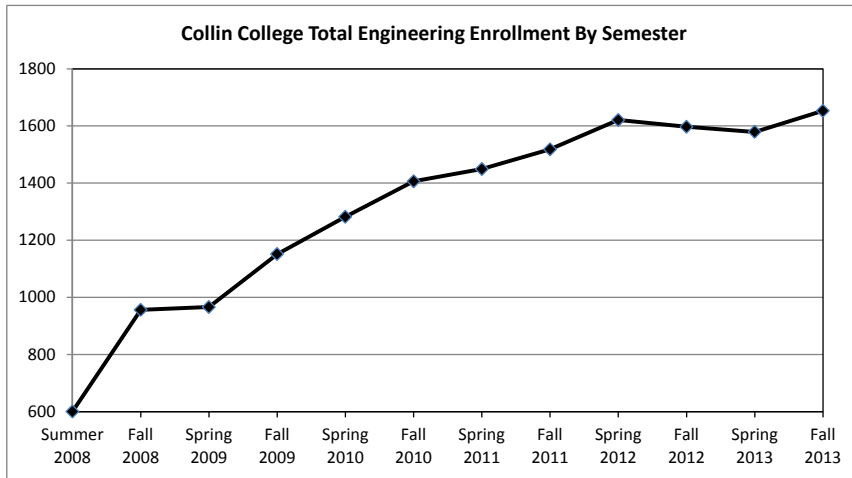


Figure 9- The Resurgence of Collin College’s Engineering Program (Duplicated Enrollment)

As with each phenomenon like this, there are a variety of reasons for these positive results. One of the reasons that has significant traction is cost. Given the low tuition at Collin College, a student can, by taking the first two years of coursework at our institution before transferring to UT Dallas, get an equivalent education paying roughly 60% of the overall total four-year tuition cost. As long as articulation pathways are trusted and clear, students are realizing that this is a very good bargain for all concerned.

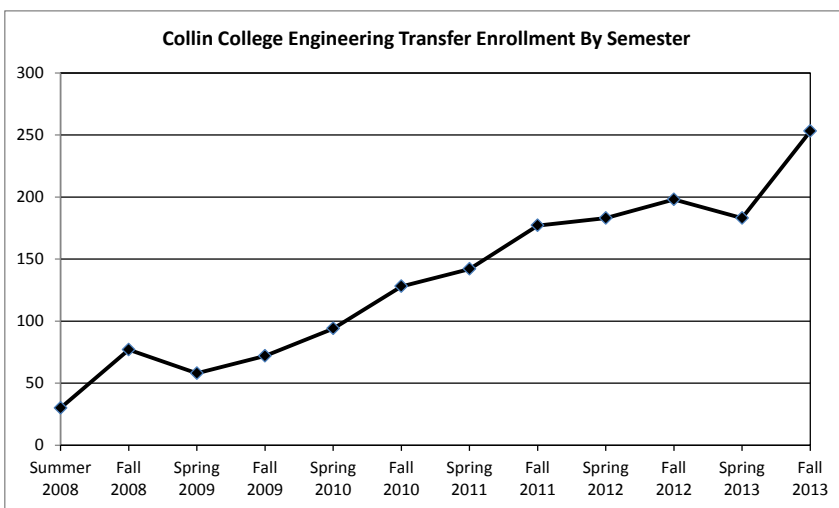


Figure 10- The Increase in Unduplicated Enrollment in First and Second Year Transfer Level ENGR Courses



## Encouraging Student Persistence, Retention And Success At The Two-Year Institution

### A. The Transfer Pathway

The trust in the pathways created by our partnership has resulted in a very positive flow of students through the STEM pipeline to Collin College from our partner ISDs and ultimately, to UT Dallas. A recent self-reported study was done in the engineering gateway classes at Collin College. Students in a variety of Calculus classes (Calculus 1 - 3, Differential Equations), University Physics 1 and 2, and the Engineering Transfer classes participated. The resulting data showed an increase in students in the engineering transfer course pipeline and, as shown in Figure 11. Due in part to pipeline clarity, UT Dallas is by far the number one transfer school for engineering students<sup>10,11</sup>.

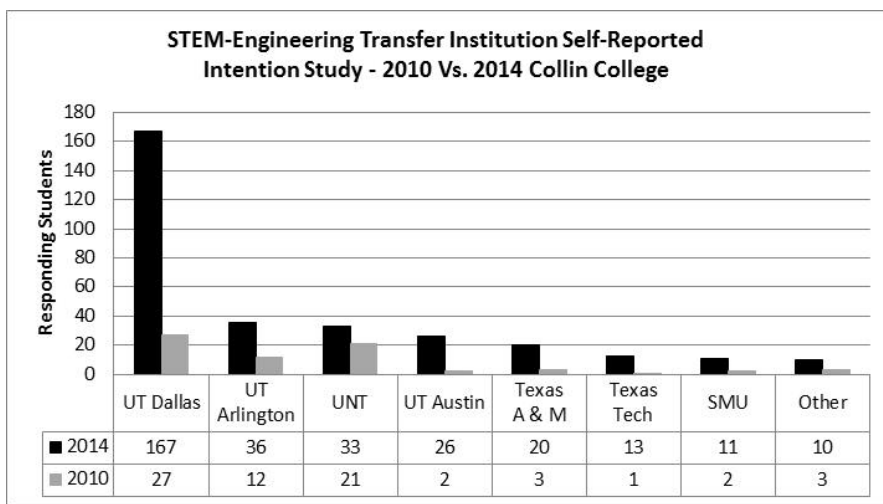


Figure 11- The Distribution Of STEM Pipeline Students Headed To Area Universities From Collin College

In order to make the pipeline flow more smoothly, our partnership is learning from survey data and establishing refined techniques to support the exact majors that students are ultimately pursuing at UT Dallas. Currently, at Collin College, we have complete course offerings for the first two years in Electrical Engineering and 80% of Mechanical Engineering. Due to the data shown in Figure 12, we will be procuring the equipment needed to offer 100% of the needed Mechanical Engineering courses. We believe that this is a Best Practice of our partnership. Given the stature of UT Dallas, other transfer schools in the area will accept many of these courses in transfer for students that intend to transfer to their institution.

In the past, breakdowns in the transfer process have proven to be challenging due to articulation confusion, poor advising and the lack of curriculum alignment through the pipeline. In order to continue to build trust and ensure success in the pipeline approach, a broad-based set of Articulation Agreements were negotiated and signed by UT Dallas and Collin College during the Course Alignment process. These Best Practice Articulation Agreements are revised regularly and “backed-up” for three years to account for students in the pipeline heading towards UT Dallas<sup>11,12</sup>. Participants in the course alignment process have agreed to enhancements to current

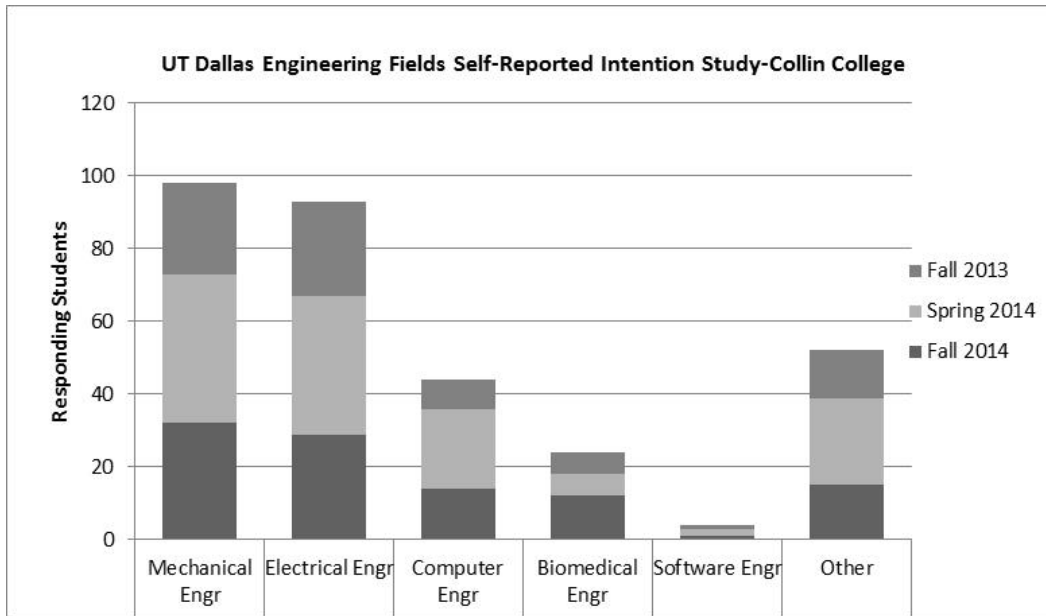


Figure 12- The Engineering Major Declarations For Transfer Students To UT Dallas

course content to facilitate acceptable transfer between institutions. In the updated table shown in Figure 14, students are able to determine exactly what transfers from Collin College for a specific STEM degree pathway in Engineering and Computer Science at UT Dallas. These matrices have been widely received as an excellent tool for college advisors and students. The ability to clearly see transfer options allows the student to view the 2+2 transfer process as a seamless effort. In order for students to be successful on the Transfer Pathway, students need to be careful not to transfer early<sup>12,13</sup>. As seen in Figure 13, proper transfer timing produces equivalence to “Native” university students. These clear articulation pathways and the understanding of transfer timing have provided Collin College with the tools required for Enhanced Intrusive STEM Advising.

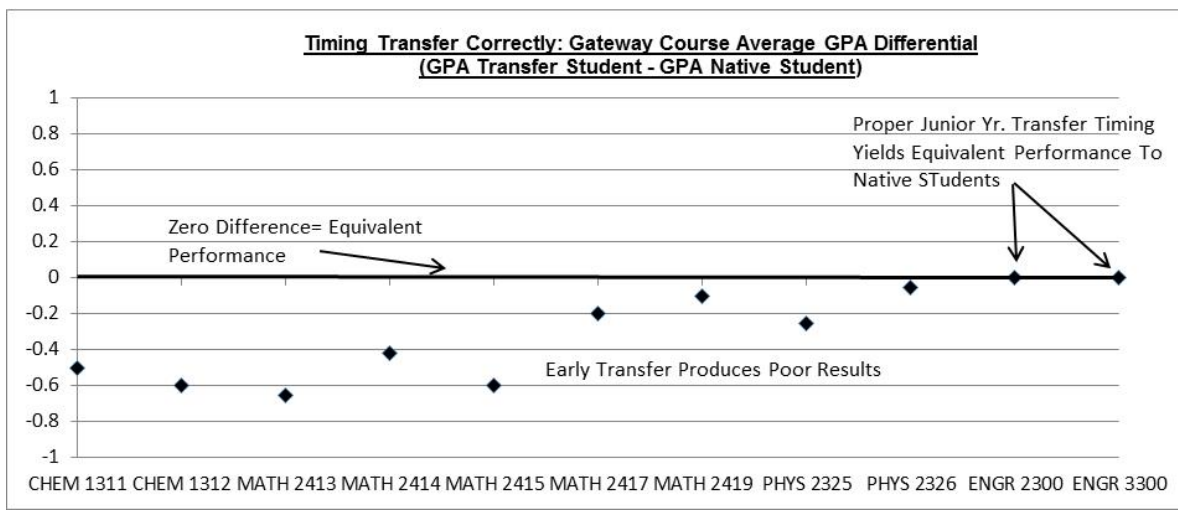


Figure 13- Ensuring Student Transfer Success by Proper Transfer Timing<sup>12,13</sup>

University of Texas at Dallas and Collin College Course Specific Articulation Agreement Matrix							
Collin Course	UTD BS Electrical Engineering Course	UTD BS Telecommunications Engineering Course	UTD BS Computer Engineering Course	UTD BS Computer Science Course	UTD BS Software Engineering Course	UTD BS Mechanical Engineering Course	
ENGR 1201 and ENGR 1172 (If Required)	ECS 1200 and EE 1202 (Student To Make-up 1 Credit at UT Dallas)	ECS 1200 and TE 1202 (Student To Make-up 1 Credit at UT Dallas)	ECS 1200 and CE 1202 (Student To Make-up 1 Credit at UT Dallas)	ECS 1200 (ENGR 1172 Is Not Required)	ECS 1200 (ENGR 1172 Is Not Required)	ECS 1200 (ENGR 1172 Is Not Required)	
ENGR 2310 and ENGR 2110	EE 2310 and 1 Credit Free Elective	Not Required	CE 2310 and 1 Credit Free Elective	Not Required	Not Required	Not Required	
ENGR 2300	ENGR 2300	Not Required	ENGR 2300	MATH 2418 (Additional 1 Credit From Calculus MATH Hours*)	MATH 2418 (Additional 1 Credit From Calculus MATH Hours*)	ENGR 2300	
MATH 2413, MATH 2414, MATH 2415 and MATH 2320 (If Required)	MATH 2417, MATH 2419, MATH 2420 and 3 Credits Free Elective	MATH 2417, MATH 2419, MATH 2420 and 3 Credits Free Elective	MATH 2417, MATH 2419, MATH 2420 and 3 Credits Free Elective	MATH 2417, MATH 2419, and 4 Credits Free Elective (MATH 2320 Is Not Required)	MATH 2417, MATH 2419, and 4 Credits Free Elective (MATH 2320 Is Not Required)	MATH 2417, MATH 2419, MATH 2420 and 3 Credits Free Elective	
MATH 2305	Not Required	TE 2305	CE 2305	CS 2305	CS 2305	Not Required	
ENGR 2332-Lecture Only (Future Offering)	Not Required	Not Required	Not Required	Not Required	Not Required	MECH 2320-Lecture Only	

\* Applies to students completing the 3 course Calculus Sequence at Collin College.

Figure 14- The STEM Engineering Course Transfer Matrix Developed For Collin College and UT Dallas

## **B. Enhanced Intrusive STEM Advising**

Enhanced Intrusive STEM Advising, a critical program to the success of the partnership, reaches back into the ISDs through the course alignment effort (i.e. Figure 7) and the Technical Dual Credit effort. To date, it has met with great success. While it is difficult to successfully encourage students to enter the STEM pipeline, retaining students that have made the decision to enter the pipeline is critical. As indicated previously, our partnership believes that traditional “weeding out” is the wrong approach. A Best Practice of mitigation of things that happen in a student’s life during the eight to ten years that they are in the pipeline attempting to successfully exit into the workforce is a key factor in terms of retention and persistence. Many factors, some of which are beyond the student’s control and/or the ISD/college/university’s control, can derail a promising student. It is widely reported that less than one in two students that start the pipeline journey complete to receive a STEM degree<sup>14</sup>. Therefore, high school teachers and college/university professors, counselors and college advisors can play a key role in the mitigation process. They play the role of the gate keepers that have the unique ability help students deal with a multitude of problems that arise on the long STEM pathway journey. In addition, through these actions, they have the ability to quickly raise the success percentage directly and relatively quickly<sup>8,15</sup>.

## **C. The AAS Pathway**

As stated previously, the two-year institution is in a very unique position to impact the STEM pipeline. Not only can it reach back into the high schools, it has two pathways to student success within the institution. The Associate of Applied Science (AAS) two-year terminal degrees can be used to provide a lower level math pathway and allow the student to pursue a more hands-on >50% lab educational workforce environment. Further, financial problems can be mitigated by offering a direct pathway to employment whether a permanent end in itself or an interim pathway while the student attends a four-year institution albeit on a slower path while employed. In our experience, AAS degrees also provide a pathway to the STEM industries as an alternative to quitting and dropping out of the STEM field altogether due to academic problems either with engineering theoretical modelling or with the mathematics that is required to perform that modelling.

An example of the Best Practice of Retention Intervention with a student that has a math weakness is found in the Electrical Engineering transfer pathway to UT Dallas. In order to keep students not strong enough in math for this pathway engaged in STEM, we recommend the two-year AAS in Electronics Technology. This is an Algebra/Trigonometry based program which uses the same equipment set as the transfer pathway. In that the student can exit the program in two years to become a productive STEM participant in local industry rather than choosing another field of study (e.g. accounting), this pathway is viewed very positively by students and by our industrial partners. Using the above approach, the student is “retained” in the STEM pipeline and even may, at some point, be strong enough to complete a four-year degree in Electrical Engineering.

Finally, there are many STEM students that believe that they want four-year engineering degrees initially, only to realize that they believe that because they enjoy hands-on work in labs. The Cyber Security AAS degree offered by the Collin College Engineering Department is a great example of this type of program (see Figure 15). Finding and supporting these types of programs is a Best Practice in order to fill the STEM pipeline with students that may not be strong in math skills, but can contribute to the STEM pipeline through the acquisition of an AAS degree, professional certifications (e.g. A+, Network +, Security +, Cisco CCNA, Cisco CCNP) and hands-on lab skills critically needed by industry.

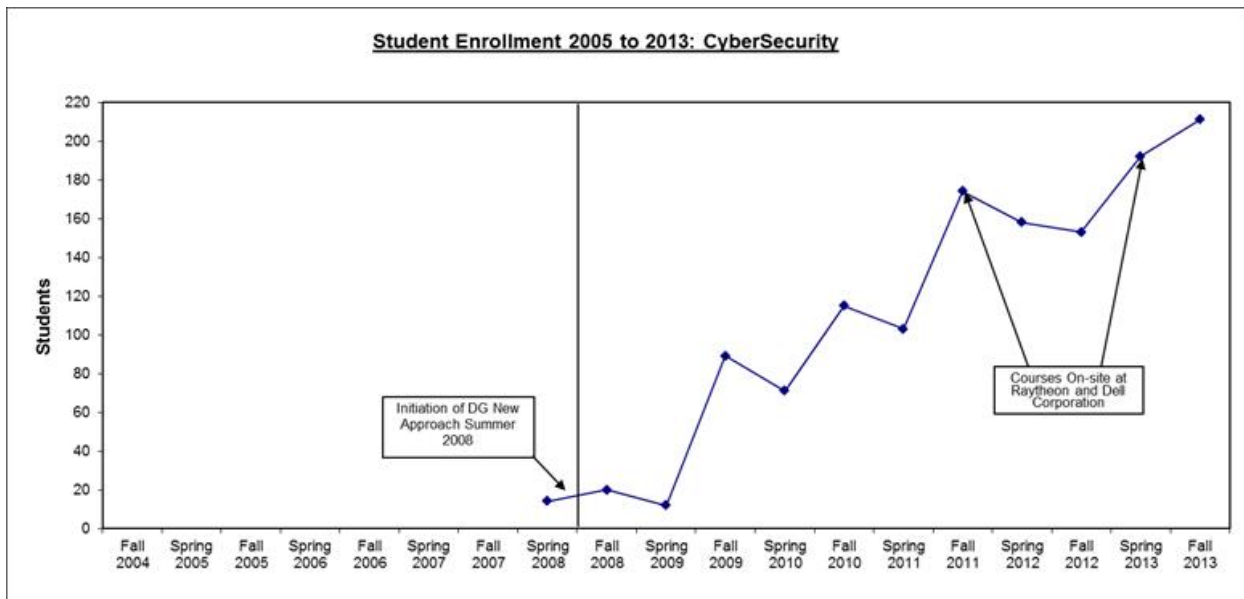


Figure 15- AAS Cyber Security Program Growth Supported By Collin College

**D. Purposeful Engagement: Competitions, ISD Outreach and Professional Societies**

Our partnership has come to the conclusion that encouraging student engagement creates many positive impacts in terms of student persistence, retention and success at two-year institutions. While hard to measure, the impacts are obvious to the students and professors involved. The two year academic duration of a student at the lower division college necessarily means less engagement as the student is “starting” and, then, looking forward to “finishing.” Both of these states (“starting” and “finishing”) make it hard for the student to justify the effort to engage the institution. Further complicating matters is the fact that many students that proceed through the two-year institution do so for financial reasons. In many cases, these same financial factors force students to work while in school. If this is the case, students have even more conflict in terms of engagement. Our partnership believes that a Best Practice in this environment involves engagement through two methods. First, students must be recruited during their first year for opportunities such as student internships and tutors during their second year. The identification of promising students is a key function that must be done by engaged faculty in gateway classes. Following these students during their first and second semesters of their first year is essential in order to be able to encourage them and other faculty members to partner for student internships, student assistant positions and student tutor positions during their second year at the institution.

Second, students must be intrusively engaged to join in student clubs and organizations in which either they have an academic interest, an avocation interest, or a professional interest. From the professional interest perspective, Collin College has started a section of the Society of Women Engineers (SWE). The SWE chapter has completed its first year very successfully as the only two year college section in the country. The chapter is fulfilling the networking and support needs of our female engineering students in their male dominated major<sup>16</sup>. Further, the SWE chapter is helping the Engineering Department address the concern regarding helping young women persist through co-sponsoring the “Girls Night Out With Female Engineers” events at local high schools as indicated earlier. The SWE chapter has been an instrumental co-sponsor of the “All Girls Mentoring” Robotics Camps. These efforts have been recognized as Best Practices for student engagement and retention.

The Collin College Robotics Club is considered a Best Practice by our partnership on a number of different levels. As noted previously, the Club performs outreach for the department at a variety of robotics camps and competitions. While the students really enjoy these functions, the main reason that the students are excited about the club centers around the opportunity to compete in the annual ASEE Robotics Competition. This involves a design effort over the course of the entire year and culminates in a trip to the ASEE conference city where the Club squares off against 20 to 30 other colleges in a complex competition. Through the mentoring of the Club advisors and a lot of hard work, the team was able to solve the problem posed for the autonomous robot and successfully compete at this past year’s ASEE National Meeting in Indianapolis and at the competition the year before in Atlanta. In order to be autonomous, the robots are required to use complex electronic sensor technology and develop a sophisticated computer algorithm to accomplish the required design task. Further, a presentation of the design, a CADD rendering of the design, a project log, an engineering change log and a presentation poster are required as part of the judging process, in addition to the actual “four trial” running of the robot. The reward of this competition at the end of each academic year ensures that throughout the year a nucleus of bright students will be engaged and participate in the critical departmental functions associated with robotics and STEM outreach for the college.

### **Building Pathways For Business And Industry STEM Pipeline Involvement**

At the end of the day, the purpose of STEM education and the STEM pipeline concept is directly related to the needs of local, national, and international business. Increasing the number of students in the STEM pipeline is vital to a growing technology-based country. It is effectively a supply and demand equation with many variables that relate to economic trends, demographic trends, geographic trends and socio-educational trends. While the econometric model of the US economy is prohibitively complicated in terms of the need of STEM students, a number of trends are clear. These trends pose a clear and present danger to the growth of a diverse and highly skilled labor force. Trends that concern business are directly centered on business’ ability to do business based on the supply of talent in a particular industrial sector, in a particular geographic area, or in a particular design space. As the average age of the US worker is now 48 years old (and increasing) and as baby boomers retire from STEM fields in significant numbers, for the first time companies are being forced to do succession planning. As these firms look out on the horizon, they see their need for high technology STEM workers increasing (demand). In some states like Massachusetts, the corresponding supply of younger STEM workers is projected to decrease over the next 20 years<sup>17</sup>. Even in states like our state where there are modest increases

projected in the STEM workforce as younger workers enter, the increases in supply are not nearly enough to compensate for the projected requirements of local employers.

As businesses analyze their needs for STEM talent and observe the educational process, a few concerns become readily apparent.

- 1/ The educational system which “weeds out” potential STEM workers must be changed to be a more supportive environment that has high standards, but does not “leak” good technical workers simply for the purpose of “weeding out” those that are not the absolute best.
- 2/ As the high technology educational process takes 7 to 10 years (from the choice to be an engineer in 10<sup>th</sup> grade through a BS (7 years) or an MS (10 years), effectively what is currently in the pipeline for the next 5 years or so is a fixed quantity that is too small to fulfill business requirements in a rebounding economy.
- 3/ Outsourcing can only go so far in terms of bringing more supply to the market. Numerous high technology firms have been compromised by the intellectual property lost by out-sourcing to foreign countries. Therefore, many of them are re-on-shoring their most critical intellectual design and development activities. This trend requires more STEM workers.
- 4/ As the decision-making consumer population is now significantly greater than 50% female and the number and purchasing power of consumers from underrepresented populations is increasing, the need for female and other underrepresented populations to participate in the product design process is a key factor moving forward. This need to have a more diverse workforce is driving the requirement to have a more diverse population in the STEM education pipeline<sup>9</sup>.

With these factors in mind, employers that have been simply the end of the pipeline now must reach back into the pipeline process and try to guide the educational process towards what they project as their future needs.

As employers try to determine what actions they can take to assist STEM educators in redefining the STEM pipeline and reconceiving how students are educated, employers are now looking for ways to become engaged. Our partnership has identified three Best Practices for engagement that have worked quite well. Our first Best Practice is to believe that it is critical to engage local firms that are potential end-of-pipeline employers specifically and directly through Advisory Board membership. All educational entities (ISDs, high schools, Career and Technology Centers (CTEs), two-year colleges and four-year universities) have Advisory Boards. The partnership has many Advisory Boards across all institutions. As these employers will eventually hire students from the given program, they are significant stakeholders. Our Best Practice is to realize that, as stakeholders, businesses need and want to spend resources to guide curriculum decisions, determine the faculty expertise required to teach a course (possibly a specific industry certification) and guide decisions associated with equipment and the facility used for content delivery. We have found that businesses become so committed to helping programs that they often offer personnel from their technical ranks to become instructors, provide lab equipment for courses, and money to cover equipment expenses that academic institutions need but cannot afford.

Our second industrial Best Practice is to recognize the need to further increase the number of students entering the pipeline in order to satisfy future business requirements in our specific geographic location. Our partnership has found that corporations do not want to be bystanders.

They have a strong desire to be engaged partners in the education process. Realizing this fact, our partnership has defined engagement of companies and their foundations to be a Best Practice. Specifically, the Collin College Robotics camps have obtained direct corporate scholarships in order to reduce camp fees and make the STEM engagement process described earlier affordable to all potential STEM students. Further, direct corporate foundation support of outreach and scholarships for higher education can be very valuable to institutions needing to attract diverse populations of students. As an example, the Texas Instruments Foundation has given a scholarship endowment to Collin College. The result is a set of six full scholarships for deserving engineering students each year that commit to going ultimately to UT Dallas and, potentially, to work for Texas Instruments after their studies are complete. During their school experience, they are eligible to work at Texas Instruments as interns. Finally, internships of all types are available from businesses. Internships are an effective way for business to identify good future workers without a firm employment commitment to them.

Our third industrial Best Practice is to recognize the high value and efficiency created by working with Economic Development Corporations (EDCs). In that the EDCs and Chambers of Commerce desire to increase the numbers of workers in a geographic location and the quality of employee performance in that specific region, they make excellent outreach and strategic partners. Specifically, in our region, our partnership has identified the Metroplex Technology Business Council (MTBC) as a strategic partner in STEM education. The organization represents 300 member companies in a variety of high technology STEM disciplines. The partnership has three members that sit on the MTBC STEM Talent Advisory Board (Lynn Mortenson, Gena Martin, and Dave Galley). Through the work of the STEM Talent Advisory Board, a variety of industrial leaders have engaged 12 participating school districts in a number of outreach activities including STEMFire, a web portal where teachers in the ISDs or professors in higher education can be matched for a given need with industry professionals that want to give back to the community. Many activities can be “matched” such as science fair judging, field trips to plant sites, Advisory Board participation and in-class lectures that augment the skills or curriculum that the educator is trying to convey. Our partnership is right in the middle of the effort to engage all parts of the STEM pipeline with its participation with the MTBC. Recently, the MTBC STEM Education Summit was hosted by Collin College. The 12 engaged school districts (including our three partner ISDs) participated as did the two higher education institutions in the partnership. These entities discussed their many needs and concerns with the numerous businesses that attended. Expectedly, the businesses welcomed the opportunity to meet educators and understand ways that partnerships could be developed and alliances formed. The more than 100 participants were very engaged with the agenda and with each other. As shown in Figure 16, the agenda topics were centered on engagement between industry and educators.

As one recognizes the importance of building pathways for business and industry involvement throughout the STEM pipeline that result in relevant curriculum that meets the ultimate needs of the local workforce, one must realize that engaging the employers as the final stakeholders is crucial to the success of the STEM students seeking employment. Further, engaging business through the proven Best Practices of the partnership allows employers to participate in the



MTBC STEM Education Summit at Collin College	Extremely Valuable	Very Valuable	Valuable	Moderately Valuable	Not Valuable
1. Session 1- How the MTBC is Supporting STEM	80%	15%	5%	0%	0%
2. Session 2-STEMFire-Creating Connections Between Industry and Educators	77%	13%	10%	0%	0%
3. Session 3-What's Currently Happening in STEM Education?	64%	29%	7%	0%	0%
4. Session 4-How is House Bill 5 Changing STEM Education?	73%	4%	23%	0%	0%
5. Session 5-How Can the Dallas STEM Gateways Collaborative Impact Your ISD?	49%	31%	15%	5%	0%
6. Session 6-What Are The Key Components of An Industry/Educator Partnership?	63%	26%	11%	0%	0%
7. Session 7-Creating Opportunities For Partnership	63%	27%	10%	0%	0%

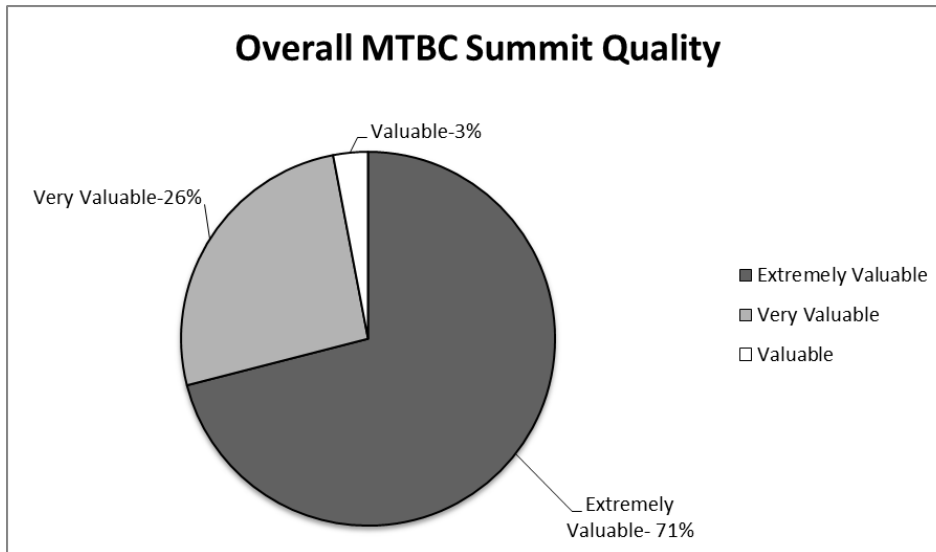


Figure 16- MTBC STEM Summit Survey Results

production and development of the types of talent that will be required in the next one or two decades by their companies. Creating a business and education strategic partnership builds win-win situations which ultimately bring synergy and leverage to the STEM pipeline that do not exist without the recognition that the partnership is critical for our students and our metropolitan areas.

### Conclusions

In order to re-establish the manufacturing and technology base of the United States, we need “One Million Additional STEM College Graduates” over the next decade<sup>2</sup>. In this paper, we have described our partnership and have discussed a number of Best Practices throughout the STEM pipeline that we have discovered/invented/adopted with excellent results to date. Ultimately, the strength of our pipeline is a tremendous synergistic benefit for our students, our partner ISDs, higher education professionals and the industrial base that we serve in our geographic area. The strength of the pipeline is derived from the trust that all involved have placed on the need to cooperate, clear hurdles from pathways, provide clear explanations of the articulated pathways to students/parents and work to the greater good in terms of the best interests of our students. Recognizing that hurdles can come from academics, financial problems, and life situations, our partnership strives to support and retain students in the STEM pipeline

rather than “weed them out.” As relayed earlier, it was recommended by the President’s Council of Advisors on Science and Technology (PCAST) in their 2012 report<sup>2</sup>, the fastest way to generate graduates and attain our goal is through different methods of teaching, supporting and retaining students. The variety of Best Practices disseminated in our paper are intended to create food for thoughtful discussion in education circles, inspire industry stakeholders to help us as actively as possible, and place the focus of our national STEM education discussion on the inspiration of our students to enter the STEM pipeline knowing that they can be successful and, ultimately, help each and every one of them be successful.

### **Acknowledgments**

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### **Addendum: Business and Industry Recognition**

As a note, the Collin College authors (Galley and Martin) would like to express our deepest thanks to our partners and to the local Education, Business and Industry leaders that saw fit to recognize the Engineering and Technology Department at Collin College with both the 2014 Wylie Way Award (the highest honor given out by one of our partner ISDs) and the 2014 MTBC Tech Titan University Level Award for excellence in aggressive pursuit of STEM Education goals in the DFW Metroplex. This award is the highest level of achievement possible in the DFW Metroplex and represents recognition of our desire to “broaden the STEM discussion” to include Business and Industry in our view of the successful STEM education equation.

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