# Developing and Implementing an Innovative First Year Program for 1000 Students

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Abstract

In the past decade, learning experiences for first year engineering students at Ohio State have evolved. This article provides an overview of that evolution with emphasis on the student experience in 2000. It will cover course topics, teaching staff, facilities, faculty development, assessment and feedback methodologies, and results to date. Two important factors in bringing about change were Ohio State's participation in the NSF-funded Gateway Engineering Education Coalition and substantial support from the Dean's office. Many subjects briefly discussed in this paper will be covered in more detail in separate papers presented at this and other conferences.

## I. Introduction

In the 1991-92 academic year, the Engineering Graphics (EG) Department provided two courses for all engineering students. These were a four-credit hour course (quarter hours) in Engineering Graphics and computer aided design and drafting (CADD) and a four-credit hour course in Engineering Problem Solving. The Engineering Graphics Department employed 12 full-time and one 1/3 time emeritus faculty members, about 15 graduate teaching assistants, and a number of undergraduates who graded homework problems and drawings. The classes were taught in six classrooms without computers and in three computer labs having a total of about 100 computers.

The course content for the Engineering Graphics class (EG166) included graphics done by hand and using CADD. Students also learned about some aspects of manufacturing including fastening and joining. During the last two weeks of the course, teams of 4 students each designed and prepared drawings for a device selected from a list of options provide by the instructor. The teams made brief presentations on their designs.

In the Engineering Problem Solving course (EG 167), students used both FORTRAN and Maple. The assignments were engineering problems, and the student used SGI networked work stations with PCs serving as X-terminals.

Engineering Graphics 166 was a prerequisite for EG167, and pre-calculus was a co-requisite for EG 166. Students were not required to take EG166 their first quarter, and in fact, about half of the students did not begin the EG sequence until their sophomore year.

## II. Retention

In Autumn 1996, the College of Engineering at Ohio State completed a study of retention of engineering students. The study was conducted for students entering Ohio State as new first quarter freshmen in Autumn 1988 with a declared interest in completing a degree in engineering. By June 1996, 75% of those students had earned a degree from Ohio State, but only 37% of the initial group of students had graduated as engineers.

At Ohio State, engineering students are not admitted to their major departments until they have finished a prescribed set of core courses, which usually takes about two years. Our data showed that after a student was admitted to his or her major department, the probability of completing an engineering degree was greater than 90%. In addition, the average time required to complete an engineering degree was 14.5 quarters in residence (almost 5 academic years), and the time in the major department was about 2 years. Students were generally spending significantly more than 2 years completing the core requirements.

For several years, faculty and advisors had observed that many students dropped out of engineering before completing the core curriculum, and they had begun to develop new programs to improve the core. The data from the study of the class of 1988 confirmed that changes were important.

## III. Surveys

In 1992 and 1997, the College of Engineering surveyed 20% of the most recent five year graduates [1,2,3]. The survey was about their basic engineering, math, and science preparation and their preparation for communications – written, oral, and graphics. The results showed that the graduates and their supervisors felt that they needed more communications skills, more teamwork skills, more design experience and that there was a need for more work in engineering graphics communications.

## IV. The Gateway Coalition at Ohio State

In the early 1990s, the National Science Foundation (NSF) created an Engineering Education Coalitions program. The goal was to address the issue of poor retention in the face of the need for more engineers. The need was generated by our society incorporating more technology. Ohio State worked with nine other schools to form the Gateway Engineering Education Coalition. Drexel was the lead university for this group of largely urban schools. Gateway's goals included improving retention, increasing diversity, using technology, developing faculty and students, and developing a dynamic modern curriculum to meet the rapidly changing needs of the world.

The nine schools agreed to adopt or adapt Drexel's E4 program for freshman and sophomores and put engineering up front, include hands-on labs, and to incorporate design[4,5,6,7]. Drexel had managed to get engineering, science, mathematics and humanities faculty to create an integrated program. The schools also agreed to develop innovative upper division courses.

At Ohio State, the College of Engineering was able to get mathematics and physics to work with the engineering faculty to create an adaptation of E4. In the first four years (1993-97), the Department of Mathematics offered an accelerated calculus sequence that allowed the students to complete four quarters of calculus in three quarters. Originally there were three quarters of Engineering Mechanics – statics, particle dynamics, and rigid body dynamics. Physics worked with this group and replaced the particle dynamics with the first course in physics. The coordinated program was called the Gateway Program and the students accepted into the program were those whose math background allowed them to start the accelerated calculus sequence[8,9,10,11,12,13,14]. For the first two years (1993 – 1995), approximately 35 students were enrolled in this program. This program was in effect almost an honors program and did not serve the students who were not calculus ready.

For the second and third year, a second program was created that divided up the first engineering course into two courses and then followed with the second and third engineering courses. This program also started the students on a two course sequence in pre-calculus and the first course in calculus. The students then followed the normal rather than accelerated calculus sequence. This program assumed that students who were not ready for calculus also needed to take an introductory course in Physics to improve their Newtonian concepts prior to taking the first course in calculus based Physics. Approximately 65 students were enrolled in the modified version of the Gateway Program for the 1994-95 and 1995-96 academic years

Longitudinal tracking showed that the students in the accelerated program were being retained at an 85-90 percent rate as compared to 70 percent for a matched control group. Longitudinal tracking for the modified program showed that the students were being maintained at a 46 percent rate to the junior year as compared to 26 percent for a matched control group.

These programs were taken to the College Committee on Academic Affairs as a proposal for all students. The College Committee did not feel that the Gateway Program could be implemented for all students because they felt that the longitudinal data was not sufficient to support the expansion of the program. In all likelihood, it was the fact that they had not been involved in the development of the Gateway Program, therefore did not understand what was being done and could not support the Program.

## V. Introduction to Engineering 1997 - 2001

### Development

After the study of the retention rate for engineering students who came to Ohio State as new first quarter freshmen in Autumn 1988 was completed, the Dean formed a Task Force "to formulate

a plan for a new Lower Division Program to be taken by all engineering undergraduates in the College which both addresses the needs of all our stakeholders and provides an open framework for continuous improvement; and to develop proposals for the implementation of that plan." The Task Force began work in Autumn 1996. At the end of the 1996-97 academic year, the Task Force submitted a report to the Dean suggesting several changes to the core curriculum. Chief among those suggestions was the development of a 3-course sequence for all freshmen entitled Engineering Fundamentals and incorporating a series of hands-on laboratory exercises in a variety of engineering disciplines.

Throughout the 1996-97 school year, members of the Task Force had attended faculty meetings in each engineering department to gather information on what weaknesses faculty members had noticed in the backgrounds of their upper division students and what topics should be included in the Engineering Fundamentals course. Drafts of course syllabi were circulated to faculty for comments.

In 1997-98, the Dean expanded the Task Force to include faculty members from all departments, academic advisors, college staff personnel, and a student representative, and charged the group with developing the plan to implement Engineering Fundamentals. More meetings with department faculty were held, and in April 1998, when the final draft of the syllabus was complete, faculty were invited to a day-long retreat to discuss the course. Approximately half of the 270 engineering faculty and many academic advisors attended the retreat and participated in the very lively discussion. At the end of the day, the course sequence had been totally revised. Instead of a series of modules, each dealing with a different engineering discipline and stretching over three quarters, the faculty settled on a two-quarter sequence consisting of instruction in basic skills and hands-on laboratory experiences centered around one or two engineered products. The courses would give the students a chance to explore how various skills and engineering concepts from different disciplines were utilized in the design and production of a specific object or system.

## Implementation

Proper approvals to offer a new, experimental course were obtained by early June 1998, and in the summer of 1998, a team of about 20 faculty, staff, and graduate students, prepared the new course sequence, now called Introduction to Engineering. The first course was to be offered Autumn Quarter 1998. Three sections of 35 students each would be included in the pilot. To teach the course we would need 105 students, instructional staff, course materials, space, equipment, and an assessment program. In addition, to preparing for the 1998-99 pilot, it was important to remember that the goal was to be able to offer Introduction to Engineering to all engineering students except those who participated in the Freshman Engineering Honors Program. That meant the courses needed to be developed in such a way that they could be scaled up to accommodate perhaps 800 students. In addition, the pilot needed to be run and assessed in such a way that faculty and the administration could determine whether it should be approved for full-scale adoption.

Students were recruited for the pilot during summer orientation. Each incoming student spends two days on campus during summer orientation learning about the university and planning a schedule for his or her first quarter. Each engineering student at the 1998 summer orientation heard a presentation on IE and was invited to apply to participate. Three hundred and fifteen students applied to take IE. That provided enough students to select a pilot group and a matched control group whose compositions accurately represented the entire incoming class.

The instructional team consisted of faculty, graduate teaching assistants (GTAs), and undergraduate peer mentors. Since one goal of IE was to expose beginning students to many different engineering disciplines, faculty to teach the courses were selected from volunteers across the College. Faculty from almost every discipline participated in the pilot. Preference was given to faculty who had won teaching awards or were known for their enthusiasm. GTAs were selected on the basis of their enthusiasm for engineering, communications skills, and interest in teaching. Peer members, upper division undergraduate engineering students, were hired to provide individual attention to the freshmen during class and labs. Students, both graduate and undergraduate, who had struggled with early engineering classes but succeeded were considered as strong candidates for the positions. It was hoped that they could provide the freshmen with practical tips for succeeding in engineering at Ohio State as well as with daily proof that success is possible.

Very few of the faculty and none of the GTAs or peer mentors had experience teaching freshmen. In a large public, land grant institution such as Ohio State, classes of beginning students have a wide range of abilities, preparations, motivations, learning styles, and so on. Teaching all of those students effectively is demanding. The Office of Faculty and TA Development worked with the College of Engineering to prepare and deliver a 2-day orientation program for the entire instructional staff. The program included a discussion of what behavior to expect from freshmen, tips on teaching freshmen, resources available to students who have various types of personal problems, and of course, details on the material to be taught in the course.

Development of course materials began with a list of course objectives. Teams of faculty and staff prepared presentations, laboratory exercises, and homework assignments to support those objectives. The presentations were done in Power Point and were installed on the instructor's console in the classrooms where they could be projected for the students to see. In addition, the Power Point slides were printed, 3 to a page with space for notes, and included in the student course package along with some supplemental reading material and assignments. Students purchased the course packages in place of a textbook. Providing faculty with the visual aids helped to ensure the same material was covered in every section and minimized the instructors' preparation time. Copies of the slides were placed in the student materials package because there was no text for the IE course and freshmen often lack note-taking skills.

The course assessment plan, assessment instruments, and a timetable were developed concurrently with the course materials. An educator who specialized in assessment was hired to prepare the plan and instruments. He attended virtually all meetings of the course materials

development teams and served as a resource for them. A staff member from the Office of Faculty and TA Development attended most team meetings as well.

Since the three sections of IE offered in 1998-99 were experimental, no new facilities were used. The basic skills such as sketching and use of various computer tools were taught in classrooms normally used for EG 166. Lab space was shared with the FEH program. Laboratory exercises were designed to use common, inexpensive materials.

Space for the Freshman Programs

In early 1999, the two IE courses were deemed to be acceptable and were given permanent course numbers. Following analysis of assessment data from the complete 1998-99 pilot, the faculty voted to require the IE or FEH sequence of all engineering students. There was not time to prepare space and materials for the entire 1999 incoming class. The IE program was, however, scaled up to accommodate 9 sections of 35 students each during the 1999-2000 school year. During the summer of 2000, an entire floor of the main engineering building was renovated to provide classrooms, laboratories, and instructional and administrative team offices for IE and FEH. Beginning in Autumn 2000, all engineering students at Ohio State were taking either the IE or the FEH course sequence. This renovation is documented in a paper entitled "Developing and Implementing a Facilities Plan for a Freshman Engineering Course Sequence" and is being presented at this conference[14].

With the IEP program going to ~800+ students and the FEH program going to 215 students, the College of Engineering gave up the newly renovated space in the basement and renovated six classrooms on the 2nd floor in what was the Engineering Graphics space.

VI. Freshman Engineering Honors Program 1997-2001

In Autumn 1997, approximately 70 students were in the Gateway Program. As the year progressed, the name of the program was changed to the Freshman Engineering Honors Program (FEH) to reflect that it had been approved as an Honors sequence. At the same time, only students designated by the University as Honors could participate. A critical event happened in Winter of 1997 when Dr. Freuler joined the program to teach the Engineering Problem Solving and stayed to become a permanent part of the FEH Program. The presence of two faculty members ( Dr. Demel and Dr. Freuler ) who each taught all three courses and who helped with recruiting had a positive effect on the enrollment in the program. By 1997, we had also gathered good longitudinal data about how being part of the program meant better grades, a shorter time to enter the major, better chances to get an early co-op or internship job, and a shorter time to graduation. The presence of the two faculty members and the longitudinal tracking information were the key issues to getting more students involved. The enrollment increased as follows:

| Year | # Students | Year | # Students | Year | # Students | Year | # Students |
|---|---|---|---|---|---|---|---|
| 1997 | ~70 | 1998 | 100 | 1999 | 175 | 2000 | 215 |

With this large increase in enrollment it meant that more faculty had to be involved, more graduate and undergraduate teaching assistants were required, and the robot competition had to move. In Spring 2000, the competition moved from the lobby of the engineering building to St. John Arena, the old Ohio State basketball arena. Beginning with the 1997 group, 80% of the students were staying in the FEH Program for all three quarters. Of the students who stay in for three quarters, almost 100% stay in Engineering. Of the 20% who drop out after 1 or two quarters, at least 85% stay in Engineering. This compares to only 70% of the matched Honors control group who stay in Engineering.

The documentation on the hands-on labs and design-build projects for both the IEP and FEH Programs is covered in an overview paper entitled "Developing and Implementing Hands-On Laboratory Experiments and Design-Build Projects for Freshmen" which being presented at this conference. This paper also references papers with more detail on the development and effectiveness of the IEP experiments that have been submitted for journal publication.

## VII. Evaluation and the Role that it Played in IEP and FEH

The assessment and evaluation for the First Year Programs includes longitudinal tracking of the pilot groups and matched control groups. The tracking includes retention in major, overall grade point average, grades in critical math and science courses, participation in co-op and internship programs, time to get to major and time to graduate. Courses are evaluated but separately from teacher evaluation. The faculty are surveyed about their responses to questions concerning their teaching at the freshman level. Students are surveyed at the end of the quarter and during the quarter. The students submit anonymous electronic journals with responses to weekly questions and with open comments on the program in general or program details and include suggestions for positive changes.

These assessment results are critical selling points for the new programs when talking to industry, the administration, faculty, and especially to prospective students and their parents. Another paper is being presented at this same conference and is entitled "Assessment and Feedback for a First Year Engineering Program" [17].

## VIII. Summary – Program Effectiveness

Improving retention of first year engineering students was one of the important goals for developing these new programs. Approximately 70 percent of the calculus ready (and normally Honors) students historically have earned their BS degrees. The control groups for the early Freshman Engineering Honors program have continued to earn their degrees at the same percentage. However, if students complete all three FEH courses >95 percent are earning their BS degree. If the students start the FEH program but complete only one or two courses, they are being retained at about an 80-85 percent rate.

The preliminary results for the IEP program pilots show that ~ 90 percent are retained to the sophomore year and, for Pilot 1, that about 70 percent are being retained to the junior year. The control group of students who did NOT volunteer for IEP show a 46 percent retention to the

junior year. The good news is that the worst group in 2000 is the average for 1990. Now that we have dealt with the loss of students in the first year we need to address the loss of students in the second year of the program particularly for those students who are not calculus ready when they enroll at Ohio State.

Faculty who have never taught at the freshman level are being engaged in the enterprise, and through the faculty development program, they are learning more about educational methodology and technology. The culture is changing as a result of these program developments for the first year students.

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