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Preparing Materials Engineers for Cross-Disciplinary Careers

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Abstract

Materials engineers must design materials and processes for a wide variety of applications (*e.g.* from aerospace to biomedical to microelectronics to automotive) and thus must be prepared to work on cross-disciplinary problems. In response to this need, the materials engineering curriculum at Auburn University has recently been redesigned to better prepare students for these cross-disciplinary challenges. The modified curriculum enhances the cross-disciplinary experience of students in two directions - providing opportunities for materials engineers to learn other disciplines and opportunities for students from other disciplines to learn materials engineering. In the modified curriculum, materials engineering students take a nine-semester-hour (minimum) sequence in another technical discipline. Students can design individual programs based on their interests providing that the sequence builds to an advanced-level course in another discipline. The modified curriculum has also been designed so that more courses are available and appropriate for students from other disciplines. In this paper, the revised curriculum will be described and some of the issues raised by the introduction of this cross-disciplinary experience will be discussed.

I. Importance of Cross-Disciplinary Preparation

Engineering undergraduate curricula generally focus on providing students with education and training in the student's chosen discipline. While engineers do need to develop expertise in a particular discipline, complex engineering problems require teams of individuals with complimentary experience and expertise. The effectiveness of an engineer in working on such problems can be enhanced if the engineer has had previous training in or exposure to other disciplines. In response to this need, one of the educational outcomes in Engineering Criterion 2000 is that students have an ability to function on multi-disciplinary teams (Criterion 3d)[1].

Materials engineers are employed in a wide variety of industries and will thus likely need to work with individuals from other disciplines. For example, materials engineering working in the microelectronics industry will need to work with electrical engineers and physicists, while those working in biomaterials will need to work with biologists and physicians. Thus, the ability to work on multi-disciplinary teams is particularly important for materials engineers.

II. Materials Engineering Revised Curriculum

Auburn University recently (Fall 2000) went through the transition from the quarter system to the semester system, which required that all curricula be revised accordingly[2]. This change coincided with the introduction of EC 2000, so the transition provided an opportunity to respond to the new accreditation criteria. One of the objectives in modifying the materials engineering curriculum was to enhance the cross-disciplinary experience of engineering students at Auburn University. Modifications were made to benefit both materials engineering students as well as students from other disciplines.

One of the modifications was the addition of a cross-disciplinary sequence. The previous curriculum included only one technical elective. With only one technical elective, students could often not take desired technical elective courses, because they had not taken the prerequisite courses. To enable students to take advanced-level courses in other disciplines, the revised curriculum includes a nine-credit-hour series of technical electives. Students can select from pre-approved sequences in various disciplines or design sequences according to their individual interests. One requirement of the sequences is that they build to an advanced course or courses in another discipline.

Some example cross-disciplinary sequences are given below:

<u>Microelectronic Devices and Fabrication – Electrical Engineering</u>
Advanced courses: Microelectronic Fabrication and Solid State Sensors
Leading courses: Electrical Circuit Analysis (for Electrical Engineers) and Digital Electronics

<u>Product Reliability / Quality Control – Industrial Engineering</u>
Advanced course: Reliability Engineering or Off-Line and On-Line Quality Control
Leading courses: Engineering Probability and Engineering Statistics

<u>Mechanics and Dynamics – Mechanical Engineering</u>
Advanced course: Advanced Mechanics of Materials or Mechanics of Electronic Packaging
Leading courses: Kinematics and Dynamics of Machines and Mechanics of Materials.

The leading courses are sophomore- or junior-level courses and the advanced courses are senior-level courses. In some cases, some of the required courses outside of the cross-disciplinary course are modified. For example, as shown above, students selecting the Microelectronic Devices and Fabrication sequence will take the circuits course with electrical engineering students, rather than the circuits course designed for non-majors. Likewise, students selecting the Mechanic and Dynamics sequence will take the statics course taken by mechanical engineering students. These modifications are made so that the materials engineering students will be better prepared for the advanced courses.

The curriculum was also modified to increase the availability of materials courses for students outside of materials engineering. Previously, there was a sophomore-level series of introductory courses which students from outside materials engineering would need to take as prerequisites for the junior-level courses. In the new curriculum, there is an introductory course, but this has been designed for the needs of the mechanical engineering curriculum, and is not a required course for materials engineering students. There is a series of three courses in Engineering Materials (Metals, Ceramics and Polymer), which materials engineering students take in their junior year. These courses do not have any materials engineering prerequisites, so students from other disciplines can take these courses as technical electives. Two of these courses (Metals and Polymers) have laboratories, but the laboratory is listed as a separate course, so that students can take the lecture portion of the course without the associated laboratory.

III. Impact of Curriculum Modifications

Materials engineering students at Auburn will now gain significant exposure to another technical discipline, which will broaden their educational experience and better prepare them for working on cross-disciplinary projects and teams. The cross-disciplinary specialization could provide an advantage for the student when searching for employment. For example, the Microelectronics Fabrication and Devices specialization listed above would help the student obtain employment in the microelectronics industry. Even if the specialization is not specifically applicable to the job, the broader experience could be attractive to potential employers.

The effective increase in technical electives needed to have nine semester-hours for the cross-disciplinary specialization required a reduction in other areas. The reductions were applied in two areas. One area is the elimination of the advanced chemistry requirement. In the quarter curriculum, materials engineering students took a ten-quarter-hour (6.67-semester-hour) sequence, beyond the freshman chemistry sequence, in either physical chemistry or organic chemistry. This, combined with the three-quarter-hour (two-semester-hour) technical elective that existed in the quarter curriculum, should have provided the required hours. However, university restrictions on the maximum number of hours and core curriculum requirements required additional reductions, so the number of hours of materials engineering courses was also decreased. The reductions in the materials engineering hours were in two areas. One was in reducing the coverage of metallic materials, which was more extensive than the coverage of other classes of materials. Some additional hours were obtained by eliminating the repetition of some material. While repetition of material is certainly useful for learning, this was considered the least critical area for reduction. The assessment process being implemented for EC2000 will be used to identify any problems associated with the reduction in the hours of materials engineering coursework.

The junior-level courses in metals, ceramics and polymers are now accessible to non-materials majors, because the sophomore-level introductory courses were eliminated from the materials engineering curriculum, and thus as prerequisites for the junior-level courses. As mentioned above, this required moving some material to the junior-level courses and eliminating some repetition of material. The semester curriculum just began in Fall 2000, but the effect of making the junior-level courses more accessible to non-majors has already become apparent. Of the eight students enrolled in the metals course, two were from other disciplines. One was from textile chemistry and one was from mechanical engineering. One of these students even took the laboratory course and is considering graduate studies in materials science and engineering. Also, of the eight students enrolled in the ceramics course, one was from electrical engineering.

IV. Further Enhancements

The ideal cross-disciplinary experience would involve students working with other engineers, and non-technical students, on a complex project – for example on a senior design project. Comprehensive implementation of such a system would require coordination at the college level (or higher if non-technical majors are involved). While such a comprehensive program is not likely imminent, cross-disciplinary projects have been used in specific senior design projects. The cross-disciplinary specialization will help students to include non-materials aspects in their senior design projects. In addition, materials engineering faculty will work toward developing projects in collaboration with faculty from other disciplines to enhance the cross-disciplinary aspects of the projects.

At Auburn University, a minor in Business-Engineering-Technology is being developed in response to the need for employees cross-trained in business and engineering as identified by surveys of employers. The minor is planned for implementation in Fall 2001 and will include a series of courses taught by both engineering and business faculty. Initially, the program will be offered only to a select group of students, but, if successful, could be expanded to include a larger number of students in the future.

V. Conclusions

The materials engineering program has implemented a new curriculum, which is designed to encourage and enable students to cross disciplinary boundaries, and thus enhance their ability to work on multi-disciplinary projects and teams. The curriculum was implemented in Fall 2000, so the effectiveness of curriculum in not yet known, but will be evaluated through the EC2000 assessment process.

Bibliography
1. ABET, URL: http://www.abet.org/eac/conventional.htm
2. Auburn University Bulletin, URL: http://www.auburn.edu/student_info/bulletin/

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