Curriculum Development via Segmented Courses

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Courses in the Department of Materials Science and Engineering (MSE) at the Oregon Graduate Institute have been divided into segments for separate credit delivered over portions of a term. This segmentation facilitates curriculum development around basic and generic subjects. It also reduces the effort associated with developing new courses, and makes education more cost effective through reduction of the duplication of course material. This is especially true for graduate subjects, where enrollments typically are relatively low, but also applies to undergraduate study in specialized areas. The segmentation has made it possible, with the assistance of support from the National Science Foundation, to introduce specialized segments in MSE, like Heat Transfer in Materials Processing, to introduce segmentation into courses in Electrical and Computer Engineering (ECE), and has facilitated efficient joint development with ECE of a new master's program in electronic packaging.

Introduction

Graduate education in engineering is faced with simultaneous challenges. Like higher education in general, it is challenged for efficiency. However, at advanced levels and in specialized areas, classes generally are small compared with typical undergraduate classes. Thus, academic programs can have difficulty offering all classes that are deemed appropriate academically. At the same time, graduate education has to satisfy the needs of a diverse population of research-oriented doctoral students, practice-oriented masters students, and targeted-goal part-time students from industry in dynamic and rapidly-changing fields. This paper reports on an approach for flexible and efficient curriculum development leading to an efficient mode of delivery.

The basic approach taken is to break courses into credit-bearing segments. These segments typically are delivered during portions of the term. The segments isolate components of courses that provide core material for several subjects in a given department or in more than one department. The result is a reduction in current and potential (from new courses) duplication, and a reduction in the effort associated with development of new courses.

While the two benefits cited — reduction of duplication and flexibility in curriculum development — are the principal perceived benefits, there are several additional features. One is the simplification of prerequisites and an associated reduction in the number of actual credits needed to obtain desired elective courses. Another is the simplification of make-up prerequisites for students transferring from other institutions. A third is the ability to adapt segments for delivery as short courses to engineers from industry.

One of the original motivations behind initiating segmentation was indeed to provide a convenient mechanism for delivery of educational materials to industrial students. Courses in Materials Science and Engineering (MSE) were decomposed into segments. Simultaneously, the MSE faculty was developing a new joint master's program in Electronics Packaging with Electrical and Computer Engineering faculty. The potential benefits of course segmentation on curriculum development soon became apparent.

A seed project has been initiated at the Oregon Graduate Institute with the support of the National Science Foundation. The focus has been on curriculum development in Materials Science and Engineering (MSE) and in Electrical and Computer Engineering (ECE), with a view toward identifying broader educational implications.

Below we shall describe examples of how the segmentation project provides the types of benefits cited above. Specific project examples will be used.

Application to Heat Transfer

The MSE department at OGI had been offering a course in Heat Transfer. This subject is of importance in materials because much of materials processing involves application (e.g. in welding) or removal (e.g. in quenching) of heat. However, to maintain broad appeal, the course offered has been a traditional course designed to appeal to any student taking the subject.

The MSE and ECE faculties needed a course in Thermal Management in Electronics for the electronics packaging program. One option was to develop a totally new self-contained course. This would have required duplicating materials associated with basic heat transfer. To require all of the traditional heat transfer course as a prerequisite would have added more material and credits than desired to the packaging program.

Electronic packages rely extensively on conduction and convection heat transfer. Devices typically are restricted to relatively low operating temperatures, so detailed study of radiation is of less importance. Study of heat exchangers, a topic frequently included in heat transfer courses, is of even less concern. Accordingly, the approach taken was to utilize existing one-credit (each) segments on Conduction and Convection together with a new two-credit segment on Thermal Management in Electronics.

The development of the new course has been simplified by ability to rely on the existing segments. Duplication of part of an existing course was avoided. There were two results. One was reduction of the development effort for a new course. The second was the increased efficiency associated with multiple sources of students for the existing Conduction and Convection course segments.

While heat transfer is an important topic for MSE, the standard heat transfer offering does not address specific topics of concern in materials processing. For example, the traditional heat transfer course emphasizes steady-state correlations in the study of convection, while materials processing often deals with fast transients (e.g. in quenching). These topics are of specialized interest, not of concern to a general heat transfer audience. Accordingly, a new one-credit segment on Heat Transfer in Materials Processing is being introduced. This will build upon the Conduction, Convection, and Radiation segments.

As noted, heat transfer courses typically include material on heat exchangers. Another segment, being outlined for follow-on development, is Heat Exchange. This also will also build upon the existing basic segments, and include study of boilers, condensers, and process heat systems generally.

The subject of heat transfer illustrates how segmented curriculum works. Core segments are identified that serve as building blocks for a basic course and for branch segments that are developed for particular needs. Since curriculum development effort is devoted primarily to the branches, effort associated with curriculum innovation is reduced. Since various branches make use of core segments, overall efficiency is improved. Efficiency in delivery of core segments can help to underwrite modest enrollment in specialized low-credit branch segments, thereby aiding maintaining and enhancing the quality of graduate education.

Efficiency for the Student and the Curriculum

With the growth of knowledge and the advance of technology, there has been a concern with fitting as much subject matter as deemed necessary into curricula. Credit hour requirements increased accordingly, with resulting debate in the educational community as to whether a BS program can be done realistically in four years, and at the graduate level, as to whether a master's program can be done realistically in one. It was noted for heat transfer above that segmentation permitted minimizing the number of credits.

MSE has a course on Materials Selection which studies the characteristics of the various classes of materials. Typical MSE students are concerned with all materials, and typically would take this entire course, as a single unit or in segments. Students in the electronics packaging program would find certain portions of this course useful as an elective (e.g. polymers, ceramics), but not others (e.g. concretes, wood).

ECE has a course sequence in communications. The first portion of the first course is considered to be desirable preparation (if not a formal prerequisite) for the other components throughout the sequence. Segmentation leads to a one-credit segment on Basics of Communication Systems. A student wishing to take one of the specialized topics as an elective can now take a combination of one- and two-credit courses, rather than having to take the entire eight-credit combination.

Other Course and Curriculum Applications

Several other courses are being examined for segmentation. Priority is being placed on those classes most amenable to amplification via core and branch segments. Two examples are given below. Several others are in early stages of examination.

Finite Element Analysis (FEA) in Engineering.

MSE has had considerable involvement with this FEA, in view of extensive work in analyzing heat transfer and stress problems associated with process applications. MSE and ECE faculty currently are examining segmentation where there will be a basic core that is generic followed by branch segments on the application of FEA to heat and stress problems for MSE and to Maxwell's equations (electricity and magnetism) for ECE. Future potential application for fluid mechanics is anticipated at a later date.

Mechanics of Materials

Core mechanics of materials segments will set the stage for branching into application to large structures, and to application to thin films and electronics. The latter will be new curriculum development oriented to the new joint program in electronic packaging.

Summary

Segmentation of courses into smaller for-credit units has been found to be an effective mechanism for stimulating curriculum development while avoiding and reducing duplication.

Biographical Information

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