

## **Developing and Implementing a Facilities Plan for a Freshman Engineering Course Sequence**

**Robert J. Gustafson, John A. Merrill, Audeen W. Fentiman,  
Richard J. Freuler, John T. Demel  
The Ohio State University**

### 1. Introduction

The College of Engineering at The Ohio State University has recently implemented new freshman engineering course sequences for all engineering freshman. Facilities for two tracks of the freshman engineering courses need to accommodate approximately 1,100 students per year. Approximately three-fourths of the honors qualified students ( $0.75 \times 330 = 252$ ) are expected to select an honors track (Freshman Engineering Honors, FEH) consisting of three courses, one each quarter for the academic year. The remaining students (approximately 850) follow the regular track (Introduction to Engineering, IE) and take a two-course sequence. It is assumed that regular track students can follow a pattern of either AU,WI; AU,SP; or WI,SP for the two course sequence. This allows for some leveling of instructional load across the year while still allowing all students to complete the sequence in the freshman year. Students not fully calculus-ready are offered a one-credit class AU and follow the WI, SP pattern. Some programs, computer science in particular, want the option for students to take a first programming course WI quarter. This fits well with an AU, SP pattern for the two courses.

Other courses in graphics are offered by a Department in the College to both engineering and non-engineering majors. Since it was anticipated that the new program would at least partially share space, needs of these programs were also considered. Since open computer laboratories are available to freshman students in other nearby spaces, it was not necessary to plan for open computer lab time in the new facilities.

Both IE (2-course sequence) and FEH (3-course sequence) have two components to each course: basic skills and laboratory exercises. In the basics skills portion of the class students study sketching, visualization, oral and written communication, and use of computer packages for word processing, spreadsheets, computer aided design, mathematical calculations, and preparation of visual aids. In the laboratory portion of the class, they design and conduct experiments to investigate fundamental concepts, take apart off-the-shelf products to explore the engineering design process, and then design, build, test and document a product of their own. Development and content of these courses are described in companion papers.

### 2. Desired Characteristics: Basics and Laboratory

The “basics” and “laboratory” portions of the class require different facilities. Room design needed to accommodate the fact that both the Honors and regular course sequences put high priority on collaborative learning and teamwork in basics as well as laboratory. Characteristics of those two facility types needed are described in this section.

## 2.1 Basics

It was desired to have a facility for the basics instruction that would a) promote collaboration in teams of 2 or 4 students, b) provide space for individual activity and computer access, and c) still support instructor presentation/lecture. The spaces for basics instruction needed to accommodate 72 and 36 students per class for the IE and FEH class respectively. Given the number of sections and section sizes to be accommodated, separate spaces for the two programs was desired.

## 2.2 Laboratory

Although different laboratory exercises are used in the two course sequences, both have the goal of hands-on experimentation, reverse engineering projects in small groups, and doing small-team design projects. Since some instruction is presented in the laboratory room, presentation capability is needed.

## 3. Facility Developed

The first experimental course, which eventually led to the Freshman Engineering Honors (FEH) program, was offered in the 1993-94 academic year. The entire course was taught in a regular classroom equipped with fixed tables and movable chairs rather than individual desks. Laboratory experiments and design/build projects were kept small so that all of the required equipment and components could be put in easily transportable containers and brought to class each day they were needed. This remained the mode of operation until 1997-98 when the laboratory portion of the class was moved to an old environmental engineering laboratory with workbenches and some utilities.

The next year, the 1998-99 academic year, three sections of Introduction to Engineering (IE) were taught as a pilot. IE laboratories used the same space as FEH lab sessions, and some equipment and storage space were added to accommodate the IE classes. In 1999-2000, a recently vacated basement room was temporarily equipped as a laboratory for 5 sections of FEH and an expanded pilot of 9 sections of IE. The basics portions of both FEH and IE were taught in regular Engineering Graphics classrooms with a computer for each student and an instructor’s console.

Lessons learned while teaching IE and FEH in several different facilities were valuable when it was decided to require IE or FEH of all engineering students and to renovate existing classroom space specifically for those courses. The renovation was done during the summer of 2000. This section briefly describes the original space, the renovated

facilities for basics and laboratory portions of the courses, and lessons learned during and since the renovation.

### 3.1 Constraints of Available Space

Space designated for renovation consisted primarily of 6 rooms, each 22 ft by 63 ft, on one floor of one building. The current facilities, designed in the early 1960's, would not meet the needs of the new program. Having done pilot programs in computer classrooms converted from Engineering Graphics instruction and having shared laboratory space with environmental engineering, the College recognized that a major renovation was needed.

Early in project planning, the decision was made to use a section size for laboratory of 36 students. Based on experience gained in a prototype lab facility, this number of students could be accommodated for laboratory work in a 22 ft by 63 ft room. This fit well with current practice of 36 students for honors sections of basics and laboratory. However, it was deemed necessary to have larger sections of the basics element for the regular section classes. To meet the capacity needs of the program for laboratory and basics presentation and related courses, three laboratory rooms, two 36-student and one 72-student basic presentation rooms were needed. A solution was developed for the 72-student room by removing one wall, to combine two rooms into one 44 ft by 63 ft room. This accommodated a 72-student room for basics. This left the plan short one room. A 36-student basics presentation room has been partially renovated on another floor of the same building to accommodate the program. Full renovation is being planned for in the near future.

Figure 1 shows a floor plan of the renovated area to be described in the following sections.

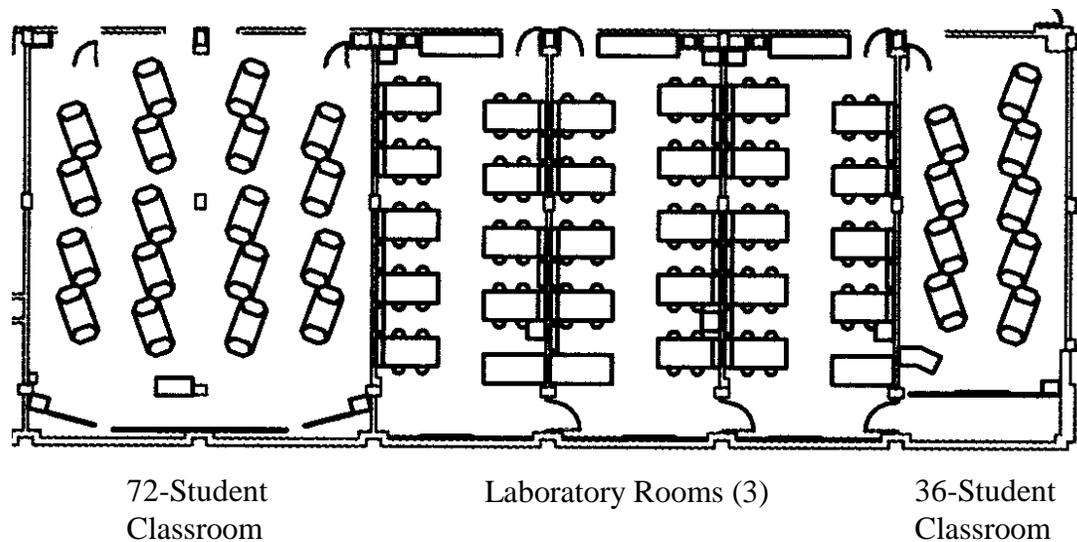


Figure 1. Floor Plan of Renovated Area

Room security is enhanced by a common key card access to all rooms. Any single room or combination of rooms can be locked at any time. Campus security centrally monitors door, during non-class time periods.

### 3.2 Basics Presentation Spaces

#### *Four-student module*

Given the desire to have a space which a) promotes collaboration in teams of 2 or 4 students, b) provides space for individual activity and computer access, and c) still supports instructor presentation/lecture and the physical room constraints, a specialized furniture configuration was needed. The four-student module, shown in Figures 2, is the basic unit within both the 36-student and 72-student basics spaces.



Figure 2a. Four-Student Module - Picture

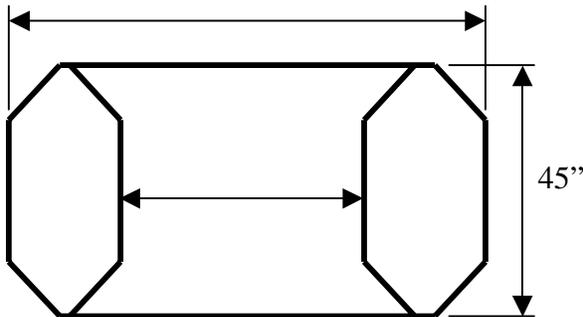


Figure 2b. Four Student Module - Schematic

Each table is equipped with four computers. Network connections and power enter from a 3-inch raised floor. The dropped ends of the tables allow students to see presentation screens and the instructor in the front of the room over the monitors. It also allows students to be seen by the instructor. Computer CPU's were suspended under the tables at the ends. This was done to leave maximum clear space for student collaboration, in two's or four's as desired, as well as individual access to computers.



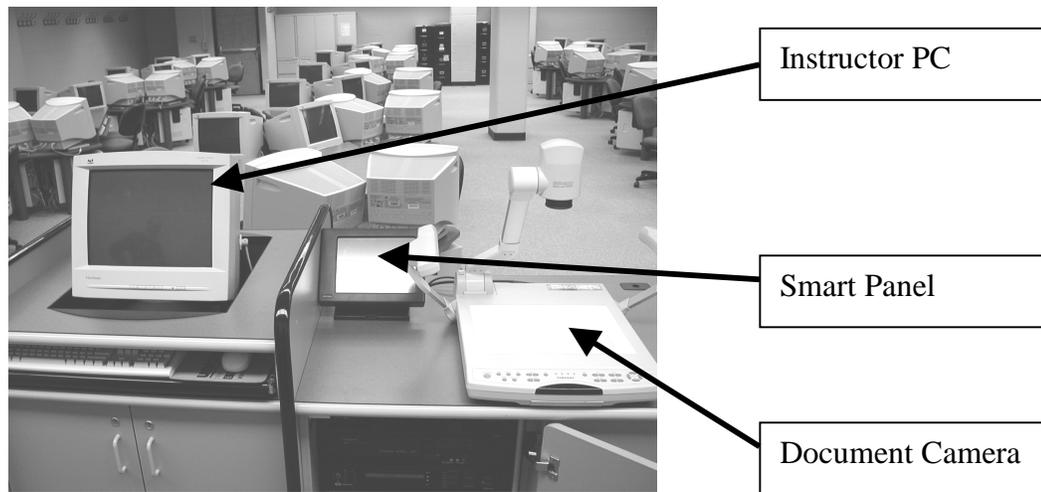


Figure 4. Presenters Station

The presenter station (Figure 4) includes display sources of in-room computer, connection for laptop computer, document camera, and VCR. A “smart panel” along with audio mixing and amplification units controls both audio to ceiling mounted speakers and video to ceiling mounted LCD projection units. To accommodate instructor movement, both wireless microphone and mouse for computer control are available. Design of the audio and visual equipment was done in collaboration University personnel responsible for such technology campus-wide. Their advice throughout the project on layout to meet audio and visual needs, selection of equipment and placement of equipment and furnishings was very valuable to the project.

All computers are individually addressable via a network. A classroom computer software control system, NetOp School, is used to display presentation material on each student’s machine. It can also be used more broadly for computer-to-computer interaction.

### 3.3 Laboratory facilities

Three laboratory rooms support the two freshmen engineering programs. All are standardized to the same size and with the same base equipment. The common room configuration is shown in Figure 5. The rooms have nine four-student laboratory stations (See Figure 6) with stools, thereby giving 36-student capacity. One of the stations, as well as room access and routing, are ADA compliant. Overhead bin storage for loose equipment is located at each station and helps to minimize movement about the room. Additionally, each station has a complete computer system with all hardware and software necessary to support the laboratory curriculum, and all computers are networked.

A movable laboratory instructor presentation unit (Figure 7) is positioned at the front of each laboratory. Each unit has a computer with monitor, videocassette recorder/player, and full screen projector. The computer system is also networked and has control over all

computers in the laboratory. For example, information on the presenter's monitor screen can be brought up on any one, or all, of the station monitors for easy viewing by the students.

Multiple storage cabinets are located to the rear of each laboratory room. Items used on a regular basis are stored in the cabinets for easy set-up/take-down. This storage feature is also useful since the laboratory space may, on occasion, be used for regular classes. (For regular class use, all lab items must be stored/secured). Storage for student use is provided by lockable, stackable storage boxes (15W x 12H x 22D inches) located under each bench. Any lab related apparatus, developed during lab sessions, can be stored in the boxes.

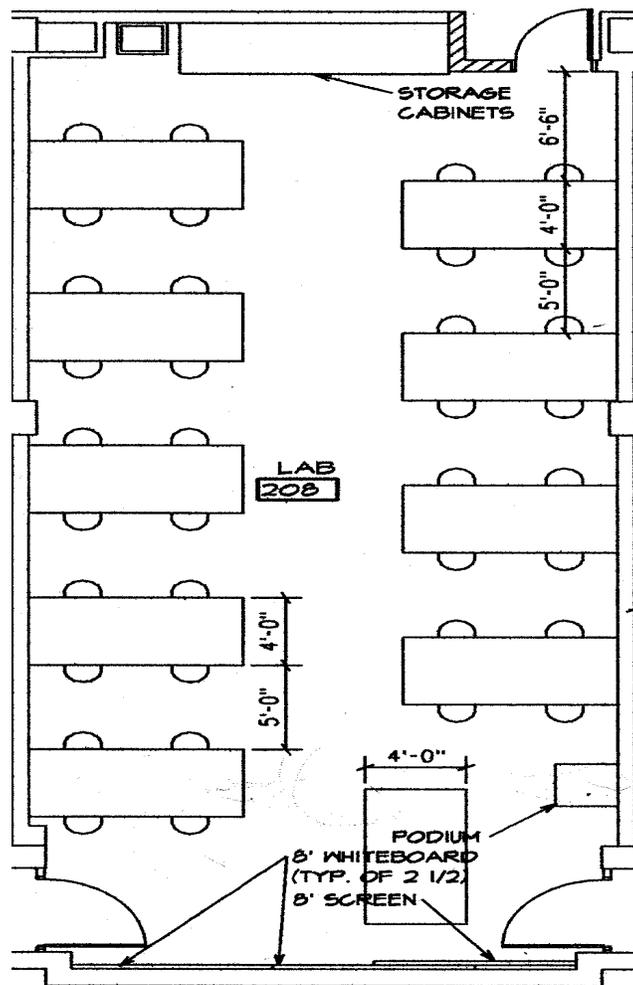


Figure 5. Floor Plan of Laboratory Room



Figure 6. Four-Student Laboratory Station (Table Basic Surface 105L by 48W inches)

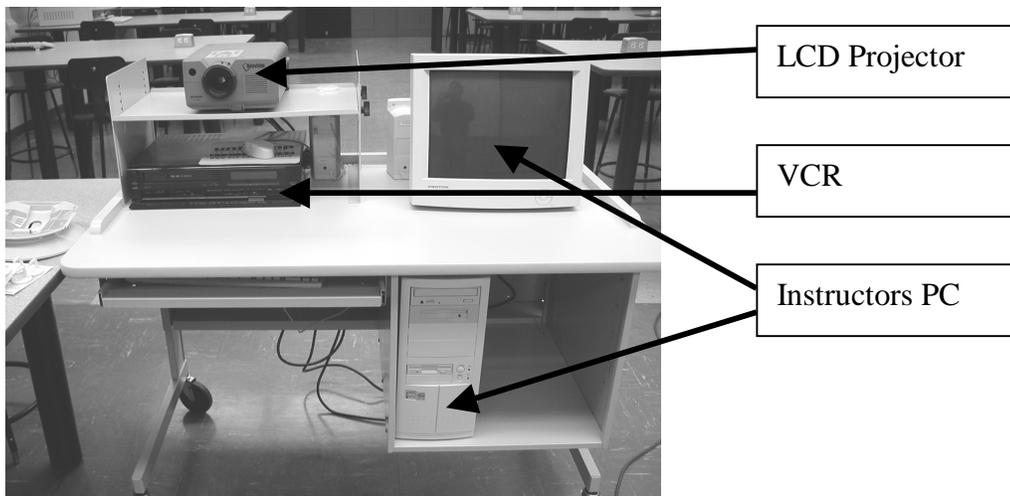


Figure 7. Laboratory Instructor Presentation Unit

#### 4. Support Personnel and Facilities

##### *Development Lab*

Separate space, called the development laboratory, is used to support the enhancement of experiments or to development new experiments. Bench test equipment, balances, computers, power supplies, and other support equipment are available in the development lab.

##### *Staff Offices*

Staffing for the freshmen programs includes managing staff (2), instructional staff (faculty), permanent technical support staff (2.5), graduate teaching assistants (12), and undergraduate teaching assistants. Faculty members are recruited from college faculty, therefore office space is not provided to them. All regular staff has offices adjacent to the renovated area.

## 5. Lessons Learned

Configuration for student collaboration in the basics presentations areas appears to be working well. Laboratory space has been found to be very flexible in accommodating needs of the classes. Students and instructors both seem very pleased with the function of the spaces. It is certainly leading to more opportunities for building collaborative learning into program. Storage space for equipment was anticipated to be an issue. Additional equipment storage area within easy access is still needed.

As would be expected, planning well in advance of such a project is necessary. Actual room renovation and installation of new equipment for this project was accomplished in a three-month period, only because of the very diligent guidance of University Physical Facilities personnel. Use of a University service for planning and equipment selection for audiovisual equipment resulted in a high quality system, which is consistent with other units on campus. Although raising the cost modestly, the raised floor in the basics presentation rooms has been deemed a very good investment. Appearance of the rooms and flexibility in moving about in the room is much enhanced by having all utilities in the floor.

## 6. Assessment

At this time the assessment of the effectiveness of the new facilities is mostly anecdotal. The instructors who have been using the facilities find that the projection systems, wireless mice, and remote microphone allow them to interact with the students better than in traditional classrooms. The classrooms and laboratory rooms are promoting students knowing more of their classmates. In one of the electronic anonymous journal responses from students in the FEH program when asked how many students they felt that they knew in the program, the students in the new configuration responses showed that they knew at least one more person than the students who are still using the traditional classroom. Students who have used both configurations are definitely in favor of the new configuration based on an informal poll of students in the Winter Quarter 2001. The final item is probably not as important in the function, but the new rooms help sell engineering at Ohio State to prospective students and their parents.

### ROBERT J. GUSTAFSON

Robert J. Gustafson is a Professor of Food, Agricultural and Biological Engineering and Associate Dean for Academic Affairs and Student Services for the College of Engineering of The Ohio State University. Dr. Gustafson is a registered professional engineer and is actively engaged in development of first-year engineering programs and teaching improvement. Dr. Gustafson received B.S. and M.S. degrees in Agricultural Engineering from the University of Illinois in 1971 and 1972 and a Ph.D. in Agricultural Engineering from Michigan State University in 1974.

### JOHN A. MERRILL

Dr. Merrill received his Ph.D. in Instructional Design and Technology from The Ohio State University in 1985. He has an extensive background in public education, corporate training, and contract research. He is currently Program Manager for the Introduction to Engineering (IE) Program at The Ohio State University. His current responsibilities include management and assessment for the IE Program, including the use of

web-based instruments. He also collaborates with the Associate Dean for Academic Affairs/Student Services, and with key faculty, in the establishment of outcome-based assessment processes. These activities were instrumental in helping the College of Engineering prepare for its accreditation visit under new criteria issued by the national Accreditation Board for Engineering and Technology (ABET).

#### AUDEEN W. FENTIMAN

Audeen W. Fentiman is an Associate Professor in the Department of Civil and Environmental Engineering and Geodetic Science. She also serves as the Associate Dean for Outreach and Special Programs in the College of Engineering and as Director of the interdisciplinary Environmental Science Graduate Program. Her research is in the areas of radioactive waste management, environmental engineering risk assessment, and engineering education. She holds B.S. and M.A. degrees in mathematics and M.S. and Ph.D. degrees in Nuclear Engineering, the later two from Ohio State University.

#### RICHARD J. FREULER

Richard J. Freuler is a Senior Researcher in the Aerospace Engineering and Aviation Department of the College of Engineering at The Ohio State University. Dr. Freuler is the Associate Director of the department's Aeronautical and Astronautical Research Laboratory and conducts scale model investigations of gas turbine installations for jet engine test cells and for marine and industrial applications of gas turbines. He is also the Faculty Coordinator for the OSU Freshman Engineering Honors Program. Dr. Freuler received the B.S. and M.S. degrees in Aeronautical and Astronautical Engineering and the B.S. in Computer and Information Science in 1974 and a Ph.D. in Aeronautical and Astronautical Engineering in 1991 from The Ohio State University.

#### JOHN T. DEMEL

John T. Demel is a Professor of Engineering Graphics in the Department of Civil & Environmental Engineering and Geodetic Science. Dr. Demel is a registered professional engineer in Texas and is involved in engineering education research. He is a co-author on four textbooks. Dr. Demel serves as the Faculty Coordinator for the Introduction to Engineering Program and teaches in both the IEP and the Freshman Engineering Honors (FEH) program. He helped create and develop the FEH program. Dr. Demel earned his BSME at the University of Nebraska-Lincoln in 1965 and his MS and PhD degrees in Metallurgy from Iowa State University in 1968 and 1973 respectively. He taught at Savannah State College and Texas A&M University prior to joining the faculty at Ohio State in 1980.