Undergraduate Research Through NASA Initiatives

GAFFAR GAILANI, PH.D

Dept. of Mechanical Engineering and Industrial Design Technology (DMEIDT)
New York City College of Technology
Dr. Gailani is an assistant professor in the DMEIDT received his Ph.d in Mechanical Engineering from the City University of New York in 2009. His research work is focused on poroelasticity and its application in biomechanics. He has more than 15 journal publications and conference proceedings and one book.

SIDI BERRI, PH.D

Dept. of Mechanical Engineering and Industrial Design Technology (DMEIDT)
New York City College of Technology
Dr. Berri is a professor and chair of the DMEIDT. He has MS and Ph.D in Mechanical Engineering from NYU Poly in Brooklyn. His expertise is in Manufacturing, Robotics and Computational Mechanics.

NIEVES ANGULO, ED.D

Mathematics Dept. Hostos Community College, Bronx, New York is an Associate Professor in the Mathematics Department and the Coordinator of the Engineering Program in the department. She has a pure B.A. and M.A. in Mathematics from Hunter College of CUNY, and an M.S and Ed.D in Mathematics Education from Columbia University. She has been very active in externally funded initiatives dedicated to improve proficiency in STEM education including collaborative projects with NSF, DoE and NASA.

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Abstract

There was a common belief that research should only be introduced at the graduate level or at least the senior undergraduate year. Research in the freshman year was not even a topic for discussion. Today, throughout the City University of New York, colleges are stepping forward and conducting research at all undergraduate levels and achieving good results. Conducting research as part of an internship or with a faculty member, proved to be one of the most effective ways to enhance the skills of the students in STEM by many authors. The department of Mechanical Engineering and Industrial Design Technology at New York City College of Technology, City Tech, has been focusing on research in the undergraduate level in the last three years in order to improve the quality of its graduates. The project started by half of the department faculty members who collaborated with Louis Stokes for Minority Participation in STEM, LSAMP, to implement research activities in freshman and sophomore classes. The work went further when the department obtained two major grants, NSF ATE and NASA CIPAIR. The NASA CIPAIR project is focusing in involving students in NASA and aerospace research in their early stages in college through building partnership with NASA. The project allows students to work in NASA active projects and faculty to collaborate with NASA scientists. Curriculum enhancement to include aerospace relevant material is a part of the project. A new course in Remote Sensing has been introduced as well. On the other hand, collaboration is built with Hostos Community College to allow the engineering students from Hostos to transfer to City Tech to get their bachelor degree in engineering technology. An articulation agreement between both colleges will enhance this transfer. This project represents the most critical, logical step in City Tech's long-term plan to transform itself to a model institution for the education of under-represented students in STEM majors. The project is filling a critical gap in the engineering technology program offerings by making it more relevant to current industry needs (e.g., NASA) and creating curriculum and learning experiences for students that do not currently exist. Strategically, this project is another key piece in the college's effort to overhaul and upgrade all its science, technology, engineering, and mathematics programs. The three years project will raise graduation and retention rates and prepare students to be the future workforce of NASA.

Introduction

In the past there was a common belief that research should only be introduced at the graduate level or at least the senior undergraduate year. Research in the freshman year was not even a topic for discussion. Today, throughout CUNY, colleges are stepping forward and conducting research at all undergraduate levels and achieving good results. One of the more effective ways to enhance the skills of the students in STEM is conducting research as part of an internship or with a faculty member, Boyd and Wesemann (2009). Rising above the Gathering Storm (RGS)[a] report in 2007 warns about the relative decline in the United States in the science and technology market place and that the competitive nations had increased public funding for research and development making significant investments in higher education. The report included many statistical studies such as:

[a] Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. National Academy of Science, ISBN 0-309-65442-4, 592 pages (2007).

[a]Office of Assessment and Institutional Research at City Tech

1- The United States graduates more visual arts and performing arts majors than engineering.
2- We are ranked 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering.
3- In year 2000 the number of foreign students studying the physical sciences and engineering in United States graduate schools for the first time surpassed the number of United States students. RGS report recommended doubling the federal investment in basic research.

Critical areas within the education strategic frame work and the issues that are facing the nation and outlined in the *Rising above the Gathering Storm Report* need to be addressed. While this report addresses the problem for the whole nation, the weakness in higher education will be more severe for minority communities. City Tech was one of the colleges which participated in the Model Institution of Excellence (MIE) program. The MIE report described seven components proved to be successful. Six of these components are aligned with the particular needs of City Tech at the moment. The components are: (1) pre-college initiatives and recruitment (2) student development and support (3) undergraduate research and professional training (4) faculty development and enhancement (5) curriculum development (6) physical infrastructure development and renovation.

About City Tech

City Tech is the designated senior college of technology within the 23-campus City University of New York, CUNY, the largest urban public university system in the nation. A federally designated Hispanic Serving Institution (HSI), City Tech has a student population of 15,368. 34% of students identified themselves as Black (non-Hispanic), 31.7% as Hispanic, 18.5% as Asian/Pacific Islander, 11.0% as White, 0.5% as Native American, and 5.4% as Other. Sixty-eight percent are the first in their families to attend college[a]. Students enter with widely disparate levels of academic preparation, professional goals, and personal circumstances. As an open access institution, City Tech's historic mission has been to offer opportunities for educational advancement to students regardless of financial circumstances or prior academic achievement. City Tech plays an important role nationally in the education of future scientists, engineers, technologists, and mathematicians as shown in Figure 1. The figure shows a clear increase in enrollment and the number of students who earn a bachelor degree over the last three years.

In the Fall 2009 Fifty-two percent (52%) reported a household income of less than $30,000. Seventy-six per cent (76.8%) of incoming first-year students and 60% of returning students received need-based financial aid. The student body, which is more than 15,000 members, reported more than 134 countries of origin; countries of origin of faculty also span the globe. Thirty-five percent (35%) of students reported working 20 or more hours per week[b].

[b] New York City College of Technology (CUNY) Office of the President. Facts 2009-2010.

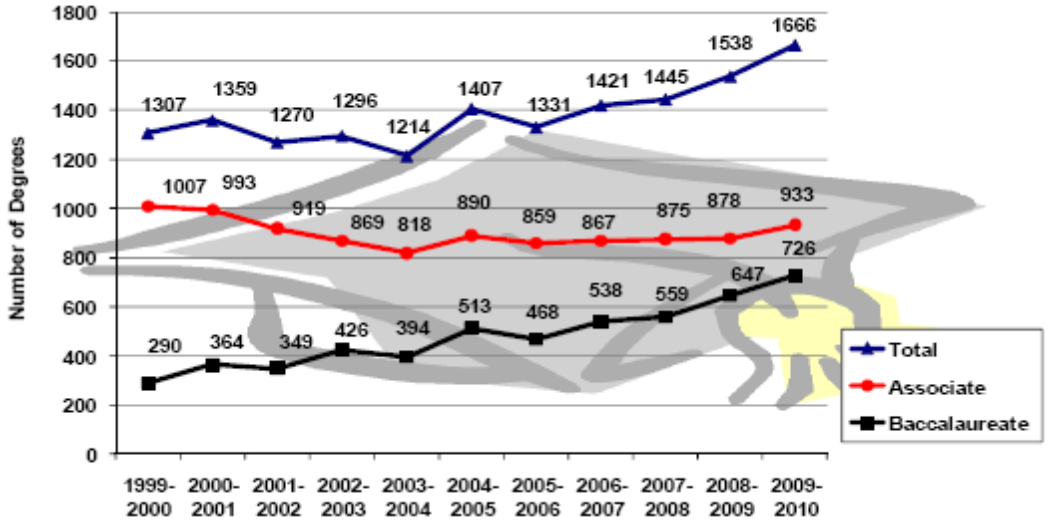

Figure 1: Number of degrees awarded at City Tech from 1999 – 2010. (*Source: Office of Assessment and Institutional Research at City Tech*)

About the Mechanical Engineering and Industrial Design Technology Department (MEIDTD)
The MEIDTD is a fast growing department. The department started offering a bachelor's degree program in Industrial Design in Fall 2010. The increase in enrollment from Fall 2006 to Fall 2010 is 50.4%. As of Spring 2011 the department has 340 students as shown in Figure 2. In the associate degree program 28% of the students are African American and 27% are Hispanics, in the baccalaureate program, 28% of the students are African American and 12% are Hispanics. The data shows clearly that a lower percentage of minority students continues to the bachelor degree level, despite the high population of minority students in the associate programs. The challenge for the department is to match this fast growth in enrollment with the quality of education in engineering that will help in retaining the students so that they continue to the bachelor level which will increasing the graduation rate.

The graduation rates in the School of Technology and Design are not impressive as shown in Table 1. Retention rates are still low as shown in Figure 3. The data justifies the need to improve the curriculum to retain students in the program. A retention rate of 46.1, shown in Figure 2, is still low for a department with this high number of students. Last year, 2010, the MEIDTD received two grants: an NSF Advanced Technology Education (ATE) to establish a mechatronics center, and an NASA CIPAIR grant to build a partnership with NASA. The demand for qualified graduates especially in this area of mechanical engineering is very high .

The Mechanical Engineering Technology Department at City Tech is one of the leading departments in engaging students in research. In the fall of 2011 the enrollment has doubled to what it was five years ago. Four students from the department received awards to present their research work at national conferences in the last two years. In the summer of 2009 three students from the department worked with Dr. Gaffar Gailani, in a collaborative project with the department of Biomedical Engineering at City College (CCNY) and were able to publish their work (Ranglin et al., 2009). Involvement of students in research and internships has

proved to be very motivating. The department started to offer a bachelor's program in the Fall of 2010 with registration already showing high enrollment.

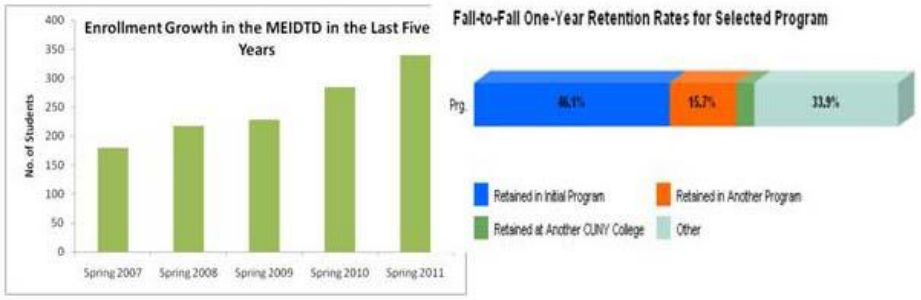

Figure 2: The growth in enrollment in the MEIDTD from 2007 - 2011, Left. Fall to Fall one-year retention rates for MEIDTD as spring 2010, Right.(*Source: Office of Assessment and Institutional Research at City Tech*)

The above examples represent the work of individual students and small teams only. In order to involve more students in research work the primary author received two consecutive awards (2008 and 2009) for Integrating of Research Strategy (IRS). The basic idea of the IRS is to introduce research to *first-year* students in a specific course and evaluate the effectiveness of the new approach. Some of the results were published in Gailani et al. (2009) and Gailani et al. (2008). The IRS revealed the following:

1) Students feel more confidence when they work in teams and they produce better results. In a response to a survey question about team work in the IRS course, 73% of the students responded that team work was extremely helpful in the IRS course.
2) Students (freshmen) show less confidence and interest in report writing. This might be an indication of the deficiency in their writing and analytical skills.

A good example of the impact of doing research at the undergraduate level is Mark Nelson, whose GPA was fluctuating between 2.5 and 3.0 during his first two years in the computer engineering technology program at City Tech and *he thought of himself as an average student. As soon as he joined the Louis Stokes Alliance for Minority Participation in STEM, LSAMP, his education experience changed for the better. He was named to the Dean's list every succeeding semester until graduating with honors in June 2010*. Today he has been accepted for graduate study in robotic engineering at Worcester Polytechnic Institute in Massachusetts[c]. This tells us we can inspire this generation to move forward if we give them the opportunity.

Goals of Building Partnership with NASA

(3a) Articulation with between Hostos Community College (HCC) and City Tech.
HCC engineering program is located within the Math and the Natural Science Departments. It was established in 2003 by Dr. Nieves Angulo, to meet the needs of the growing number of minority students who are interested in pursuing a career in engineering. The purpose of the program is to offer the first required two years in Mechanical, Electrical, Civil and Chemical engineering to students planning to enter and continue studies in those fields. The program has grown rapidly since it began in 2003 with fewer than 10 students to reach 164 students in the Spring of 2010, making it one of the fastest growing programs at HCC. Enrollment has increased 41.2% from the spring 2009.

For the same period the increase in the enrollment in the associate degree programs in liberal arts and science was only 14%. The transfer rate from the engineering program to 4-year colleges is less than 20%. This collaboration between HCC and City Tech is laying the foundation for multidisciplinary collaboration between engineering technology and the sciences at City Tech and the engineering program at HCC. The departments on both sides are working on articulation agreement to ease the process of student transfer to the 4-year programs at City Tech.

[c] New York City Alliance News, Fall 2010, page 7.

(3.b) To improve curriculum by updating existing courses and introducing two new courses: The project has a big impact on the curriculum through the revision and updating of 5 existing courses at City Tech and HCC. The project will result in

i. Developing curriculum for two *new multidisciplinary* courses "Introduction to Research Management", and "Special Topics in Remote Sensing".
ii. Updating and revising six courses to incorporate NASA-relevant material (4 courses at City Tech and 2 at HCC); the courses will be detailed in the next section.
iii. Acquiring a limited amount of engineering laboratory equipment to support the new course and the revised courses.
iv. Overall, improving the quality and content of the offerings at City Tech and HCC.

(3.c) To enhance students' skills in research. The project helps students in developing their research skills, thus raising the performance of the students and making them a model for future students. Students are trained to do research and participate in internships. The experience gained by students will be used to improve the courses. Thus, *students will participate in the curriculum committees for selected courses*.

(3.d) To Improve and strengthen the engineering program through partnership with NASA centers and other industries. A partnership is built with NASA Goddard Space Flight Center in MD, Marshal Space Flight Center in Alabama, New York City Research Initiative (NYCRI) which is supported by NASA Education Office. Ten students at least are sent every year to participate in summer internships in addition to two faculty members, one from HCC and one from City Tech.

(3.e) To strengthen faculty development and exposure to NASA research areas and opportunities. Faculty members are exposed to NASA opportunities and research areas. Appropriate faculty members gain valuable knowledge about NASA and relevant areas through visits, seminars, training, participating in curriculum development, and mentoring students.

(3.f) To raise the transfer rate to City Tech, graduation and retention rates. The improved curriculum and the partnership with HCC will result in an increase of transfer of students from HCC in particular, to the 4-year programs at City Tech. Partnership with NASA is helping in retaining these students at City Tech, thus automatically improving the graduation rate. Involvement of students in activities such as research work and internships proves to be very helpful in motivating them to succeed in their discipline. *The goal is to reach a graduation rate of 50% by June 2013*. The current retention rate for City Tech is 44%. The goal is to increase the retention rate to 65% by the summer of 2013.

(3.g) To build Multidisciplinary collaboration and articulation agreements. This collaboration between HCC and City Tech will lay the foundation for multidisciplinary collaboration between engineering technology and the sciences at City Tech and the engineering program at HCC. The

departments on both sides will work on articulation agreements to ease the process of student transfer to the 4-year programs at City Tech.

(3.h) To prepare the students to be the future work force for NASA. The exposure that students are gaining through internships at NASA centers, conducting research that is relevant to NASA and improved curriculum with NASA relevant materials will lead to a better preparation of our students to be the future work force for NASA or one of its contractors. These are all in line with NASA stated goals and objectives.

(3.i) To extend the effort to include high schools as the pipeline for STEM. This project includes a high school component in it to assist high school students to enroll in STEM and link them with college students, thus allowing a unique interaction and exchange of experience. This work is initiated by collaboration with Proyecto Access program which is located at HCC. Proyecto Access is a Pre-Freshman engineering program.

(3.j) To encourage students-faculty STEM research teams. Faculty are encouraged to conduct research work with selected students during the academic year. This will expose students to research and give them out-of-curriculum expertise. STEM faculty members are encouraged to participate in the Integrated Research Strategy (IRS) which is monitored by LSAMP. IRS encourages faculty to integrate research component in the courses they are teaching. 70% of the faculty of the Mechanical Engineering and Industrial Design Department have applied for IRS 2010.

Results

The results for the first year of the project were very impressive. A professional evaluator, Joy Quill Assoc., is hired to evaluate the project progress and assess the improvement. Surveys were conducted by the evaluator and the project directors to measure the strength and address the deficiency. After one year we have accomplished the following

1- Ten students worked in the summer of 2011 in Goddard Space Flight Center, Marshal Space Flight Center, and NYCRI. Two faculty members worked with students in NASA Goddard Center in MD, and Marshal Flight Center in AL.

2- The new multidisciplinary course in Remote Sensing, EET3132, is approved, and will be offered for the first time in the fall of 2011. The new course of Project Management, IND4750, is offered in the fall of 2011. This course was approved as part of the bachelor program package. The Computer Applications in Mechanical Engineering Technology course, MECH1240, has been updated and tested in the spring of 2011. The response of students was evaluated through two surveys. Update of the Materials Testing course, MECH2426, and Simulation and Presentation, IND2420, with NASA relevant material will start in the academic year 2011 – 2012.

3- Campus Activities: The first Research Summit in July 2011 which was attended by nearly 200 guests, including students from different universities and programs, faculty members and invited guests was a total success. The summit highlighted research activities of students during the academic year 2010 – 2011 and summer 2011 in different internships including NASA. Many programs were involved such as NASA NYCRI, LSAMP, REU, NSF-I cube, NASA CIPAIR, CUNY/GSFC HEC & CUNY/GISS CGCR. The keynote speaker was from NASA. Students gave oral and poster presentations that featured their research work.

4- Workshops:

The pre-internship Workshop: This one day workshop was to prepare students psychologically for internship. All students who were selected for internship in NASA CIPAIR, LSAMP, and NYCRI were asked to attend this mandatory workshop. Most of these students were doing their internship outside their campuses (NASA, Brookhaven National labs, and NYCRI). The workshop included all details of how to communicate with mentors, how to perform the work, how to act on the site, things should not be done in the internship…etc. More than 22 students attended the event and a survey was given at the end to measure how students were able to digest the material covered.
The Internship Workshop: The work hosted many speakers two of them were Co-PIs of NASA CIPAIR in addition to the director of the New York City Research Initiative. More than 30 students attended the workshop

5- Website: A website has been built to disseminate the project activities and recruit students for STEM. The website link is available at Citytech website and at www.cipairnasa.com.

6- Project Evaluation: C. J. Quill & Associates, Inc. was hired to evaluate the project. The head of the firm, Joy Quill, who has prior experience evaluating NASA STEM-related programs, is serving as the evaluator. Ms. Quill played a major role in the IRB approval process to conduct surveys in both campuses. IRB approval was secured in May 2011, allowing for the conduct of an online survey of City Tech and Hostos engineering and pre-engineering students before the end of the academic year. The purpose of the survey was to obtain baseline information on students' knowledge of and interest in NASA-related engineering education and careers. Demographic information was also requested. The evaluator is also conducting a process review of the first year's activities, which involves document review as well as interviews with many faculty and administrators involved in the project. A detailed evaluation report will be submitted by the evaluator before the end of August.

7- Progress at HCC: articulation agreement between City Tech and HCC that will make it easy for HCC students to transfer to City Tech to finish 4-year degree in engineering is almost complete. Four students from Hostos participated in summer internships this year. Two students accompanied Dr. Angulo to Alabama to summer internship in Marshal Space Flight Center. The other two students worked with NASA NYCRI with Goddard Institute of Space Studies scientists. Collaboration started with the Proeyctoaccess program which is nested in HCC. Proyectoaccess organizes intensive summer programs for high achieving minority students who want to pursue careers in engineering and science. This summer NASA CIPAIR helped the robotic class in Proyectoaccess acquiring some equipment for the students to use and next summer Dr. Vaninsky from the math department at HCC will design some robotic curriculum to be taught. HCC organized the Dynamic Women leadership Forum with guest speaker from NASA, Monserrate Roman the chief microbiologist in Marshal Space Flight Center.

Summary

This project represents the most critical, logical step in City Tech's long-term plan to transform itself to a model institution for the education of under-represented students in STEM majors. The project will fill a critical gap in the engineering program offerings by making it more relevant to current industry needs (e.g., NASA) and will create curriculum and learning experiences for students that do not currently exist. Strategically, this project is another key piece in the college's effort to overhaul and upgrade all its science, technology, engineering, and mathematics programs. This project is affordable, measurable, and worth doing for the significant benefits it will bring to under-represented students and faculty.

Acknowledgment

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References

Boyd, M., and Wesemann J., 2009. " Broadening participation in undergraduate research: fostering excellence and enhancing the impact." Council on Undergraduate Research (CUR)

G. Gailani, M. Benalla, R. Mahamud, S. Cowin, and L. Cardoso, 2009. "Determination of the permeability of the lacunar canalicular porosity", ASME J. of Biomech. Engr, v131-10, pp101007 (7pages).

Ranglin, S., Das, D., Mingo, A., Ukinamemen, O., Gailani, G., Cowin, S., and Cardoso, L., 2009. " Development of a mechanical system for osteon isolation". Proceedings of the ASEE Mid-Atlantic Conference, PA, Oct. 2009.

Shaul R, 2010. " Mechanical Engineering Technology Major Encourages Other students to Participate in Research Conferences". An interview with Shaul Ranglin. City Tech News, available at http://www.citytech.cuny.edu/aboutus/newsevents/2010sp/mech_ranglin/index.shtml