

## EXTENDING THE WORK OF THE ENGINEERING EDUCATION COALITIONS

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**Abstract**  $\frac{3}{4}$  *The Engineering Education Coalitions Program, sponsored by the National Science Foundation, has brought about significant changes in engineering education during the past ten years. Several coalitions, including Gateway, SUCCEED, Foundation, and Greenfield, have introduced curricular innovations that have increased retention and improved undergraduate graduation rates. These efforts have also introduced a culture change at participating universities; education has once again taken a leading role in institutional priorities. This paper describes the efforts of the New Jersey Institute of Technology (NJIT), a participant in the Gateway Engineering Education Coalition, to extend the successes of the coalition beyond its official completion date. NJIT has developed and implemented several successful innovations through its participation in the Gateway Coalition, including the Freshman Engineering Design program and NJIT's Educational Learning Assistants program. This paper describes our efforts to disseminate these results to other universities and the partnerships that NJIT is establishing with New Jersey's community colleges to strengthen their programs.*

**Index Terms**  $\frac{3}{4}$  *Coalitions, Dissemination, Engineering Education, Partnerships.*

### INTRODUCTION

The Engineering Education Coalitions program was developed to stimulate innovative and comprehensive models for systemic reform of undergraduate engineering education and to increase the retention of students, especially women and those minorities underrepresented in engineering. The coalitions created through this program have produced significant reforms that have invigorated undergraduate engineering curricula to produce graduates that are better prepared to meet the challenges of the 21<sup>st</sup> century global workforce. The coalitions have done this while simultaneously increasing diversity and student retention and graduation rates.

In 1991, the academic programs of schools of engineering were highly traditional in content, structure, and order. Most universities provided a sequential curriculum focused almost exclusively on science and math for at least two years before involving students in the subject of greatest interest to them – engineering. Design was left as an activity for the junior or senior year. With few exceptions, little

attention was paid to so-called “soft” subjects such as communication skills. There was generally little help given in showing how material covered in the undergraduate program related to real-world applications.

Individual courses were rarely inter-related. Except on an individual basis, there was little or no exchange between colleges. The faculty role was seen as that of a lecturer rather than a mentor. They were typically focused on the upper division courses in their disciplinary specialty, and rarely were involved in lower division courses.

The Gateway Engineering Education Coalition was created to address these problems. The Coalition initially created a framework for achieving its goal by identifying specific tasks in four areas of concern: curriculum innovation; new educational technologies; assessment; and human potential development.

The New Jersey Institute of Technology, NJIT, is a public research university located on a 45-acre campus in the University Heights section of Newark. The university enrolls nearly 9,000 students in 76 undergraduate and graduate degree programs. NJIT ranks among the nation's leading universities in rankings by *U.S. News and World Report* and *Money* magazine. *Yahoo! Internet Life* has ranked NJIT as one of the “most wired universities” in America for the past several years.

With this background on the Engineering Education Coalitions Program, the Gateway Engineering Education Coalition, and the New Jersey Institute of Technology, the rest of this paper is organized as follows. The next section describes some of the innovations and materials developed at NJIT through its work with Gateway. The following section describes dissemination strategies that NJIT is employing to circulate these materials and to foster their adoption. Finally, concluding remarks are presented.

### NJIT INNOVATIONS

Through their work with the Gateway Engineering Education Coalition, faculty members at the New Jersey Institute of Technology have developed a large group of deliverables that may be useful for other universities. These items range from individual simulations for single topics within a course, to manuals and workbooks for entire courses, to materials needed to implement programs for underrepresented student populations. This section describes some of these products.

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### Freshman Engineering Design

In 1992, responding to the demand for students' early exposure to the engineering profession and for the development of their problem-solving and critical thinking skills, NJIT introduced its Freshman Engineering Design course into the undergraduate engineering curricula. The course is now required for all engineering students at NJIT. It is designed to provide freshmen with early working experience as members of a design team; allow students to learn basic principles, procedures, and terminology specific to major engineering fields; and learn that engineering design is complex and interdisciplinary.

The course meets once per week for 2¼ hours. Seven weeks of the semester are devoted to design work on a project geared toward the level of the students. The remaining weeks cover such topics as presentation skills and project management, and the students' final project presentations. There are several discipline-specific projects in biomedical, chemical, civil, computer, electrical, industrial, and mechanical engineering.

The result of incorporating the FED course into NJIT's engineering curricula has been significant. Student grade point averages in their math, engineering, and English courses, as well as their overall GPAs, have increased significantly. Even more telling, graduation rates have increased from 36.6% to 54.1% [1].

Several modules have been created for this course in the various engineering disciplines. In addition, two workbooks have been created for the chemical engineering module.

### Educational Learning Assistants

Retention data indicate that students at colleges and universities across the United States are at the greatest risk of dropping out during their sophomore year, not the freshman year that many people would assume. This is especially true at NJIT for students in the Educational Opportunities Program (EOP). In 1995, the retention rates from the first to second year for EOP students was 95%; however, the rate for second to third year retention dropped to 74%.

The primary reason for the first year's success was the highly structured programs established by NJIT and its EOP program. The university offered a freshman seminars program and an early warning system to notify students that were in academic danger before the middle of the semester. In addition, EOP offered mandatory bi-weekly individual counseling sessions and weekly structured small-group tutorials.

Through the Educational Learning Assistants (ELA) program, the EOP developed a special intervention to address the high attrition rate of its sophomore students. Recognizing that sophomores, if given some additional resources and support services, can increase their retention rate, the university decided to expand its early warning system to sophomore students. In addition, the ELA

program provided assistants that lived on the same dormitory floors as their assigned students, providing a trusted peer to serve as an intermediary between the students and the university administration.

The ELA program succeeded in improving student retention from the sophomore to junior year. The introduction of the ELA program increased the percentage of sophomore EOP students successfully completing 12 or more credits from 51% to 65%. Academic suspensions decreased from 6% down to none. The number of students successfully making the transition from sophomore to junior year during one academic year increased from zero to 51%.

### Instructional Materials

In addition to the FED and ELA programs, NJIT faculty members have undertaken many other projects under the rubric of Gateway. A few are described below.

The *Intelligent Tutoring System* is a web-based framework that can be adapted for a variety of courses [2]. With support from the Gateway Coalition, a tutorial for the freshman chemistry laboratory course was developed. In addition to presenting material on specific topics, the system implements required pre-lab quizzes that students must pass prior to performing each experiment.

The *Very Simple CPU Simulator* [3] is a Java applet that simulates the internal data flow and signal assertion of a microprocessor designed in the textbook *Computer Systems Organization and Architecture* [4]. The user inputs an assembly language program and selects the type of control unit, and the simulator displays the flow of data between components in the system using low-level animation. The simulator and its source code are available at the Gateway Coalition's web site [5] and the textbook publisher's web sites [6,7].

Incoming engineering students typically aren't very good at preparing and giving presentations. In response to this problem, NJIT and Gateway created a *Presentation Skills Seminar* that focuses on the effective design of presentations and slides, as opposed to specific Microsoft PowerPoint® techniques. This presentation is given to students in the Freshman Engineering Design course every semester. In addition, NJIT has created a 1-hour streaming media version of this presentation that can be accessed online.

### DISSEMINATION STRATEGIES

Too often in academia, universities try to develop many of their own programs and materials themselves. This results in much duplicated effort as several universities reinvent what are essentially the same materials from scratch. As part of its work with the Gateway Coalition, NJIT seeks to disseminate the materials it has developed to other universities. Some may use the materials directly, while others may adapt the materials to meet their specific needs. In either case, much less effort is required, freeing up

resources that can be better used elsewhere. This section examines several dissemination strategies being employed by the New Jersey Institute of Technology.

### **The Usual Suspects**

Publishing results in refereed journals, and presenting them at conferences, remains one of the most popular methods to disseminate the results of one's work. Although the initial audience may be somewhat limited in size, the audience is likely targeted directly at the focus of the paper or presentation. In addition, interested persons can access archival papers at future dates. However, such publications merely describe the actual product to be disseminated; they do not directly supply the product to interested parties.

When the deliverable products are available in electronic format, a project web page is another good dissemination strategy. NJIT has made most of its deliverables available online via the Gateway Coalition web site [5] and its own Gateway web site [8]. Both sites provide immediate access to users, as well as links to other similar sites.

Both publications and web pages are useful dissemination strategies, but they share a common drawback. Both are passive, requiring the user to come to the materials. In addition to these dissemination methods, NJIT employs several, more active methods to disseminate its materials. The remainder of this section describes these methods.

### **Dean to Dean**

In this day of instantaneous electronic communication, there is still much to be said for direct, person-to-person interaction. S. T. Mau, NJIT's Dean of Engineering, invited deans from several universities to spend a day at NJIT. During their visits, these deans met with faculty and administrators, and were given presentations on NJIT's research and educational activities. One of these presentations focused on Gateway-related activities. The visiting deans received CDs containing some of the materials described in the previous section for immediate review and use.

To further aid in dissemination efforts, Dean Mau mailed, not emailed, a letter to all deans of engineering in the United States. The letter described the CD that was distributed to the visiting deans, and offered copies to those who were interested. The reply rate was much greater than expected; almost 30 universities requested copies of the CD.

### **Teacher to Teacher**

Attending a conference is a good way to disseminate your work. Hosting a conference, or a workshop, is even better. Although it requires a lot of work, organizing a conference gives the host the opportunity to disseminate materials in a more targeted manner. The conference may be focused more on the areas of interest to the host institution, thus guaranteeing an audience more interested in the same areas.

### **International Conference on Engineering Education**

During the past five years, with support from the Gateway Coalition, NJIT has hosted a 1-day conference, the Innovations in Teaching and Learning Conference. This conference draws participants from universities and community colleges in New Jersey and surrounding states. The focus of the conference, undergraduate engineering education, is well aligned with the goals of the Coalition. As host institution, NJIT has offered workshops on incorporating some of the innovations developed through Gateway as part of these conferences.

### **College to College**

Working directly with partner universities or colleges is another method to disseminate educational innovations and products. By assisting another college to incorporate these materials into their curricula, the materials creator goes beyond dissemination. The effect is immediate and tangible.

The New Jersey Institute of Technology has joint admission agreements with most of the community colleges in the state of New Jersey. Students may enroll in a community college that has such an agreement with NJIT and complete their first two years of study, obtaining an Associates degree. These students then transfer to NJIT with full junior-level standing.

To facilitate this process, NJIT has been working with New Jersey's community colleges to export its Freshman Engineering Design courses. NJIT makes all of its FED modules available to community colleges that wish to include the NJIT courses in their curricula. NJIT also works with community colleges that wish to develop their own, similar courses. Two community colleges in New Jersey currently offer courses based on NJIT's FED modules, and more are planning to do so within the next few years.

### **SUMMARY**

Gateway has made a major difference in the way NJIT faculty approach teaching. Through Gateway, NJIT has incorporated the need for faculty to learn and share innovations in educational technologies. Faculty members are more willing to incorporate innovations into their courses, and to develop their own educational innovations.

Although the Coalition's duration will soon end, this project has encouraged linking and sharing in many ways. NJIT and the other coalition schools have established partnerships with other universities, and are continuing to develop collaborations to advance the state of undergraduate engineering education.

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