Ensuring Students Have the Prerequisite Skills for a First Course in Engineering

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1. Introduction

A common problem in a first course in engineering is the variation in prerequisite skills of students. These skills might include manipulation of units, data analysis, interpolation, and curve fitting. If class time is dedicated to teaching these skills, students who already have them are not challenged while others may struggle to master them in the limited class time available. An attractive solution to this problem is to make students responsible for mastering these skills outside of class, employing self-paced, on-line resource materials and diagnostic tests to let students know when they have mastered the material.

This approach allows the instructor to immediately begin covering new topics without using class time to cover this prerequisite material. It is also possible to schedule diagnostic quizzes throughout the course so that prerequisite skills are available when needed.

2. Current Status

A series of web-based, self-paced learning modules were developed to teach students the manipulation of units, data analysis, interpolation, and curve fitting skills needed in an introductory course in chemical engineering. The web site was organized around the review sections of the textbook[1] and included HTML pages, Word Documents, Excel Sheets, Streaming Quicktime movies, flash, and PDF files. The choice of format for a given situation depended on the format of existing material and the type of activity to be presented on the web.

As part of a larger project, a Windows notebook computer with Internet Explorer, Microsoft Office, and other software was lent to each student in the course. With this configuration, a wide variety of media could be seamlessly integrated into the web browser.

This concept was first used in the fall of 2002. Students were told they needed to understand the review material in the text but that it would not be covered during class. Students used the web site to study the material. An on-line diagnostic quiz covering all the prerequisite skills was available for the students to test themselves to determine when they understood the material. Students continued studying and retaking the quiz until they had mastered the material.

3. Results

The primary benefit of moving the prerequisite skills into a self-paced learning module is the time recovered for other activities. Instructors should avoid the temptation to use this time to add

new material to the course since many engineering courses are already overloaded. Instead, this should be viewed as extra time to reinforce concepts and skills already included in the course.

Figure 1 shows a picture of the current home page for the learning modules. The seven buttons (Modules, Notes, Video, Demo, Practice, Quiz, and Help) navigate to a particular section of the site. If a type of content is unavailable for a particular module, the corresponding button is "dimmed."

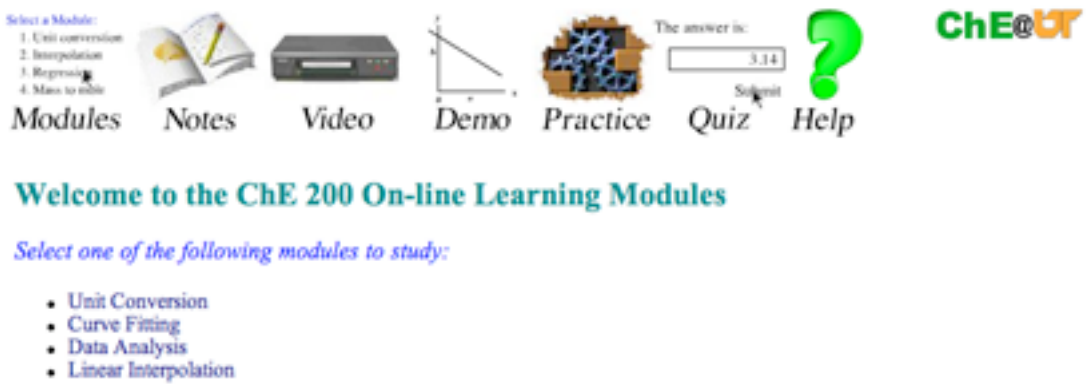

Figure 1: Web Site "Home Page"

(http://www.che.utk.edu:/200/cheonline/)

The "Modules" button returned to this home page so the student could study a different module. The "Notes" button moved to a section with supplemental notes about the topic, consisting of Word and HTML documents. The "Video" button moved to a short movie with audio of a mini-lecture (no more than eight minutes) recorded from an electronic whiteboard. The "Demo" button navigated to a flash movie demonstration of the concepts. The "Practice" button usually presented a series of Excel sheets in which the students were asked questions and then used the sheets to answer them. The "Quiz" button linked to an on-line testing system. Finally, the "Help" button linked to a page where students could contact the instructor and find answers to frequently asked questions about the course.

The diagnostic quizzes were given on-line as multiple-choice problems in the universities course management system "CourseInfo". The quiz consisted of questions that assessed the student's ability to handle unit manipulation, data analysis, interpolation, and curve fitting. Figure 2 shows a typical question from the quiz.

On Planet AR-4 orbiting the star Arcturus, the acceleration of gravity is 19.6133 m/sec^2. An object with a mass of 10.0 kg on Earth (where the acceleration of gravity is 9.80665 m/sec^2) will have a mass in kg on AR-4 that is most nearly: a) 10.0 b) 62.4 c) 98.1 d) 196

Figure 2: A Typical Quiz Question

This question is followed by an almost identical one asking for the *weight* in Newtons of the same mass on AR-4.

A total of 21 students were enrolled in the course. As shown in Figure 3, 57% of the class completed the quiz within the first week; in fact, 42% finished before the second class meeting. Of the rest of the class, 14% never took the quiz, and 10% never received a passing grade. 84% of the students who attempted the quiz passed it by the fourth week. If a deadline were to be put on passing the quiz, three to four weeks appears acceptable.

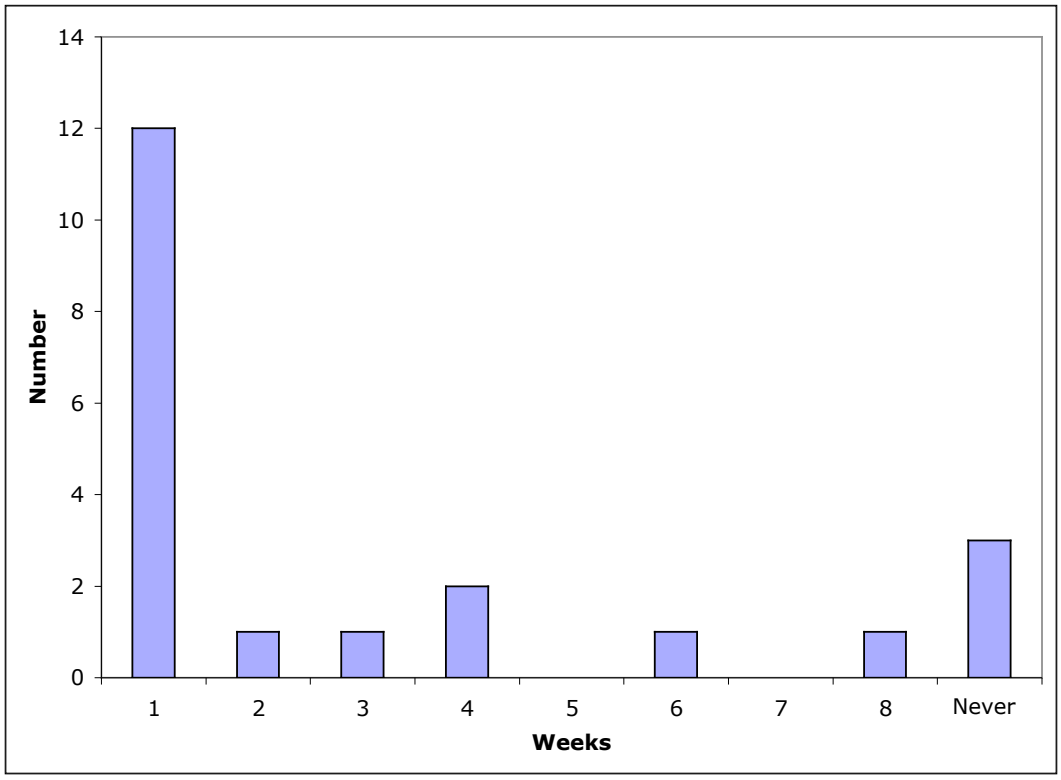

Figure 3: Weeks to Complete the Quiz

Figure 4 gives the final grade distribution for the last three times the same instructor taught the course. Although the slight increase in the number of "A's" in the course is not statistically significant, the decrease in the numbers of "D's" and "F's" is. Removing the prerequisite material from the regular classroom setting apparently did not hurt the better students and seems to have helped the poorer students move into the middle of the grade range.

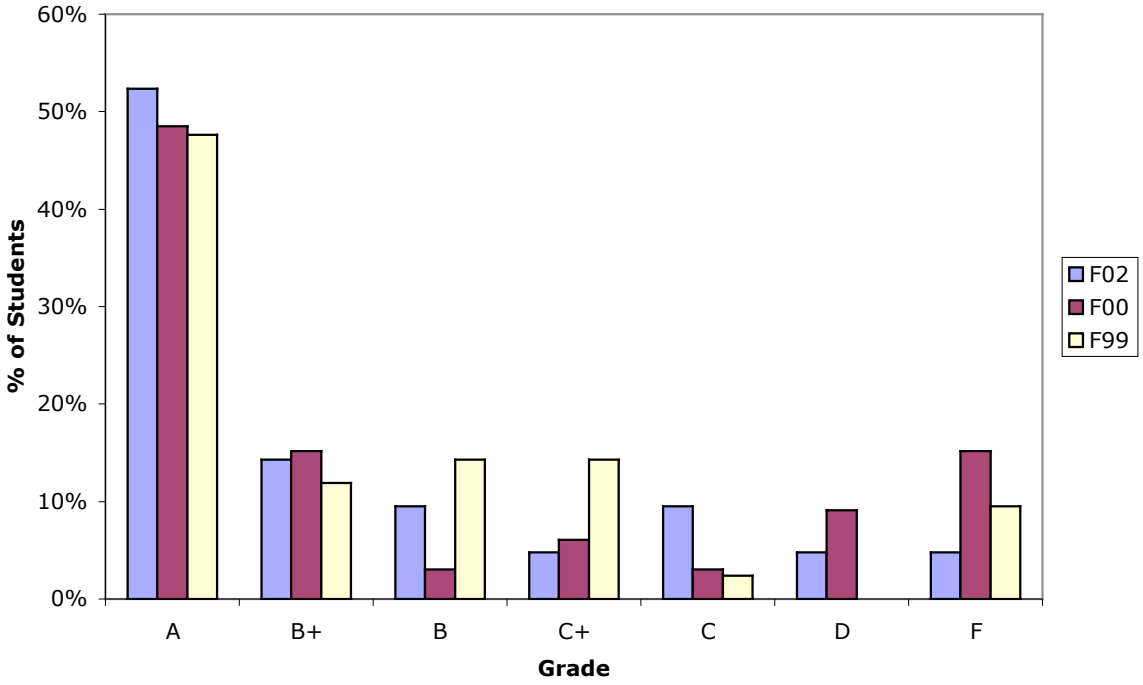

Figure 4: Course Grade Distribution by Year

This conclusion is qualitatively supported by looking at students' grades compared to their performance on the quiz (see Table 1 below). Grades for the three students who failed to take the quiz ("-") were acceptable.

Table 1: Course and Quiz Grades

Course	A	A	A	A	D	B+	B	A	A	A	B	A	A	C	A	A	C	F	B	B+	B+
Quiz	100	100	100	100	67	-	100	100	100	89	67	100	100	100	100	100	-	100	100	-	100

4. Future Work

An improved web-based testing system is being developed. Instead of the multiple-choice format, students will enter a number and have it checked against a range of values for the correct and common incorrect answers. Based on the student's input, immediate feedback will be given on mistakes leading to common incorrect answers. Quiz problems will be randomly selected from a database of problems so that each time a student takes a quiz, it will be different. This should enhance the effectiveness of the diagnostic test process.

In addition, passing the quiz will be required to pass the course. Students will have a time limit, probably three weeks, to pass the diagnostic quiz.

5. Concluding Remarks

It appears possible to move certain prerequisite material in engineering courses to a self-paced learning mode without hurting student performance. As noted previously, time saved in this way could be used either to expand topical coverage or to facilitate more thorough mastery of the

original course learning objectives. The authors favor the latter strategy.

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Bibliography:

1) Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, Chapter 2, © 2000, John Wiley & Sons.

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