A Process for Improving Objective Examinations

John A. Gumaer
Northern Michigan University

Abstract

A process is described to assist new engineering faculty in developing effective student examinations. This process can be applied in traditional classroom instruction or web-based learning settings. An effective examination begins with a set of measurable and observable test objectives. These objectives are derived from course objectives or outcomes. The test objectives should be relevant to mastery of the course material. The cognitive skill level of the objective should also be determined. Once the objectives have been established, the actual questions can be written. Effective examinations include questions that are worded clearly, concisely, and phrased positively. All answer options should be plausible and avoid use of imprecise terms or jargon. The questions are then reviewed for test objective congruence, technical correctness, and grammatical errors. The result is an examination that provides a precise evaluation of student learning, streamlined grading, fewer arbitration issues, and support for distance or web-based learning.

Introduction

New engineering faculty usually have minimal prior experience in creating exams to effectively evaluate student learning. These newcomers typically will integrate their exam experiences as students with exam techniques used by their peers to arrive at a workable exam. The results may be unsatisfactory. Knowing a subject and knowing how to write an exam to test knowledge of a subject are two separate matters. The goals of an effective student examination are to understand student mastery of course content, minimize grading time to improve feedback ("turnaround") time, and to reduce the potential for arbitration and complaints due to student misunderstandings and confusion. An effective examination has the following characteristics[1]:

1. Samples the spectrum of important objectives
2. Measures examinee's understanding or ability to apply concepts
3. Perceived as a fair test by students successfully completing course
4. Low probability of yielding a high score for students who have not mastered the test objectives
5. High probability of yielding a high score for students who have mastered the test objectives

The examination development process described in this paper will be targeted towards objective learning since this type of learning is the focus of most engineering coursework.

The first step in creating an effective examination is to determine the test plan and objectives. The next step is to create the questions. These questions should be reviewed. During and after the exam, observation and feedback should be used to improve future examinations. Examples and tips will be presented throughout this process to illustrate the concepts. Finally, the application of this process to an engineering technology course is discussed.

Test Plan

The foundation of an effective examination is a test plan containing test objectives organized in a hierarchical manner. Each test objective should have a clear relationship with mastering a particular topic[2]. Test objectives may be drawn from course objectives or outcomes. A test objective should be measurable or observable. The objective should be relevant and important to mastery of the course material. In addition to establishing the test objective, the cognitive skill level of the objective should be determined.

Bloom has identified a hierarchy of six cognitive skill levels: knowledge, comprehension, application, analysis, synthesis, and evaluation[3]. The recall of information is classified as the knowledge skill level. The comprehension level requires understanding and interpreting information. The use of methods or concepts to solve problems characterizes the application skill level. The analysis level is defined by recognition of patterns or the organization of components. The synthesis skill level involves drawing knowledge from different areas or creating new ideas from old ones. The ability to compare choices or ideas is demonstrated at the evaluation skill level.

A sample test outline for a module in trigonometry dealing with the Pythagorean Theorem could be:

Topic 1 - Pythagorean Theorem
- 1.1 Define hypotenuse
- 1.2 Describe the Pythagorean Theorem
- 1.3 Apply the Pythagorean Theorem to determine shortest mileage between two points

The cognitive level of objective 1.1 is knowledge while that of objective 1.2 is comprehension, and objective 1.3 is application.

Question Development

Using the test plan, questions can be developed which correspond to each test objective. One or more questions may be developed for each test objective. A question is composed of a stem, correct answer, and distracters[4]. The stem is the interrogative portion, and the distracters are incorrect answers. Three common question types are multiple choice, multiple response, and true/false. A multiple choice question has a stem, one correct answer, and should have three or more distractors. A multiple response question has a stem, and two or more correct answers. A true/false question presents a statement and the option of selecting true or false. The multiple choice and multiple response question types are quite flexible and are preferred over the true/false type.

The questions should be written to the level of a minimally qualified student. The stem should be concise and worded positively[5]. Imprecise terms, slang, jargon, and Americanisms should be avoided. For multiple response questions, the stem should always identify how many choices to make. The correct answer or answers should always be correct given the conditions presented in the stem. The distractors should be plausible to a minimally qualified student. Distractors should be written with a parallel grammatical construction, length, and technical content. A uniform method should be used to order the responses to a question to avoid favoring one position or giving the impression of favoring a particular position. One strategy is to order responses from shortest to longest. In the case where responses have identical length, alphabetical order can be used. When working with responses containing numbers, the numbers should be ordered from smallest to largest. A sample multiple response question utilizing these concepts might be:

Which two of the following operating systems are supported on multiple hardware platforms?
(Choose two)
A. DOS
B. UNIX
C. MacOS
D. Windows 98
E. Windows NT

Examination Review

The final steps in developing an examination are to check each question for congruence with its test objective, and to perform an editorial review of the entire exam to correct typographical errors and grammatical mistakes. There are four aspects of test objective congruence to consider: technical, cognitive, importance, and difficulty. Technical congruence verifies that the question addresses the technical issue or topic of the test objective. Cognitive congruence verifies that the question is at the appropriate skill level. Importance addresses how critical a particular question is to understanding a given test objective. Difficulty assesses whether the question is too easy or too difficult for the minimally qualified student. Following a satisfactory congruence check, the exam should be editorially reviewed for typographical errors and grammatical mistakes.

Application

The author applied these techniques to improve exams given in a sophomore-level computer repair course during the Fall, 2001 semester. The course is structured such that there are weekly tests. In prior semesters, the questions on these tests had been short answer essay or fill in the blank style questions. The wording of the questions was fairly general and the answers given by students were equally vague. Classroom comments by students indicated some degree of frustration with the tests. The students also expressed their frustrations by giving an average 3.03/5.00 response to a question regarding the fairness of exams given in the course on the student evaluations. During the Fall, 2001 semester, the strategies discussed in this paper were applied. The students exhibited considerably less frustration with the weekly tests, and the student evaluation average jumped to 4.67/5.00 on the exam fairness question. Creating the examinations using this process required more effort, but the payoff was in an improved student learning experience and a reduction in grading effort.

Bibliography

1. Test Development Item Writing Guide, The Donath Group, 2001.
2. Design, Development, and Implementation of Examinations, Washington, D.C.:Dept. of Energy, 1997.
3. Bloom, B.S., Taxonomy of Educational Objectives, New York, NY:David McKay, 1964.
4. Kehoe, Jerard, Writing Multiple-Choice Test Items, ERIC/AE Digest, October, 1995.
5. Development of Test Items, Washington, D.C.:Dept. of Energy, 1997.

JOHN A. GUMAER
John A. Gumaer is an assistant professor of Engineering Technology at Northern Michigan University. He earned a BSEE from the University of Texas at San Antonio (1986) and a MSEE from the University of Texas at Austin (1990). He is a registered professional engineer in Michigan and has worked as a consultant in developing proprietary certification exams.