Study of Pre- and Post-Test Surveys in an Engineering Economy Course

Simon T Ghanat, Dimitra Michalaka and James Grayson
The Citadel

Abstract

This study examines the pre- and post-test data from two class sections of Engineering Economy taught in a 2016 compressed summer term at The Citadel. A background knowledge probe (pre-test) and course knowledge survey (post-test) were developed based on key concepts in engineering economics to assess the knowledge gained over the course of the summer term. The pre-test was administered to measure student's prior engineering economy knowledge and to identify student misconceptions at the beginning of the term. The same short-answer test (post-test) was administered on the last day of semester to assess knowledge gained as a result of the course experience. Statistical analyses were performed using the collected data. The results show that the students gained significant understanding on the various concepts in engineering economy over the course of the summer term. Additionally, the pedagogical approaches used in the classes and how they were applied in the classroom are discussed.

Keywords

Pre- and Post-test, Engineering Economy.

Engineering Economy Summer Course

Students who take the summer course of Engineering Economy at The Citadel must learn course material during a compressed summer time frame. In addition, the student population of summer classes differ significantly from those in the fall and spring. The student population can be composed of both cadet and evening, full and part-time, active duty students, veteran students, Civil and Electrical Engineering students and many have just transferred from a two-year technical college to a four-year institution. Engineering economy is required of students in both the Civil and Electrical Engineering programs. Students in the evening program may only take engineering economy during the summer term. For the day program, engineering economy is offered during the fall semester, but these students may also register for the course in the summer.

During the fall, Engineering Economy classes are taken primarily by members of the Corps of Cadets. A relatively small percentage of the classes are occupied by active duty or veteran students who take day classes with the Corps of Cadets. Evening classes are populated with students who live in the community, many of whom work full or part-time. Some veterans or active duty students may be included in the evening classes. Veterans that have been approved for Day status may also attend evening classes in the fall and spring.

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Learning Tools used in Engineering Economy

In the first section of the Engineering Economy course, a wide variety of learning tools were employed to improve the student learning environment. The learning tools used included: pre-class reading responses on the course website, applying learning objectives to real life problems (i.e., credit card statement, mortgage, amortization schedule, students' loan worksheet), weekly case studies, daily individual and team quizzes, daily assignment directly linked to the course objectives, daily presentation of homework by the peers, small group problem solving and discussions, active lecture notes that include blanks to record the key points as student follow along in class, reflective dialogue at the end of each class.

Web-based pre-class reading responses[1] were used to motivate students to prepare for class regularly. Students were required to respond to one or two open-ended questions on the course website prior to each lesson. Before each lesson, student responses were examined, and the in-class activities were tailored to meet their actual needs[1]. Frequently, clickers were employed to assess the understanding of engineering economy concepts, create an environment to engage students, and provide immediate feedback to both students and instructor[2]. At the end of each lesson, the One-Minute paper[3] or Muddiest point paper[4] was used to monitor student learning and address students' misconceptions and preconceptions. Students were typically asked to write a concise summary of the presented topic, write an exam question for the topic, or answer a big-picture question from the material that was presented in the current or previous lesson in 60 seconds. Before each class, a song about money from a list of money all-time greatest hits was played to stimulate learning and to get the student excited about the subject matter, cash flow diagrams were drawn on the board by using real money and magnets to illustrate the applications of different interest factors, the learning objectives were written on the board and also projected on the on an overhead projector[2].

Each lesson started by recap of the key concepts and by addressing the muddiest points from previous class. Next, students selected at random were asked to present the solutions to the homework problems to the peers. Students were then given daily quizzes (both individual and group quizzes) on the assigned reading for the day and the homework just turned in. After a main point was presented, one of following student activities was employed: Think-Pair-Share, small group problem solving, Brainstorming, Case studies, Debates, Subject summary exercise Students were also asked to write a test question related to one of the learning objectives with correct answer key (open response or multiple choice format) that could appear on the final exam. The best question was included on the final exam and student whose question was chosen also earned extra credit.

To review for the mid-term exams, Jeopardy-style questions were used, which required students to display mastery of key Engineering Economy concepts that goes beyond simple memorization. Category topics for the Jeopardy game included: time value of money, capitalized costs, depreciation, internal rate of return, and benefit-cost ratio. To review for the final exam, students were asked to create engineering economy crossword puzzles in their collaborative groups. Once constructed, the puzzles had to be solved by other groups in the class. The use of the games in the course truly encouraged students to take a greater degree of responsibility for their learning [6,7].

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In the second section of the Engineering Economy course, students were introduced to the course materials through several learning techniques which were proved (based on the pre- and post-survey) to have helped students understand the course material. A set of learning objectives were given to students every time a new topic was introduced. Some examples of learning objectives are: "Apply the arithmetic gradient present worth factor (P/G) to convert an arithmetic gradient G for n years into a present worth at year 0"; "Find the rate of return of an investment"; "Compare projects using the Benefit/Cost Ratio" and "Draw cash flow diagrams." Two-to-five objectives were given per class period. The concept of clearly presented learning objectives was adopted from the ExCEEd[8] Teaching model (X) because it has been proven that they facilitate the appropriate level of student achievement. Regarding the introduction of new concepts, simple examples were used as the main teaching pedagogy. For example, "time value of money" was presented using two different situations of depositing money and withdrawing a certain amount of money from an account after a number of years. When solving that problem, the concept was emphasized to make it relatable to the students. Short definitions of concepts and related equations were also written on the board so students had complete notes to study after class. After the introduction of a new concept through one or more examples, students were asked to solve problems themselves, of course, with the help of the professor or other classmates if needed. The majority of the class, about 90%, was spent in solving problems. No PowerPoint presentation was used in the course. Homework assignments were given to the students regularly, as well. Students were required to solve 8-10 problems per week. Complicated concepts and methods were taught not only by examples, but also by giving students step-by-step implementation of the concept/method and fill the blank exercises. For instance, the professor gave students several real loan examples with different amortization time periods and interest rates and students were asked to pick which of them they would have selected based on their financial situation. It should be noted that students did not have to share personal information about their finances if they were not comfortable doing so. Since class participation was crucial with the way the class was executed, 10% of the course grade was attributed to class attendance, participation and professionalism, and 10% to in-class quizzes. The remainder of the course grade was calculated based on homework (20%), and three exams (two, mid-term exams, 15% each, and one final exam, 30%).

Assessment Measure

A six-question pre- and post-test was developed based upon the key concepts in engineering economy course (see Table 1). The pre-tests were administered to measure students' prior geotechnical knowledge and to identify student misconceptions at the beginning of the semester. The same short-answer test was administered on the last day of the semester to assess knowledge gained as a result of the course experience. It is important to note that neither the pre-test nor post-test counted toward the course grade.

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Table 1. The short-answer questions on the pre- and post-test

Question 1	How do time and interest affect money?
Question 2	What is the meaning of the rate of return?
Question 3	What is the difference between APR and APY?
Question 4	What evaluation method is used to select between public sector alternatives with unequal lives?
Question 5	What is capitalized cost?
Question 6	What is the difference between tax depreciation and book depreciation?

Figures 1-2 illustrate the distribution of the pre-test and post-test scores for the students in this study (n =43), respectively. The pre-test scores ranged from zero to four out of six possible points. Fifty-eight percent of students scored zero or one on the pre-test. Ten percent of students scored a three or four on the pre-test. The results of the pre-test indicate that the students are entering the introductory engineering economy course with little prior knowledge. The same short-answer test in Table 1 was administered on the last day of semester to assess knowledge gained as a result of the course experience. The mean increased significantly from pre- to post-test and the standard deviation dropped slightly, indicating less scatter in the-admittedly-improved post-test results.

Statistical analysis was conducted on the pre-test and post-test data to detect changes in students' understanding of the concepts over the course of the semester. Comparison of the pre- and post-test scores was completed using the paired t-test at five percent level of significance, and the results are shown in Table 2. The difference between the means was statistically significant for each section and both sections combined, showing substantial improvement from pre-test to post-test at five percent level of significance. The results showed that there was a significant difference in scores for pre-test and post-test. There was an increase from an average score of 1.42 out of 6 points equivalent to 23.67 % on the pre-test to an average score of 5.09 out of six points equivalent to 84.83 % on the post-test (mean paired diff = 3.67, SE = 0.16; t (42) = 20.57, p-value < 0.001) for both sections of engineering economy (see Table 2). The difference between pre- and post-test means was statistically significant ($p < 0.001$), revealing substantial learning gain.

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Table 2. Results of Paired-t test

		Pre-Test		Post-Test				
Section	N	Mean	St Dev	Mean	St Dev	Mean Diff	t	p-value
Section 1	26	1.23	0.86	5.31	0.55	4.08	23.07	<0.001
Section 2	17	1.81	0.83	4.88	1.17	3.07	9.7	<0.001
All	43	1.42	0.91	5.09	0.87	3.67	20.57	<0.001

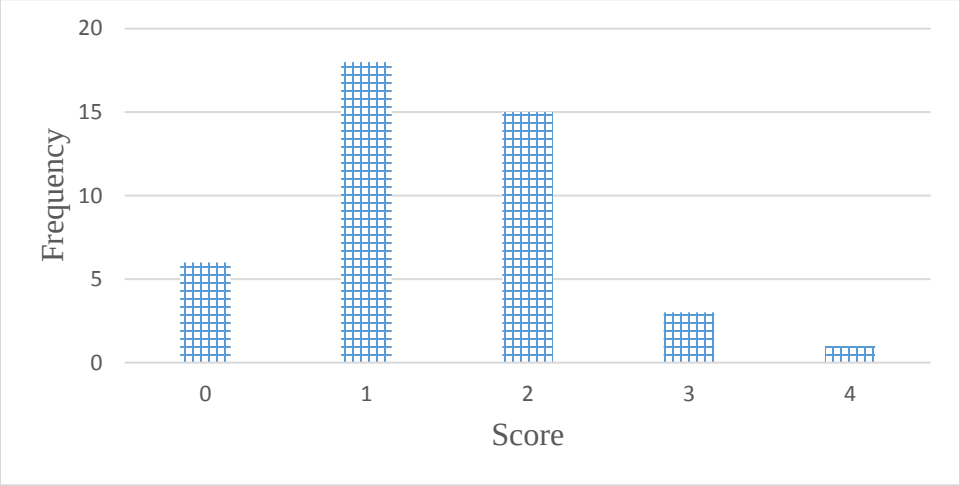

Figure1. Distribution of the pre-test scores

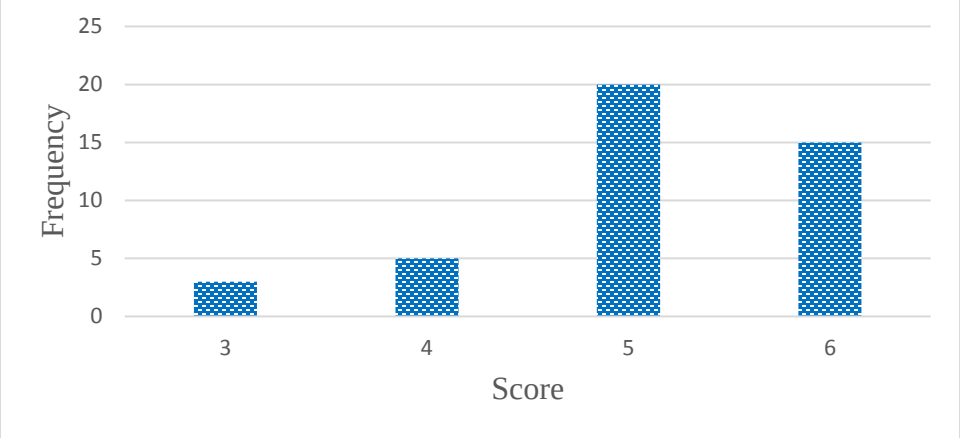

Figure 2. Distribution of post-test scores

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Conclusions

Students entered the introductory Engineering Economy course with little prior knowledge. Regardless of pedagogical techniques, students experienced significant gains in conceptual understanding of Engineering Economy concepts during the course. The difference between the means of pre-test and post-test was statistically significant, showing improvements from pre-test to post-test. There was an increase from an average percentage correct of 23.67 on the pre-test to an average percentage correct of 84.83 on the post-test. The pre-test to post-test changes in overall scores was influenced by the various pedagogical techniques used in both economic sections in this study.

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Simon T. Ghanat is an Assistant Professor of Civil and Environmental Engineering at The Citadel in Charleston, South Carolina. He received his Ph.D. in Civil Engineering from Arizona State University (ASU). Dr. Ghanat's research interests are in Engineering Education and Geotechnical Earthquake Engineering. He previously taught at Bucknell University and ASU.

Dimitra Michalaka, PhD

Dr. Dimitra Michalaka is an Assistant Professor of Civil and Environmental Engineering at The Citadel. Dr. Michalaka received her undergraduate diploma in civil engineering from the National Technical University of Athens (NTUA), after which she entered into the transportation engineering graduate program at UF. She graduated with a Master's of Science in May 2009 and with a Ph.D. in August 2012. Her research is primarily focused on traffic operations, congestion pricing, traffic simulation, and engineering education.

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