Assessment of Course Objectives Achievement

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Abstract

The advantage of using a comprehensive final exam in assessing the achievement of the instructional goals of a course is discussed. A simple bar chart can readily show where there are instructional deficiencies that can be remedied in the next semester course.

Introduction

It is sometimes difficult for an instructor to determine whether the students are mastering certain critical skills of a course. Quite often so many topics are being covered in the course that the instructor cannot sort out which of these skills are being mastered sufficiently by the students. We have used a very simple method to help us quickly ascertain whether the students have mastered these skills. That method is the use of a comprehensive final exam that is essentially the same from semester to semester. In this paper we will demonstrate the utility of this simple method by way of a specific course. At the end of each semester, we construct a bar chart that readily shows whether the students are successfully absorbing these skills. This chart readily shows where the deficiencies are occurring.

The Mercer University School of Engineering offers a Bachelor of Science degree with specializations in electrical, computer, mechanical, biomedical, industrial, and environmental engineering. The degree program is a novel integrated one in which students of all specializations take the same courses throughout the first two years and several common courses in the latter two years. This emphasizes the need for interdisciplinary and team cooperation in modern engineering professions. Mechanical engineering fundamentals are covered via a two-semester sequence in the sophomore year as are electrical engineering fundamentals. Technical Communication, Engineering Economics, and Engineering Systems Analysis are courses that all engineering students take in their latter two years. This forces students from the various specializations to continually interact with each other and learn to appreciate the other specializations’ perspectives, which makes team and interdisciplinary cooperation more attractive to the students.

The course that we will use to illustrate the method is EGR 245 and is the second in a series of two courses covering electrical engineering topics that are taken by all engineering students. The first course in that sequence, EGR 244, covers basic electric circuit analysis skills and is also taken by all engineering students. Mastering the basic circuit analysis skills in the first course, EGR 244, is critical to mastering the skills of this second course. Hence the same method of assessing a comprehensive final exam is used in the assessment of the first course.

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The Course Description and Learning Objectives

EGR 245 is broadly divided into two segments. The first segment concerns an introduction to electronics and covers diodes, zener diodes, field effect transistors (FETs), bipolar transistors (BJTs) and operational amplifiers (Op Amps). The second segment concerns energy conversion and electric machines and covers three-phase power distribution (balanced wye and delta connections), magnetic circuits and Faraday’s law, transformers (ideal and actual), principles of generators and motors (Faraday’s law and the Lorentz force equation), DC motors and generators (separately excited, shunt excited, and series excited), synchronous motors and generators, and the induction motor. This course is important to all engineering specializations. For the non-electrical engineering students it represents their first and last coverage of electronics as well as electric machines and energy conversion. For the electrical engineering students, it also represents their only exposure to energy conversion and electric machines. They will, however, take several more courses in electronics; but this course serves to get their basic skills mastered, and the later courses assume this. Hence this is a critical course for all the engineering students.

The course objectives of EGR 245 are for the student to become proficient in the analysis of circuits/devices containing the following devices/components:

**Diodes:** The Shockley diode equation and elementary principles of diode physics, load lines, and applications consisting of half- and full-wave rectifiers, the bridge rectifier, AND and OR gates, and the limiter.

**Zener Diodes:** The zener diode characteristic, load line analysis and an elementary zener regulated power supply.

**FETs:** Simple understanding of the physics of the FET, determining the DC operating point of a typical FET common-source amplifier, the small-signal equivalent circuit and calculation of the AC parameters of voltage and current gain and input and output impedance. Use of the FET as a switch is also illustrated via an elementary switching power supply.

**BJTs:** Simple understanding of the physics of the BJT, determining the DC operating point of a typical BJT common-emitter amplifier, the small-signal equivalent circuit and calculation of the AC parameters of voltage and current gain and input and output impedance. Use of the BJT as a switch is also illustrated via an elementary LED light switch.

**Op Amps:** Analysis of ideal Op Amps using the virtual short circuit principle. Important applications: the inverting and non-inverting amplifiers, the summer, the buffer, the comparator and active filters.

**Three-Phase Power Distribution:** Balanced wye and delta generator and load configurations, determination of line-to-line and phase voltages and currents, determination of the average power delivered to the load.

**Magnetic Circuits:** Ampere’s law and the circuit analogue for magnetic circuits, properties of magnetic materials such as hysteresis, saturation and eddy currents, calculation of flux in simple magnetic circuits and calculation of ampere turns to establish flux in an air gap.

**Transformers:** Faraday’s law and the right-hand rule, the ideal transformer and impedance reflection, the actual transformer and its equivalent circuit, calculation of efficiency of actual transformers.
Principles of Electric Motors and Generators: Faraday's law, the Lorentz force equation, an elementary generator and motor.

DC Generators and Motors: Calculation of the field current required, back emf versus speed and field flux, torque versus armature current and field flux. Performance calculations via the equivalent circuit for separately excited, shunt excited, and series excited motors and generators.

AC Generators and Motors: The equivalent circuit and phasor diagrams showing the relation of back emf to terminal voltage and current, synchronous motor and generator performance calculations, use of an unloaded synchronous motor for power factor correction.

Induction Motors: Basic principles of operation, slip, the equivalent circuit and performance calculations using that equivalent circuit.

Methods of Presentation of the Material

The lectures were delivered via overhead transparencies. Copies of these transparencies were made available to the students at the beginning of the course. This allows the student to listen and interact in class and avoids the inefficient and time-consuming practice of having the student copy the lecture material from the blackboard. The transparencies served the purpose of highlighting the key points of the material, and the blackboard was used for illustrating details and working problems. The lecture transparency method also allowed for the coverage of a larger amount of material than the traditional method of writing the lecture materials on the board yet gives excellent retention. The key to the success of this method is to make copies of the transparencies available to the students at the beginning of the semester via, for example, placing a copy in the local copy center.

The second important instructional feature in this course was the assignment of some 3-5 homework problems every class period. These were due the next class period and served to force the students to keep up with the material. The alternative of assigning one homework set each week does not encourage the students to keep up with the course. At the sophomore level of this course, the students are forming important study habits; and it is important for us to actively aid in this maturation process.

A third important instructional technique of this course is the devotion of each period prior to a test to an active learning session for the purpose of review of the material for the coming test. At the beginning of the period prior to the test, the instructor, along with the students, choose four major categories of material that represent the material on which the students will be tested. This had the important effect of forcing the students to “distinguish the trees from the forest” so as to focus on the major concepts rather than the details. The class is divided into groups of four, and each student in each group would select one of the four major topics for his/her responsibility. Then the students would form four “expert group” sessions and prepare a brief tutorial on that topic. After 15 minutes of preparation of the tutorial, the students would reconvene with their original groups and sequentially deliver their tutorials (7 minutes each) to their colleagues. Although each of these active learning sessions consumed a valuable lecture period, it is felt that it was a worthwhile expenditure for most of the students since it forced them to think about the important principles (since they would now become the “teachers”) rather than concentrating on minituæ or details.

The Comprehensive Final Exam

The comprehensive final exam is the key to our assessment of whether the course objectives were met and the students mastered the fundamental skills. A great deal of time was spent in designing that final, and it is used in identical form in successive semesters. (The students are allowed to review their
The construction of the comprehensive final exam is critical to its success. We outlined the important, broad principles/skills/concepts that we felt the student had to master in order to be successful in the later courses. A well-designed set of course objectives is the first and most important aspect that must be constructed and considered in preparing the final. The following represented the question categories of our final examination.

Question #1: The Shockley Diode Equation
Question #2: Diodes and Load Lines
Question #3: Diode Applications
Question #4: Zener Diode Regulator
Question #5: JFET Amplifier Operating Point
Question #6: JFET Amplifier Voltage Gain and Input Impedance
Question #7: BJT Amplifier Operating Point
Question #8: BJT Amplifier Voltage Gain and Input Impedance
Question #9: Operational Amplifier Analysis
Question #10: Operational Amplifier Applications
Question #11: Three-Phase Power Distribution
Question #12: Magnetic Circuits
Question #13: The Ideal Transformer
Question #14: Faraday’s Law
Question #15: Separately Excited DC Generator
Question #16: Separately Excited DC Motor
Question #17: AC Generators
Question #18: AC Motors
Question #19: Induction Motors

The final exam was three hours in length, giving an average of 10 minutes per problem. The majority of the students finished early.

Figure 1 shows the bar chart for the Fall 97 course.
Percentage of students who scored 80% or better, Fall 97

There are many possible ways of presenting the data, but the important point to keep in mind is that their purpose is to vividly and rapidly demonstrate to the instructor which of the objectives are not being mastered so that additional emphasis may be given the next time the course is taught. We chose to display the percentage of students who scored 80% or better on the question. For example, the chart vividly demonstrates that the students were not mastering the use and concept of load lines. This was quite a surprise to the instructor since load lines are the cornerstone to the analysis of most diode circuits. The students had taken a test early in the semester that concentrated on diodes; but when they were asked (indirectly) to use the important concept of a load line to solve a diode problem on the final exam, the load line skill had apparently been lost to many of them. Several other topics such as the JFET amplifier, AC analysis, and ideal transformers and their use in impedance reflection also were problems for many of the students.

In the following semester, Spring 98, these topics were given increased emphasis. Figure 2 shows the bar chart for that final exam (which was identical to the final exam of the previous semester). The load line concept was apparently being mastered by larger numbers of students as was the JFET AC amplifier characteristics and the ideal transformer topics. However, the zener diode regulator material had suffered a drop over the previous semester. Upon reflection, the instructor understood why this occurred. In the previous semester, the zener diode regulator circuit was explained without using load lines by instead using the idea of assumed states. In the following semester, the instructor, having been sensitized to the students’ need to learn load lines, used load lines instead of assumed states to explain how the regulator works. Evidently this was not as successful a method of explaining how a zener diode regulator works from the perspective of the students (although the instructor found it more illustrative). The bar chart also shows where previously deficient topics were improved yet previously successful topics declined. Much of this reversal was caused by the instructor’s complacency about those previously successful topics.

Figure 1.

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Nevertheless, this use of a comprehensive final exam and an associated bar chart serves as a simple but vivid appraisal for the instructor with regard to what subtopics are successfully being mastered by the students and which subtopics need further emphasis and/or different presentation methods.

Percentage of students who scored 80% or better, Spring 98

Figure 2.

**Summary**

The use of a comprehensive final exam as an assessment tool was shown to be a simple tool for highlighting subtopics of a course where students had not mastered the essential skills. It is a simple and overlooked method which, when combined with a bar chart, gives immediate feedback to the instructor about the deficient areas. We have found that after many years of teaching these subjects, we tend to assume that one method of teaching a concept that is so clear to us simply isn't that useful to the students. This comprehensive final exam and the associated bar chart are relatively simple self-assessment tools that show this to us.
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