Using Pre- and Post-Tests for Course Level Assessment

Terri Lynch-Caris, Mark Palmer, and Matthew S. Sanders
Kettering University

Abstract

The pre/post-test method of assessing student learning is discussed as implemented in the Industrial Engineering Department at Kettering University. The steps for implementation as well as the outcomes expected are presented. Three steps to implementation are considered. First, a process flow model of the relationship between all courses within the department to visually characterize prerequisite courses and independent courses is developed. Second, expectations of the process within the faculty and student body is agreed upon and communicated. Third, a test bank of questions to reflect basic knowledge required to successfully complete each course is created and maintained by the faculty.

Two primary outcomes are considered using the pre/post test assessment tool. First, the pre-test information from post-requisite courses can be shared to determine how well course topics are covered and retained. Second, the post-test results are analyzed and compared to pre-test results to determine if students gained the basic knowledge required to complete the course satisfactorily. The pre/post test assessment tool is discussed relative to a larger course level assessment methodology to be proposed university-wide.

Introduction

The pre-test and post-test process is one assessment tool used to tap into students' prior knowledge and to evaluate how well they have learned material in a given course. This process is used as an assessment tool in many educational applications. The purpose of this paper is to demonstrate the process for setting up this assessment tool in the Industrial and Manufacturing Engineering Department at Kettering University

Background

The well-known educators book "Classroom Assessment Techniques" describes the Background Knowledge Probe (Angelo, 1993, pg. 121) as a means to help instructors determine the most appropriate level at which to begin instruction. The authors propose sampling the students' background knowledge before formal instruction on that topic begins. The Background Knowledge Probe provides feedback on the range of preparation among the students in a particular class. They further describe this Background Knowledge Probe to be used as pre- and

post-assessments: before instruction, to find out the students' "baseline" knowledge level; and immediately after, to get a rough sense of how much and how well they have learned the material. Some examples of educational institutions that utilized and documented their existing pre-post test process will be described in the following paragraphs.

One example of the pre-post test process is at The Arizona State University (Arizona, 2003). They used the pre-test and post-test scores as a means to assess a Physics Course. Assessment takes place immediately after the pre-test is given to determine the students' strengths and weaknesses. A second assessment is based on conducting a t-test on pre- and post-test scores. This can serve as evidence of achievement for the student. A second example is The Paradise Valley Community College (Paradise, 2003). They promote pre-post testing as a method for measuring the value-added by a program of study. A third example occurs in the elementary through high school educational process. The Los Angeles County Office of Education documents their process as it relates to K-12 education in their website.

The authors assume that other educational institutions are also using the pre-post test process without documenting their experiences. This paper clearly describes the pre-post test process used within the Industrial Engineering Program at Kettering University as a means of measuring learning in the undergraduate experience.

Objectives

The pre-post test process has two primary objectives. First, the pre-test can be used to assess knowledge retained from prerequisite courses. Second, when used in conjunction with a post-test it can be used to assess learning in a current course. This paper addresses both objectives along with other benefits that result from the process.

This pre-post test process has been used in the Industrial and Manufacturing Program at Kettering University since 2002. Prior to 2003, the Industrial Engineering faculty was separate from the Manufacturing Engineering faculty. The different programs developed different means to assess learning in their respective courses. Both faculties used the pre-test to assess learning, or retained knowledge from prerequisite courses. The Industrial Engineering faculty also used a post-test to assess learning within a given course. The lessons learned from the two faculties resulted in a stronger overall process when merged together. The extensive assessment process was an important part of the successful ABET visit and full accreditation received in the fall of 2003

Setting up the Process

Pre-post tests are one of the course level assessment tools, which were identified by the faculty of Industrial Engineering at Kettering University to be used to measure the effectiveness in achieving specific Industrial Engineering Program Outcomes (POs), Program Educational Objectives (PEOs), and Course Learning Objectives (CLOs). The pre-post test assessment tool includes questions from prerequisite material and from the content covered in the course. Such a method not only tracks learning within a given course, but also tracks student learning longitudinally through the program.

Team Leader and Faculty Agreement

To initialize the process, one faculty member was designated as leading the assessment effort. As the ABET visit approached, an assessment team was established. In addition, the entire faculty had to agree and contribute to the process. Creating the test bank described in the following section took individual effort for each course. The faculty assessment leader in conjunction with the department secretary organized and maintained course binders and was ultimately responsible for the success of the program.

Prepare a Test Bank and Identify Prerequisite Courses

Faculty debated and agreed that a minimum of ten questions, with an understanding that no more than twenty questions would be included in the test bank to be used in both pre- and post-tests. Furthermore, faculty agreed to have 100% of the post-test questions come from the subject matter covered in the current course. At least five of the pre-test questions are to cover the subject matter from prerequisite courses and the other questions are based on the subject matter of the current course. All of the pre-test questions from the current course will be repeated on the post-test with additional current course questions added as desired.

The distribution of questions from the prerequisite courses is based on the number of prerequisite courses. Faculty discussed the relative significance of each prerequisite course for a given course and they agreed on the percentage/number of questions that need to come from each of those courses. For example, if a course has two prerequisite courses, 25% of the pre-test questions come from one of the prerequisite courses, 25% from the other prerequisite course, and the other 50% from the current course. To accomplish this and be consistent, test banks were needed for each course. As mentioned previously, a minimum of ten questions and as many as twenty questions, with correct answers are included in the test banks designed for each course.

The decision was that each faculty member was to design a test bank for the courses that they usually teach. Therefore, for some courses such as probability and statistics, which are taught by more than one faculty, there were more than one set of test banks. Note that the pre- and post-test tool used in 1st year courses was inappropriate because no prerequisite courses exist. Each of the following examples illustrates the concept known as Test Bank Instructions.

Industrial Engineering Example

The following example shows the pre-test and post-test test bank contents for an Industrial Engineering Course IEN333. As Figure 1 shows, the pre-test for IEN-333 has a minimum of 10 questions where five questions are from the only prerequisite course (IEN-332) test bank and the other five questions are from the current course (IEN-333) test bank. At the end of the term students are given a post-test. The post-test for IEN-333 has a minimum of 10 questions from the IEN-333 test bank where five of those questions are the same questions that were given on the pre-test. Post-test questions are concepts that students are expected to know by the completion of the course.

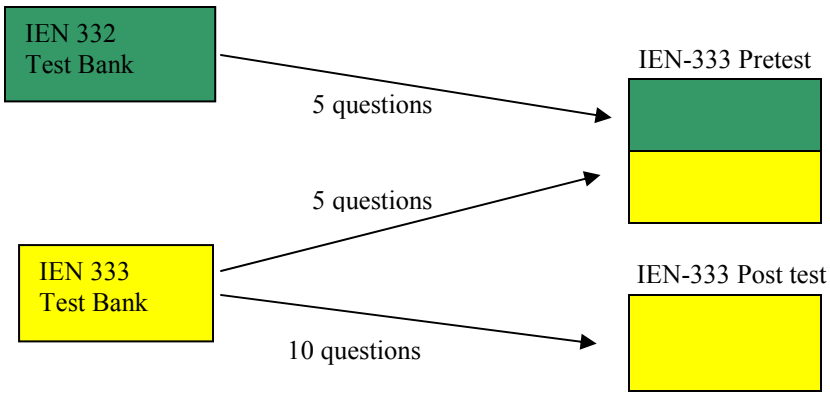

Figure 1: Instructions for IEN-333 Test Bank

Figure 2 shows a course with five prerequisite courses with the distribution of the minimum of the questions from each of prerequisite course test banks. It is appropriate to mention that if a faculty member decides to have more than 10 questions for the pre-test, the number of questions from each prerequisite course should be increased proportionally. It is also appropriate to state that a faculty member assures his/her students that neither pre-test nor post-test will harm their course grade however he/she encourages them to answer the question to the best of their ability.

Manufacturing Engineering Example

This second example illustrates how the pre-post test process was used in a Manufacturing Engineering Course. The pre-test is given to students on the first day of class and does not count as part of their grade. The faculty grades the test and the results are conveyed to prerequisite course instructors so they can make immediate use of it.

At first the individual instructors developed their own questions. For example, an instructor teaching Sheet Metal Forming (MFGG-403) would ask a series of questions based on Engineering Materials (MFGG-370), which is a prerequisite. The faculty teaching Engineering Materials made use of this information.

In some cases, it was determined that more emphasis had to be placed on certain course topics, such as stress-strain curves. When assessing how well the course learning objectives were met this was taken into account. Even though grades and student comments indicated that this topic was well covered in Engineering Materials, the instructors did not claim the highest satisfaction level because of this feedback. In another instance it was determined that certain subject matter assumed to be covered in the prerequisite course was not covered, “normal strain”, is not discussed. This communication made it clear that the post-requisite course instructor could not write accurate questions without consulting with the instructors of prerequisite courses. At the same time another instructor’s approach was discussed. One instructor, simply used questions from another instructor’s final examination. During discussion, it became clear that this was not considered to be the best approach, as certain questions had nothing to do with the post requisite course.

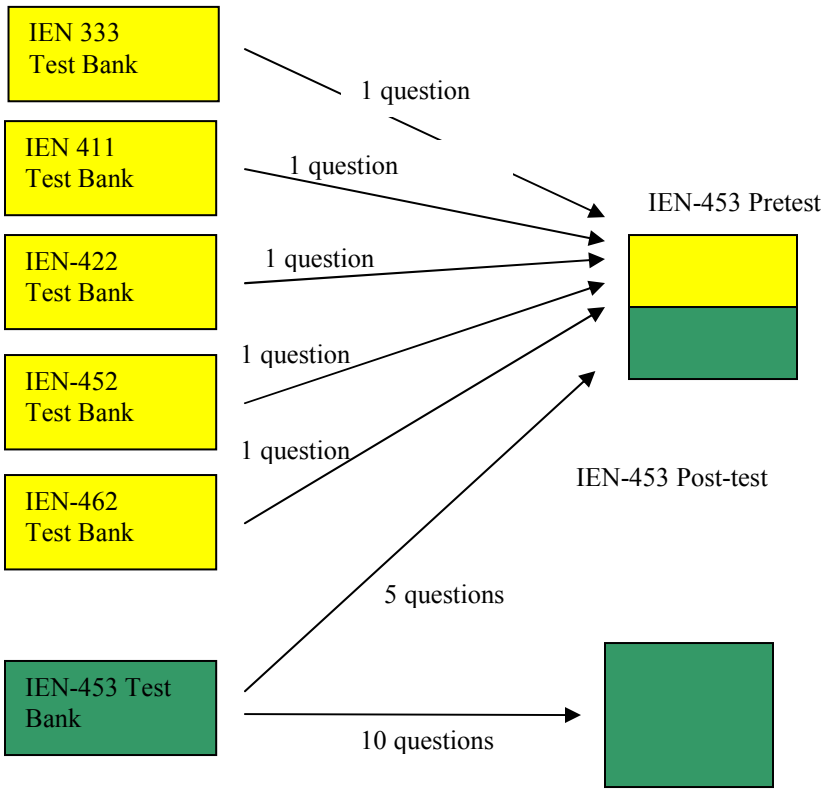

Figure 2: Instructions for IEN-453 Test Bank

By the end of the first year, it was determined that the pre-test questions should be written by the post requisite course instructor and should reflect the information required for the post requisite courses. For example, although ceramics are covered in Engineering Materials it would not be appropriate for the instructor of Sheet Metal Forming to ask about this topic.

Analysis of Objectives

There are two primary objectives stated for the pre-post test process. First, the pre-test can be used to assess knowledge retained from prerequisite courses. Second, when used in conjunction with a post-test it can be used to assess learning in a current course.

Assess Knowledge Retained from Prerequisite Courses

By reviewing and grading the prerequisite concepts from the pre-test, the instructor can quickly get a feel for the retained knowledge of the class. This information allows the instructor to immediately review necessary prerequisite concepts that were not retained to avoid "losing" a class of student who don't understand the basic concepts before moving on to more advanced concepts. As an alternative to reviewing prerequisite concepts and taking up precious class time, the instructor may offer references to the students for outside study.

A secondary benefit is that the current course instructor can feed back information to the instructor of the prerequisite course. The pre-test gives a quantitative and qualitative assessment of students' knowledge in the prerequisite course. The prerequisite instructor and the current course instructor have a meaningful dialogue about the concepts that the students should be learning in the prerequisite course in order to be successful in the current course.

There is a secondary benefit of putting current course content on the pre-test. The instructor not only can assess retained knowledge from the prerequisite course, he/she can also assess the extent of current course knowledge that the student is bringing into the class. This may foster a depth of coverage in a known topic and allow rich classroom discussion on well-understood concepts.

Assess Learning that Occurred in the Current Course

Since at least 50% of the pre- and post-test questions are identical, pairing the questions makes a perfect case for using a t-test as a statistical analysis method. The paired t-test is only appropriate for comparing the questions from the pre-test that were also asked on the post-test. A significant increase from pre-test to post-test demonstrates that learning occurred. Any additional questions on the post-test simply add credibility and additional assessment to learning that occurred in the course.

As an example, during the summer term 2002 in IEN462, ten questions were given on the pre-test from the current course at the beginning of the term. The same ten questions were repeated on the post-test at the end of the term. The fourteen students in the class were informed that these tests have no effect on their grades. Students did not know that they would have the same questions on both tests. The results are tabularized in Table 1 below with the addition of their final grade in the course. Note that Kettering uses a 100-point system for grading.

Table 1: Pre- Post-Test Scores and Final Grades for IEN462 Summer 2002

Student	Pre-Test	Post-Test	Final Grade
1	45	85	88
2	60	95	90
3	45	90	89
4	30	90	92
5	55	100	82
6	60	90	93
7	70	90	84
8	30	70	86
9	60	85	89
10	55	100	79
11	40	85	91
12	45	75	85
13	65	100	91
14	70	100	97

As Table 1 shows, the entire class scored higher on the post-test than they did on the pre-test. The average difference was 37.5 points. This shows quantitatively what one would expect after completing a course in a given subject. The paired t-test results shown in Table 2 provide evidence of statistical significance that there is a difference between the pre-test and post-test scores. An attempt was made to correlate final grades with post-test scores. The resulting scatter plot is shown in Figure 3. Unfortunately, a significant correlation was not shown to exist.

Table 2: Summer 2002 IEN462 Pre- and Post-Test Scores

t-Test: Paired Two Sample for Means

	Pre-Test	*Post-Test*	Difference in means
Mean	52.14	89.64	37.5
Variance	175.82	86.40	
Observations	14	14	
Pearson Correlation	0.63		
Hypothesized Mean Difference	0		
Df	13		
t Stat	-13.58		
P(T<=t) one-tail	2.34E-09		
t Critical one-tail	1.77		
P(T<=t) two-tail	4.67E-09		
t Critical two-tail	2.16		

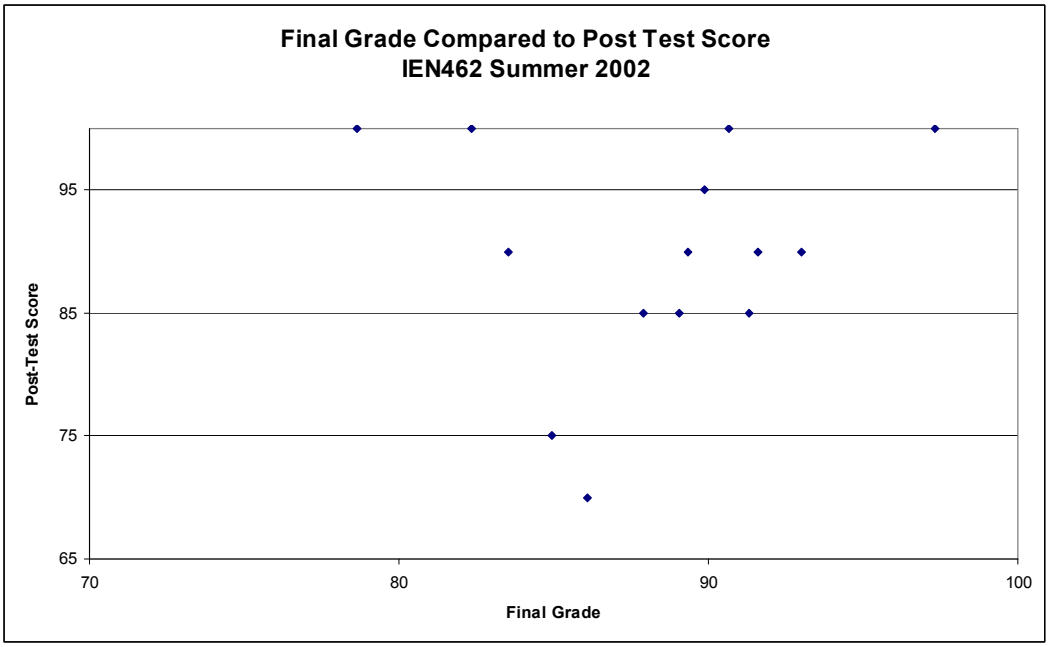

Figure 3: Scatter Plot of Final Grades to Post-Test Scores

Conclusions

Recent changes in accreditation requirements mandate that programs demonstrate that their students achieve certain outcomes. At the course level this means assessing student learning. The course assessment process is not yet fully developed however prior to the ABET visit it was recognized that information beyond grades and student comments were needed to assess student learning.

The pre-post test process is a first step towards assessing student learning within a course. The extension and analysis of prerequisite concepts taken throughout the program can give a picture of student learning throughout the curriculum. The two primary objectives of this process were demonstrated as they relate to the Industrial and Manufacturing Engineering Curriculum at Kettering University. First, the pre-test can be used to assess knowledge retained from prerequisite courses. Second, when used in conjunction with a post-test it can be used to assess learning in a current course.

Bibliography

1. Angela, Thomas, and Cross, Patricia (1993). Classroom Assessment Techniques – second edition. Wiley & sons, Pg. 121.

2. Arizona State University – Larry Dukenich (12/09/2003) Modeling Instruction Program [online]. Available: http://modeling.asu.edu

3. Paradise Valley Community College (10/20/2003) Pre-Post Testing [online]. Available: www.pvc.maricopa.edu/AI/PrePost.html

4. Los Angeles County Office of Education (2001) Student as an Historian Pre-Post Assessment Tool [online]. Available: teams.lacoe.edu/documentation/classrooms/angie/historian/pretest/sd01.html)

Biographies

TERRI LYNCH-CARIS is an assistant professor of the Industrial and Manufacturing program at Kettering University. Dr. Lynch-Caris received her Ph.D. from the University of Michigan, MS degree from Purdue University, and BS degree from Kettering University (formerly known as GMI). Dr. Lynch-Caris teaches a variety of industrial engineering courses including ergonomics, methods, simulation, and statistics.

MARK PALMER, P.E., is an assistant professor of Industrial and Manufacturing program at Kettering University. He previously served as Assistant Professor of Mechanical Engineering at Virginia Commonwealth University. Dr. Palmer's research interests include electronics manufacturing particularly the development and characterization of new joining materials, and his teaching activities focus on incorporating active learning in courses and assessment.

MATTHEW S. SANDERS is an associate professor of Industrial and Manufacturing Engineering program at Kettering University. He received his Ph.D. from Texas Tech University and both BS and MS from Indiana State University. He led the Industrial Engineering Program assessment activities for 2003 ABET visit. His interest is in systems management and systems design and has extensive consulting experience in cost related projects.