ENGINEERING EDUCATION COALITIONS: PERSPECTIVE FROM A PARTNER UNIVERSITY

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Abstract *– The New Jersey Institute of Technology (NJIT) has participated in the NSF/Gateway Engineering Education Coalition since its inception in 1992. Through this program, NJIT has improved its undergraduate programs and engineering education, both in quantifiable ways and through culture changes within the institution. By incorporating design work in the freshman year through its Fundamentals of Engineering Design courses, NJIT has significantly improved its student retention and 6-year graduation rates for engineering students. Currently, NJIT is working with New Jersey's community colleges to incorporate some of these innovations into their curricula, reaching beyond the boundaries of the Gateway Coalition. The work of NJIT within the coalition has energized faculty to take a renewed interest in undergraduate education; this is at the heart of the mission of the engineering education coalitions. This paper describes NJIT's efforts under the Gateway Engineering Education Coalition, and its experience with the coalition from the perspective of a partner university.*

Index Terms – National Science Foundation, engineering education coalitions, assessment.

INTRODUCTION

During the early 1990's, the National Science Foundation funded the creation of several engineering education coalitions. Their overarching goal is to encourage systemic reform in undergraduate engineering education. The coalitions do this through curriculum innovation, but also by introducing a culture change into the engineering education community. The coalitions have fostered a new way of thinking about engineering education, both within participating universities and in universities outside of the coalitions, on both a national and international scale.

NJIT is one of the founding members of the Gateway Engineering Education Coalition, along with current participants Columbia University, Cooper Union, Drexel University, Ohio State University, Polytechnic University, and the University of South Carolina. Started in 1992, this coalition has six primary focus areas: assessment; professional development; underrepresented populations; instructional technologies; linking and sharing; and curriculum development and implementation. NJIT has participated in and achieved successful results in all focus areas.

The rest of this paper is organized as follows. A few of NJIT's projects undertaken as part of the Gateway Engineering Education Coalition are described next, followed by an assessment of the benefits the coalition has brought to NJIT and the engineering education community, and that NJIT has brought to the coalition and community. Finally, concluding remarks are presented.

NJIT PROGRAM HIGHLIGHTS

NJIT has undertaken several projects as part of its work with the Gateway Engineering Education Coalition. This section describes three of these projects. The Fundamentals of Engineering Design (FED) courses introduce engineering design "up front" in the undergraduate engineering curricula at NJIT. NJIT also introduced stereolithography into the undergraduate curriculum and served as a fabrication facility for other partner universities. Several programs to improve retention for students from underrepresented populations have also been introduced at NJIT under the Gateway program. These activities are described in more detail below.

Fundamentals of Engineering Design

The Fundamentals of Engineering Design program was initiated at NJIT in 1992 with the development of a single design course. The course was 4 1/2 hours in length and carried a 2-credit load. The course was required for all entering first-time full-time freshmen starting in the 1993-1994 academic year.

Since that initial offering, the FED course sequence has undergone several modifications. The sequence was expanded to two courses, encompassing engineering design and computer aided design (CAD). The courses emphasize interaction with the freshman-level humanities courses to improve student's presentation skills and technical writing abilities. NJIT is currently modifying its joint admission and articulation agreements with New Jersey's community colleges to require the FED courses, or equivalent, for all entering transfer students.

The design component of the FED course sequence consists of several discipline-specific modules; each student is assigned to one of these modules. Students are not assigned to modules based on their intended majors. Rather, they are assigned somewhat randomly. This ensures that

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most students will be exposed to a discipline other than their selected major while still providing a good, introductory design experience. Typical FED design topics include the siting of a wastewater treatment plant, the design of a simple circuit to turn a light bulb on and off depending on the amount of light in a room, and a case study of the design of a 3.5" floppy disk drive.

The FED courses have been one of the greatest successes of the Gateway Coalition. NJIT's internal assessment [1] demonstrates a 15% increase in retention and 6-year graduation rates for students who participated in this course. This may be due to one or more of the following factors:

- Students learn skills in these courses, such as the basic concepts of design and teamwork, which improve student performance in other courses in the curriculum.
- Students see engineering at the beginning of their program. Students in the first year of a traditional engineering program, who take only math and science courses during the freshman year, might decide not to pursue engineering because they haven't seen any engineering work in their studies. Putting engineering up front helps these students make more informed choices, which may lead to increased student retention.
- Students interact with faculty members in the FED courses more closely than they do with instructors in other courses. This forces students to become more active learners, which may affect their performance throughout the engineering curriculum.

The FED courses have had a positive impact on the faculty as well as the students. Senior faculty members teach many of the FED sections, and senior faculty members developed many of the FED modules. Several faculty members reported becoming revitalized by their participation in the FED program, and have become energized to revisit their undergraduate curricula, introducing changes beyond those sponsored by the Gateway Coalition. In this respect, the Coalition has met its goal of fostering a culture change in engineering education.

Stereolithography

In **199***, NJIT acquired a stereolithography machine as part of its work with the Gateway Engineering Education Coalition. Students first design a product or component using a CAD package. Then the computer sends data to the stereolithography machine, which fabricates a hard wax mockup of the product. This introduces students to concepts of rapid prototyping, allowing them to see and touch what they have only designed on the computer.

NJIT was the first university in the Gateway Coalition to acquire a stereolithography machine. Since they were quite expensive at the time, NJIT partnered with other schools so they could also make use of this machine. Students at the coalition's partner schools created designs on their campuses and transmitted the design files to NJIT electronically, typically via FTP. At NJIT, the files were downloaded into the stereolithography machine and parts were fabricated. The parts were then shipped back to the school that submitted the design file. This linking and sharing of facilities is one of the goals of the Gateway coalition.

During the past few years, the price of stereolithography machines has decreased significantly, particularly for entry-level machines. The universities that had sent files to NJIT for fabrication now have their own machines. Having access to NJIT's stereolithography machine allowed these schools to begin their work in rapid prototyping sooner than if they had to wait to acquire their own machine. This early access also allowed them to develop their courses more fully and improve the pedagogy of using the machine to teach design and manufacturing.

Serving Underrepresented Populations

NJIT has a very diverse student body. In the college of engineering, African-American, Latino, and Asian-American students comprise 49% of the full-time undergraduate student body [2]. Many of these are at risk of not completing their undergraduate studies. Through the Gateway Engineering Education Coalition, NJIT has implemented several program to help these at-risk students successfully complete their undergraduate degree programs.

The Educational Learning Assistants (ELA) Program was designed to increase the retention rate for students in NJIT's Educational Opportunity Program (EOP). The objective was to develop a special treatment, highlighted by the assignment of educational learning assistant role model peer students to work closely with the EOP sophomores. The peers coordinated tutoring and provided peer counseling. The ELA program also provided academic support workshops to participating students. The Gateway Coalition provided funding to this program to support the educational learning assistants. This support included a stipend and housing in NJIT's dormitories, an essential component in the program's success. The ELA mentors resided in the same dormitory as their assigned EOP students, which allowed them to develop a rapport with the students and to maintain regular contact with them. This allowed the mentors to provide feedback to the professional staff in a timely manner, which enabled intervention before problems became insurmountable. As a result of this program, the percentage of participating students on academic probation decreased from 37% to 29%, and the percentage of students successfully progressing from the sophomore year of the curriculum to the junior year in one year increased from 0% to 44% [3].

COALITION BENEFITS

NJIT has realized many benefits from its participation in the Gateway Engineering Education Coalition. Many of these

benefits are quite tangible and easily seen. These include the materials developed for the FED courses, and the improved student retention and graduation rates resulting from the introduction of FED into the engineering curricula. The improvement in performance of students who participated in the ELA program is another tangible benefit.

Less quantifiable, but equally important, are the intangible benefits that have resulted from NJIT's participation in the Gateway Engineering Education Coalition. At NJIT, we have noted a change in the culture of engineering education; we suspect this change is being felt at other universities participating in all of the engineering coalitions as well. Through the FED courses, NJIT senior faculty members have become revitalized. They are actively participating in this course and are revisiting the undergraduate curricula, seeking ways to improve the education we provide to our students. Such efforts are at the heart of the coalitions' mission, to foster a cultural change that will lead to systematic reform in undergraduate engineering education. Education and educational research are seen as important activities at NJIT.

In general, faculty members often work in a vacuum, working on their own tasks while not seeing the results of similar work performed by others. The Gateway Coalition has fostered faculty sharing and collaboration, both among faculty within NJIT and among faculty from different partner institutions. As an example, students from Columbia University come to NJIT once or twice per semester to use NJIT's class 10 clean room for fabricating integrated circuit chips. Without Gateway, this would not have happened.

The work of the Gateway Engineering Education Coalition is spreading beyond its borders and is affecting other colleges and universities. Like a pebble that is dropped in a pond, the waves of innovation are emanating from the coalitions to touch on colleges beyond the coalitions' partner universities. At NJIT, for example, the FED courses are being disseminated to New Jersey's community colleges. Students transferring from the community colleges to NJIT will be required to take the FED courses or their equivalent as part of their admission to NJIT. The community colleges have expressed significant interest in adopting NJIT's FED courses; three of these colleges, Burlington County College, Essex County College, and Hudson County Community College, already offer FED-type courses based on NJIT's design modules.

SUMMARY AND FUTURE WORK

The Gateway Engineering Education Coalition is scheduled to complete its work by the end of August 2002. However, the effects of the coalition will be felt for many years beyond this date. The innovations spawned by the coalition have been embedded in the undergraduate engineering curricula at NJIT and the other partner universities, and are being incorporated into the curricula at colleges outside of the coalition.

The National Science Foundation's goal of encouraging systemic reform in undergraduate engineering education has been, to a large degree, successfully met by the coalitions. The coalitions have done this through curriculum innovation, such as the introduction of freshman design courses, but also by introducing a culture change into the engineering education community. The coalitions have introduced a renewed concern for the quality of undergraduate education; this concern will ultimately produce the most significant and important changes to undergraduate engineering education, and will have more far-reaching affects than any one innovation introduced through the coalitions so far.

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