

## **Creating Institutional Bridges to Engineering for Underserved Populations: Examining Associate-to-Bachelor Engineering Programs**

### **Dr. Lola Brown, City College of the City University of New York**

Lola Brown is a scientist, educator, and entrepreneur. She is an expert in the academic success of students in math and science, from kindergarten to post graduate, with a specialization in equipping PhD students with the tools to successfully complete their doctoral studies and obtain gainful employment in their area of interest.

Dr. Brown is currently an Adjunct Assistant Professor in Biomedical Engineering and the Assistant Dean of Academic Initiatives at The Grove School of Engineering at The City College of New York (CCNY). One of her major projects was the development and roll out of City College's master's program in translational medicine. In addition to her leadership role at CCNY, Dr. Brown has found time to reach out to the non-technical communities and share her passion for science and engineering education. She had an academic enrichment business for middle and high school students specializing in science, technology, engineering, and mathematics (STEM) and was a teacher at the Ron Clark Academy in Atlanta, Georgia. She has provided research mentorship and training to scores of undergraduate and graduate students throughout her career.

Lola obtained her bachelor of science from Brown University in biology where she conducted research studying tissue engineered heart valves. She took her master of science from the joint department of biomedical engineering at Georgia Tech and Emory University studying the stroke pathology in children with sickle cell anemia. She went on to complete her PhD in biochemistry as a NSF Graduate Research Fellow solving the structure of proteins involved in HIV. Immediately following the completion of her PhD, Dr. Brown began postdoctoral research in biomedical engineering at Yale University.

Her highly interdisciplinary training and skill set, which combines biomedical engineering, structural biology, and molecular biology, which makes her well suited to analyze projects from multiple perspectives. Lola has a deep commitment to teaching and mentoring and was awarded the 2009 "30 Under 30" Award for her science outreach efforts. Lola is committed to contributing to STEM education in a manner that values high achievement and meaningful community impact.

### **Prof. Ardie D. Walser, City College of the City University of New York**

Dr. Ardie D. Walser is the Associate Dean of Academic Affairs for Graduate and Undergraduate Studies at the Grove School of Engineering and Professor of Electrical Engineering at the City College and Graduate Center of the City University of New York. His current research interest is in the study of nonlinear enhancement of polymers embedded with nano-materials such as quantum dots and carbon nano-tubes. He has given numerous technical lectures and seminars at professional meetings and universities and has published a number of journal and conference papers in the areas of nonlinear effects in polymers, solids and semiconductors. Dr. Walser has served as the divisional chair of the Minorities in Engineering Division (MIND) of the American Association of Engineering Education (ASEE) from 2000 to 2006. He is the recipient of many awards for teaching, including the Faculty of The Year award from the engineering honor society Eta Kappa Knu and the faculty award of the National Society of Black Engineers.

### **Mr. Rawlins Beharry, City College of the City University of New York**

## Creating Institutional Bridges to Engineering for Underserved Populations: Examining Associate-to-Bachelor Engineering Programs

### **Abstract**

A major challenge in K-16 education is a prevalence of students who desire to pursue an undergraduate engineering degree, but are unprepared for the rigors of a post-secondary engineering curriculum. Many challenges with the high school-to-college transition in engineering are due to a lack of rigorous mathematical and technical education at the secondary level. This issue is particularly significant in secondary schools that serve traditionally underrepresented and underserved populations. One solution is for students to obtain an associate of science (AS) degree in an engineering related discipline from a community college (CC), and to then transition to an undergraduate institution for a bachelor of engineering (BE) degree. This approach allows students to fill in any academic gaps in learning during their secondary education, confirm their interest in engineering, while maintaining any requisite work or family obligations. Although this can be a successful model to an engineering bachelor degree, a lack of communication and coordination between the community college and senior college can result in classes not being transferred, missed registration periods, and semester gaps which can result in a lack of retention. To address these issues and create a straight forward pathway from AS to BE, between 2003-2009, The Grove School of Engineering (GSOE) at The City College of New York (CCNY) developed four AS/BE dual degree programs with each of two local CC, both of which serve large populations of underserved and underrepresented minorities.

The current study revisits the progress of these programs, 13 years after the creation of the first AS/BE program, to investigate the degree of academic success in the program. Longitudinal data on the number of students enrolled, credits earned per semester, and average GPA will be examined. Best practices as well as continued challenges will be presented. Finally, we investigate how changes in the technological, financial, and socio-economic/socio-political landscape over the past several years has impacted these programs and will offer revised best practices and recommendations on expanding AS/BE programs.

### **Introduction**

Two-year schools are attractive to many students who are identified as a member of an underrepresented group (e.g., women, Black, Latino, Native American) in science, technology, engineering and math (STEM) careers because they offer lower tuition costs, regularly scheduled remedial courses, an array of support services, supplemental instruction and are generally located near the student's home [1-2]. Many of these students seek to continue their education, aspiring to attain a bachelor degree at a four-year institution and some ultimately seek to earn a graduate degree. However, making the transition from a two-year college to a four-year academic institution is a challenge for most students. Students who begin their higher education at two-years colleges are less likely to attain a baccalaureate degree at a four-year college than students who begin their

higher education at four-year institutions [3 – 6]. Due to a host of reasons including, academic expectations, social and culture differences, and personal demands at home, transfer students may experience a difficult adjustment process once they have entered the environment of the four-year college.

Other factors that can impede the successful attainment of the bachelor degree for transfer students are: inconsistent transfer course policies, ineffective articulation agreements between the two-year and four-year schools, inaccessible course and program information at the four-year college, poor advising at both institutions and a disconnect between the faculty and administration between the two schools. To address these and other issues, The Grove School of Engineering (GSOE) at The City College of New York (CCNY) developed four AS/BE dual degree programs with Hostos Community College and LaGuardia Community College, both of which serve large populations of underserved and underrepresented minorities. On average (over the past couple of years), approximately 80% of Hostos Community College students are African-American or Hispanic-American. Hostos Community College is located in one of the poorest congressional districts in the United States of America. Most of its students do not pass the City University of New York (CUNY) skills test in math. Our joint/dual degree programs is one of the only pathways that students who are facing such odds in terms of being underrepresented in the engineering field, being economically-disadvantaged and/or not having adequate academic preparation from secondary school for the pursuit of an undergraduate engineering major, can access an engineering education. These factors are sometimes inter-related for inner city youth: negatively compounding their chances of access and success. In Fall of 2015, the ethnic distribution of LaGuardia Community College's student population was as follows: Asian: 21%, Black – 21%, Caucasian – 14% and Hispanic – 43%. Over 55% of LaGuardia's students received financial aid in 2015 and over 55% of its students who were living with their parents belonged to homes with a family income of less than \$25,000 while over 75 % of its students who were living away from their parents belong to homes with a family income of less than \$25,000. The lofty goal of joint/dual degrees is to bridge the gap that divides the number of students from underrepresented and underserved populations who can access and earn an engineering degree so that more engineering degrees can be earned to better reflect the nation's diversity.

In the AS/BE program, the student spends two years at the community college, and upon receiving an AS degree, enters our engineering program as a 3rd year student. The benefits for students who participate in our AS/BE dual degree programs include: 1) advanced level status as bachelor candidates (3rd year undergraduate) once receiving the AS degree; 2) CC classes readily transfer to the senior college and satisfies bachelor of engineering degree requirements; 3) lower CC tuition for two years before entering the more costly senior college; 4) individualized academic support services from their CC, and 5) more flexible times for course offerings during their first two years at CC so work or family obligations can be managed. A number of studies have looked into the progress of these programs, looking at initial assessment of student progress (persistence and student GPA), and best practices [7-10]. Table 1, Table 2, and Figure 1 describes the enrollment and academic performance of our AS/BE students.

## **Best Practices**

Our institution has successfully developed and implemented eight dual degree programs with two local CCs. As a result, we have identified 3 key best practices that support the development of a successful dual degree program, including establishing a ‘living contract’, targeted communication, and academic and administrative coordination.

### **Dual/Joint Degree Programs: A living contract**

Articulation agreements are usually finalized with a document that is signed by officials from partnering institutions. This is also the case for the joint/dual degree programs. However, the nature of joint/dual degree programs is embodied in the relationship between partner institutions where the physical document symbolizes a “living contract”. Although the core of the agreement is a formalized document, changes in curriculum, adaptations to new enrollment management policies and practices, and resource reallocation continue to shape the dynamics of the dual degree program. In short, the junior and senior colleges must be willing and able to adapt both the formal agreement and the practices that constitute the dual degree program in order for the program to be effective in helping students attain their bachelor degree.

### **Communication**

Even within the same college, there are instances when a change in course content or its requisites is not fully relayed to the advisors or faculty of other academic programs that use such a course towards its degree requirements. While this may be an annoyance for students that will complete their education at one school, for a transfer student who is moving to a four-year program this could easily lead to the student deferring or simply ending their efforts of attaining the bachelor degree. Communicating curriculum changes to the community college partners so they can stay abreast with what is transpiring at the four year school is imperative in order to sustain the joint/dual partnership; it is essential that pertinent information be conveyed to community college partners in order for them to adequately prepare the joint/dual degree program students so that they will have mastery of the requisite coursework at the four-year school.

### **Coordination**

A myriad of departments and divisions at the partnering institutions are involved in the successful functioning of joint/dual degree programs. Coordination between faculty who teach Math, Computer Science, Science and Engineering courses need to be arranged between both partner institutions. There are regular meetings between the department chairs at both GSOE and the partnering CC institutions. Enrollment management offices such as Admissions, the Registrar’s Office and International Students also play important role in the enrollment of these students so that there is a seamless transition from the CC to the GSOE. All of these parties have to be working in sync, especially in terms of the information that is being disseminated to students and other stakeholders. Joint/dual degree program students from Hostos CC also take courses while still at their home school through a permit process; these students are able to take courses at their home CC

that count towards their BE degree from GSOE. As such, the students at Hostos CC are able to be physically present and engaged with the students at the four-year college and engineering school. This gives the two-year college student the unique opportunity to take engineering courses before becoming an engineering major, which provides them the opportunity to make an informed choice as to whether engineering is the field that they should would like to continue pursuing. As such, Hostos CC students who take courses on permit are able to understand the rigor and intensity of an engineering curriculum before committing to the engineering bachelor degree.

## **Challenges**

Similar to most academic programs, even successful AS/BE programs experience challenges that require monitoring. Notable challenges that can impact a dual/joint program include having consistent data, alignment of curriculum, providing adequate support services, and supporting student with academic difficulties.

## **Data Consistency**

The lack of conformity with regards to data poses significant challenges when dealing with different institutions. One major question is whether a joint/dual degree program student should be classified as such when s/he first enters into a program at the community college or at some defined stage afterwards. Our community college partners may accept students into their schools even if the student is not skills proficient in reading and/or writing and/or math; these students then take remedial or developmental courses so that they can become skills proficient in reading and/or writing and/or math. At the senior college, all of the students who enter into the school of engineering as freshmen are skills proficient. Once a student is accepted into the school of engineering, s/he is classified as an engineering major and once s/he begins as a first-time, full-time student, the student is part of the cohort that is tracked and reported for retention and graduation data analysis.

In order for information to be consistent, the cohort of students in a program has to be defined. The initial cohort into a joint/dual degree program at the community college stage is not as defined; it is either when the student enters into the college and indicates that he or she would like to participate in the joint/dual degree program or when the student is actually accepted into the joint/dual degree program. It is important that when tracking data that there be a fixed baseline. With engineering majors, the focus is on math preparation. Students with a stronger math preparation have a higher likelihood of academic success in engineering at the senior college[11]. Some students in community colleges begin their education at the two-year school taking Algebra, which is normally taken by a traditional engineering student within or before the first two years of high school. Even though these students possess a career interest in engineering, the pathway (and chances of success) for students that begin their studies under the level of Pre-Calculus is very difficult (and low).

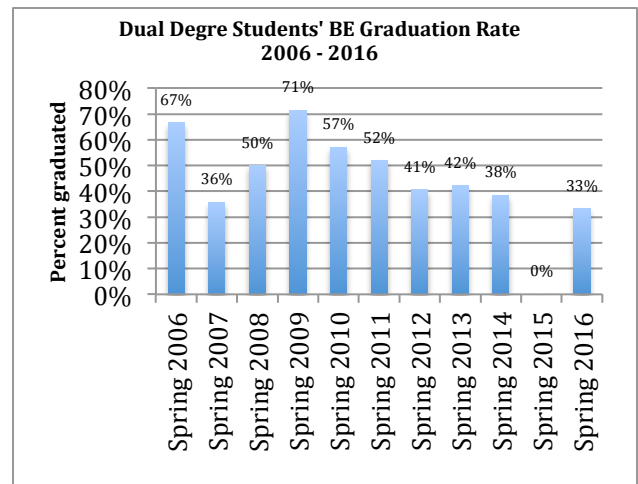
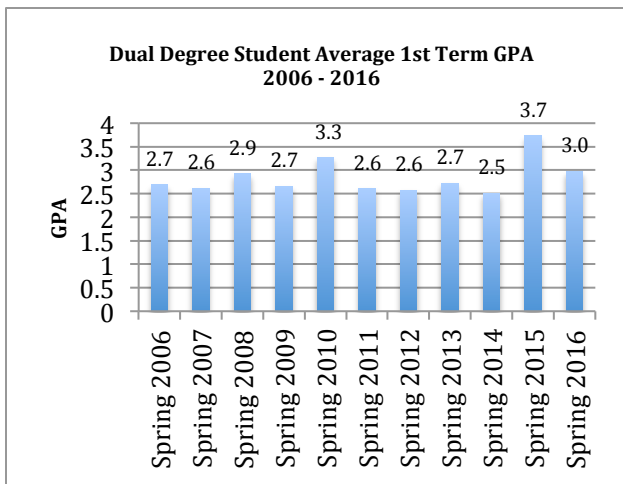
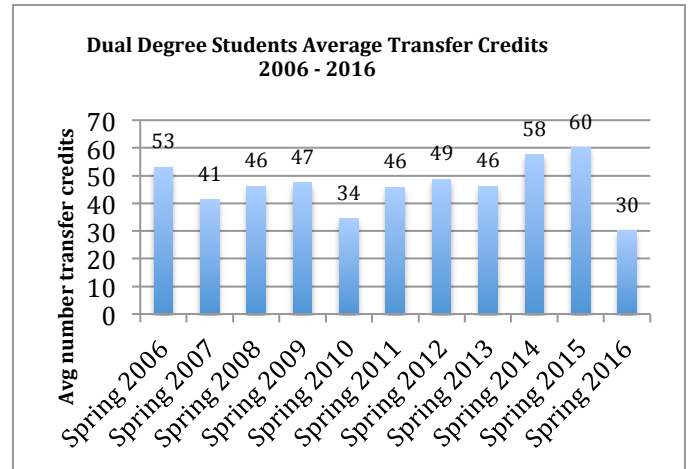
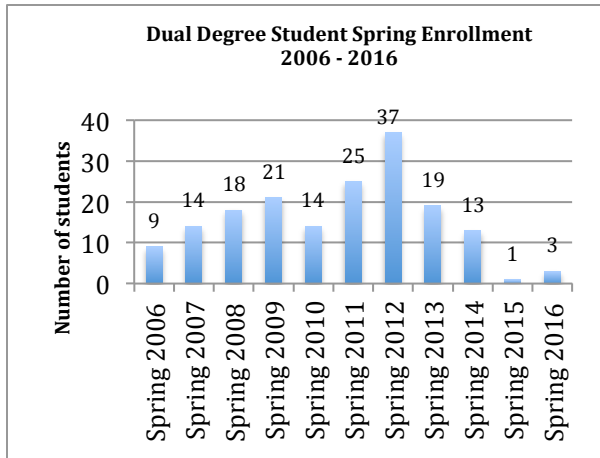
**Table 1: Enrollment and academic performance of students in AS/BE program at The City College of New York, The Grove School of Engineering**

<b>Semester</b>	<b>Number enrolled</b>	<b>Avg GPA</b>	<b>No. credits attempted</b>	<b>No. credits earned</b>
Spring 06	9	2.69	12	10
Summer 06	7	2.67	8	5
Fall 06	27	2.24	8	6
Spring 07	13	2.55	9	8
Summer 07	18	2.37	10	9
Fall 07	18	2.53	10	8
Spring 08	18	2.92	8	7
Summer 08	15	3.15	11	11
Fall 08	25	3.01	9	9
Spring 09	21	2.66	9	8
Summer 09	21	2.90	9	9
Fall 09	33	2.54	9	9
Spring 10	13	3.25	13	13
Summer 10	15	3.04	14	13
Fall 10	42	2.39	9	8
Spring 11	25	2.61	9	8
Summer 11	7	3.29	10	10
Fall 11	47	2.53	9	9
Spring 12	37	2.57	9	8
Summer 12	15	2.76	9	8
Fall 12	54	2.72	10	8
Spring 13	19	2.72	9	9
Summer 13	5	3.01	13	12
Fall 13	28	2.46	9	9
Spring 14	13	2.51	9	9
Summer 14	2	2.35	4	4
Fall 14	7	1.48	5	4
Spring 15	1	3.73	7	7
Summer 15	2	1.20	5	5
Fall 15	1	0.00	7	0
Spring 16	3	2.98	8	8
Summer 16	1	3.85	6	6
Fall 16	3	1.64	6	4
<b>Avg per semester</b>	<b>17</b>	<b>2.59</b>	<b>9</b>	<b>8</b>

**Table 2: Average GPA and total number of students enrolled in The Grove School of Engineering AS/BE Program from 2006-2016**

	<b>Total number enrolled since spring 2006</b>	<b>Avg GPA</b>
<b>Hostos CC</b>	121	2.44
<b>Laguardia CC</b>	444	2.68

**Figure 1: Enrollment (top left), Average Transfer Credits, (top right) first term GPA (bottom left) and graduation rate (bottom right) of dual degree students at The Grove School of Engineering at The City College of New York.**



Even though the school of engineering considers the students in the joint/dual degree programs as its students in terms of relationship building, technically we define the cohort as students that have graduated with their Associate of Science degree in an engineering discipline from the partner community college and have started taking classes at the senior college one semester after graduation in the same engineering discipline. As such, accurate record keeping among the 2-year and 4-year college is necessary.

Another important factor is to know the fraction of students that graduate from the community college and successfully transition to BE portion of the program. Additionally, the community college must also keep track of what senior college the student attends, as some dual degree students that perform particularly well receive admission offers to other engineering schools. Notably, these numbers would also not include students who decide to leave the 2 year college before getting the AS, and transferring into the 4 year engineering program. Also, the joint/dual degree program culture promotes that its students start working towards the completion of their bachelor's degree immediately upon graduation from the AS degree rather than delaying the continuation of their studies before "returning" for the completion of the "final two years" of their baccalaureate studies.

### **Alignment of Curriculum**

Articulation agreements have generally facilitated select courses from a two-year school being able to transfer into the four-year school that the community college has the agreement with. Joint/dual degree programs takes this a step further; they facilitate the alignment of the curriculum for core courses in the program so that the content, rigor and requisites of courses at the community college match that of the four-year institution. This type of arrangement is very sensitive to changes in the course content. Course changes including (but not limited to) adding/removing course to/from the curriculum, changing a requisite for a course, changing the emphasis for a particular course, altering the design or programming component do not only impact the students at the 4-year school, but it also affects the students at the partner community colleges. Our partnering CCs have to go through their governance process to make similar changes at their school, which could have significant impact on their schools and their students. This type of information should be relayed to the community college partners periodically even during the process at the 4-year school since the governance process for making changes takes time to be realized at public institutions. If a requisite changes for an engineering course, the timeline for degree completion and the ability for students to take a full-time course and to receive financial aid/maintain their international student status can be affected. If a new track within an existing curriculum is added at the community college level and the four year school is not informed about this development, the students in such programs may not get the benefits that are associated with a joint/dual degree program. An understanding that these programs are not initiatives nor driven by grant funding, but that they are core to the students and to the colleges involved are essential to the integrity and



sustenance of these degree programs; they are not experimental in nature since student's lives are involved and the academic core has to remain intact.

### **Support Services**

Student services at partner community colleges are more robust than the services that are provided at four-year institutions. Within the last couple of years, essential functions in the domains of academic advising, academic standards, and academic affairs have been prioritized at the Grove School of Engineering while student services operate with fewer experienced and skilled professionals. Fiscal responsibility has resulted in restructuring and focus on essential priorities in these areas. At the community college, support services are an integral component of the student experience. It is important that students who transition from the community college partner institutions to a four year institution to be aware of the fundamental differences between a community college and a four-year school, engineering studies versus non-engineering education and a research-intensive university versus a teaching or Liberal Arts college so that the transition is smooth. As the profile of the entering class of freshman students into the engineering school is becoming stronger, it is more important that AS/BE students have the support needed to perform on par with their future classmates. The joint/dual degree programs have served as a pathway to an engineering education in this City. The engineering school at is the only public engineering school in the city. As the entering freshman class continues to perform better, space in courses at the upper-level of the curriculum are more likely to be filled with students who started a freshman and who are progressing in the curriculum. The freshman class at the school of engineering has significantly increased in numbers within the past couple of years; the infrastructure and focus on essential services that can better serve the current undergraduate population at the school of engineering is of prime importance.

### **Students with Academic Difficulties**

It is important that students who are having academic difficulties with their coursework at partner institutions have a plan of action towards their future in these programs both at the community college (short term) and at school of engineering (long term) including whether they are making strides (good academic progress) towards their pursuit of an engineering major considering its academic intensity. Some joint/dual students who do not meet the admissions standards for transfer entry into the school of engineering are under the impression that they are still eligible for transfer into Grove because of being a part of the joint/dual degree program. However, whether students are external transfer applicants or are trying to gain entry from another (non-engineering) major at the College into the school of engineering, they must meet the transfer admissions standards for entry. This is also applicable to joint/dual degree program students who are sometimes under the misconception that since they are part of a joint/dual degree program that they are accepted into the 2nd phase of their bachelor's degree education automatically. It is therefore very critical that students in the program are made aware of what makes them "our" students and what standards that they have to meet to progress satisfactorily through the different phases in their education. Students who are not performing up-to-par at the community college phase have to be reminded that they may not meet the

criteria for transitioning into the GSOE, about the admissions requirements for transition into GSOE. They should have also been told in an orientation upon entrance into the program about the requirements that are essential to progress to each phase of their baccalaureate studies. The identification of such students early in the process and a corrective plan of action to address any problem areas are essential for these joint/dual degree students who are facing academic difficulties to make informed choices since some of these students would have to be counseled to pursue alternative majors while others may pursue engineering majors at other institutions where they could meet the admissions criteria for entry.

## **Measuring Success**

### **Individual Success versus Community Success**

Many of the students from community colleges are often times seeking higher education as a means to gain upward mobility. They want to be successful to not only better their own lives, but the welfare of their families and to improve their communities. Despite the diversity of urban public schools, they often have to conform to norms of success at 4-year institutions; a mold of success that they see from role models who became successful based on self rather than the success that they have been able to accomplish up until that juncture at their community colleges which incorporated the essence of success through the lens of their individual multicultural experience.

Some partner educators at the Community College pride themselves in not only educating and improving the lives of the students whom they educate, but also, that the welfare of the entire community where the student resides is also made better through the education of its students.

Many consider LaGuardia Community College as New York City's Community College for the world; its students represent its location in Queens as the symbol of true diversity since many cultures reside in Queens making it the most diverse urban area in the world. The City College of New York provides an avenue for excellence through its educational programs. Grove's joint/dual engineering degree programs facilitate the lofty goals of these educational institutions and these ideals are all compatible. However, the realities on the ground challenges the joint/dual degree program students to assimilate into one identity as New Yorkers who are pursuing an engineering degree: to adapt, to be resilient, to master the skills that they have acquired in their community colleges and make these work for them at a four-year institution, to understand early the differences between a community college and a four-year institution and to make sacrifices in their lives to achieve their goals while still being true to their core which comes from their values, their families and their communities of which they are conjoined. They do not always seek acknowledgment from external parties who may have a part in determining their future, but they believe in the core values of America: hard work and being able to rise to the challenge to achieve their goals.

The joint/dual degree program can be defined by how many engineers were produced by the program, how successful were the program graduates (highlighting particular student achievement), the grade point average of different cohorts of joint/dual degree program participants as compared to community college students who transferred into the Grove School of Engineering and were not part of the joint/dual degree program or even as compared to students who started at GSOE as freshmen, the time to degree completion for joint/dual degree program students, etc. Any numerical evaluation of the program would have to take into account resources (institutional support) to assist these students, the socio-economic status of these students, the language barriers of these students, etc. These factors are not typical nor are they easily delineated. Even a few students who are successful in these programs are more than what is in existence without these programs since these are not programs that work with the “best and brightest” (even though some of these joint/dual degree program students are competitive in academics, research and scholarship with their “traditional” and honors peers); these are programs that provide access to the excellence that is typically afforded only to the best and brightest and which has produced graduates who are successful in their respective engineering disciplines despite real barriers and substantive obstacles to the attainment of their degrees.

## **Conclusion**

Associates-to-Bachelor degree programs have great promise in developing a new generation of non-traditional engineers. The program at The Grove School of Engineering has developed a sustainable program which can serve as a model to other schools seeking to institute similar programs.

## Bibliography

1. Kasper, H. T. (2003). The changing role of community college. *Occupational Outlook Quarterly*, 46(4), 14-21.
2. Chubin, D. E., May, G. S., & Babco, E. L. (2005). Diversifying the engineering workforce. *Journal of Engineering Education*, 94(1), 73-86.
3. Astin, A. W. (1975). *Preventing students from dropping out*. San Francisco: Jossey-Bass.
4. Astin, A. W. (1977). *Four critical years: Effects of college on beliefs, attitudes, and knowledge*. San Francisco: Jossey-Bass.
5. Astin, A. W. (1993). *What matters in college: Four critical years revisited*. San Francisco: Jossey-Bass.
6. Pascarella, E. T., & Terenzini, P. T. (1991). *How college affects students: Findings and insights from twenty years of research*. San Francisco: Jossey-Bass.
7. Walser, A., Beharry, R., & Bernal-Carlo, A. (2010, March). Pipeline to Engineering Diverse Future in New York City. In *Setting Sail For the Future: Leveraging Diversity For a Stronger Crew*.
8. Alting, A., Barba, J., Krudysz, M., Walser, A. D., (2012) Success of Joint Programs Between Junior and Senior Colleges Proceedings. Increased Retention ASEE Annual Conference & Exposition.
9. Krudysz, M., Walser, A. D., & Alting, A. (2012). Success of Joint Programs between Junior and Senior Colleges. In *American Society for Engineering Education*. American Society for Engineering Education.
10. Walser, A. D., & Karim, M. (2004). Developing a Joint/Dual Program and Its Impact on Underrepresented Engineering Students. In *American Society for Engineering Education*. American Society for Engineering Education.
11. Zwölfer, A., & Joanneum, G. (2015). Correlation between engineering students' performance in mathematics and academic success. In *American Society*