Enhancing Students' Learning Experience Using Case Studies

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Introduction

One tool commonly discussed in an engineering economic course is decision tree analysis. This tool is used to help apply costs to a probabilistic event to determine the likely overall costs that may occur given a series of options. This is an important concept for our students to learn since they will need to be able to determine the likelihood of an event's occurrence along with the possible costs that those events will incur. As academics, we often test our students' understanding of these concepts through testing during the semester. This paper looks at this evaluation method and discusses an incident that has led us to question how we teach this concept to our students.

For our specific incident, faculty and students from the Engineering Technology department at Tarleton State University (TSU) were asked to participate in a mass casualty simulation. Because of the courses we teach, the Engineering Technology Department was interested in the simulation and in performing a cost analysis of the simulation. In this particular simulation, the students evaluated the likelihood of different types of injuries that would occur and costs associated with the different types of treatments. What we found was that the students had a hard time understanding how they could account for the different types of injuries and costs. This caused this part of the project to be protracted while the students were retaught materials they were presumed to have already known.

As stated before, cost analysis is an important element of engineering economic analysis of alternatives because decision-making happens based on this information. Thus, this paper introduces the use of a simulation of an event with the purpose of helping students understand the economic analysis of the possible alternatives that may occur. Previous to the simulation, students were taught probabilistic events during their engineering economics course but the students did not feel that they completely understood how to perform analysis and with what costs. Therefore, it is expected that with the use of real time and resources, the simulation can help build the bridge between theory and practice by helping students identify the most likely costs that would occur in specific situations. The traditional method of teaching involves classroom instruction of theory and then reinforcement of this by solving problems. However, this method has been long recognized to fail to provide the link between the theory and practice. This paper describes the use of a simulation that occurs in real time and consumes resources, where cost analysis was performed using the decision tree analysis tool.

Background

The case teaching method has been used in engineering since the 1970s; however, very few cases are ready to be used in the classroom for faculty. [8] The traditional method persists; the teaching scenario in engineering economy is introduction of theory and problem solving. This traditional method happens when the instructor introduces theoretical concepts and then illustrates the applicability of those to classroom problems. In the process, the inability to demonstrate the link between theory and practice results in a gap between theory and practice. In their paper, Raju and Sankar (1999) reported that the ""Lectures by telling" is the traditional and most widely-used mode of instruction in engineering colleges."

Arguments about advances in teaching engineering can be found in the literature. Spreadsheets, simulations, and cases are often mentioned as method to improve students learning. Needy, Nachtmann, Lavelle, and Eschenbach (2000) published results of a two year study to learn about the status of the teaching of engineering economy in engineering while finding evidence of spreadsheet, project, and case teaching amongst those involved in the survey. However, the "lack of focus in real-world problem" remains in the areas of science, technology, engineering, and mathematics [10]. Hartman (1999) recounts that the that efforts for improving the teaching of engineering economy and more specifically cost analysis have not been advancing and that represents a disadvantage for students that will face economic decisions in real world problems. He offers suggestions for teaching engineering economy at the undergraduate level and discusses the importance of cost analysis and evaluation of alternatives.

In their research, Prince and Felder (2006) classified the different teaching methodologies as deductive and inductive. Deductive relates to the traditional lecturing way whereas the inductive manner involves exposing students to scenarios of real situations where the student needs to solve a problem. Case-based teaching falls within this category [6]. Hackney, McMaster and Harris (2003) in their research explain the one common method to teach in their area is by using cases. Moreover, case teaching has proved to be greater than traditional lecture [4]. In their research, they explore several cases used to teach in information systems. They argue that case use in the classroom provides students the opportunity to develop "high-order reasoning skills." Additionally, these authors also support the concept of using cases in classroom because "students can get involved and can learn by doing."

Methodology and Results

Decision analysis theory is covered during an engineering economic analysis course. The course is offered to students in their second academic year and for this study, 20 students were involved. The typical course content for a one semester is listed in Table 1.

Table 1 List of Topic Covered in the Engineering Economy Course

Topic
Intro to Making Economic Decisions
Engineering Costs and Cost Estimation
Interest and Equivalence
Equivalence For Repeated Cash Flows
Present Worth Analysis
Annual Cash Flow Analysis
Rate of Return Analysis, Review
Other Analysis Techniques
Uncertainty In Future Events – Decision Tree Analysis
Depreciation
Accounting and Engineering Economy

Students were asked to answer a series of questions twice. First, students were exposed to the decision tree analysis and then asked to solve numerical problems. After students were exposed to the theory and numerical problems, they were asked to respond through a survey the first time. A week later, the group was introduced to the simulation case and then asked for a second time to provide responses to the same survey. The scale used is 1 through 5 ranging from 1 as strongly disagree and 5 as strongly agree. We must however mention that the scale used provides only an understanding of the possible differences between the values obtained in the before and after surveys. We cannot really measure by how much between the two choices, for example, what the difference was that they perceived between agree and strongly agree. Table 2 shows the questions asked and provides means to the responses to the before and after. Figure 1 displays the mean responses and Figure 2 displays the standard deviations.

Table 2 Mean Responses of Students to Survey

Question	Before Mean	Before Std. Dev	After Mean	After Std. Dev	P-values Alpha =0.05
1. I have no idea how to use what I learned in class given a real situation.	2.15	0.79	2	0.89	0.624
2. If given the narrative of a case, I can identify the data.	3.75	0.54	3.85	0.73	0.629
3. If given the narrative of a problem, I know how to use the data.	3.65	0.85	3.65	0.65	1
4. I can define the correct tree diagram.	3.7	0.71	3.75	0.7	0.833
5. I can describe each alternative.	3.5	0.74	3.9	0.62	0.088
6. I can correctly determine the probabilities associated to the different alternatives.	3.6	0.92	3.9	0.62	0.229
7. I can correctly determine the present worth value associated with each of the alternatives.	3.9	0.7	3.75	0.89	0.577
8. I can calculate the expected value of the problem.	3.8	0.87	4.1	0.77	0.300
9. I can explain and interpret the expected value outcome.	3.35	0.91	3.9	0.94	0.102

N=20

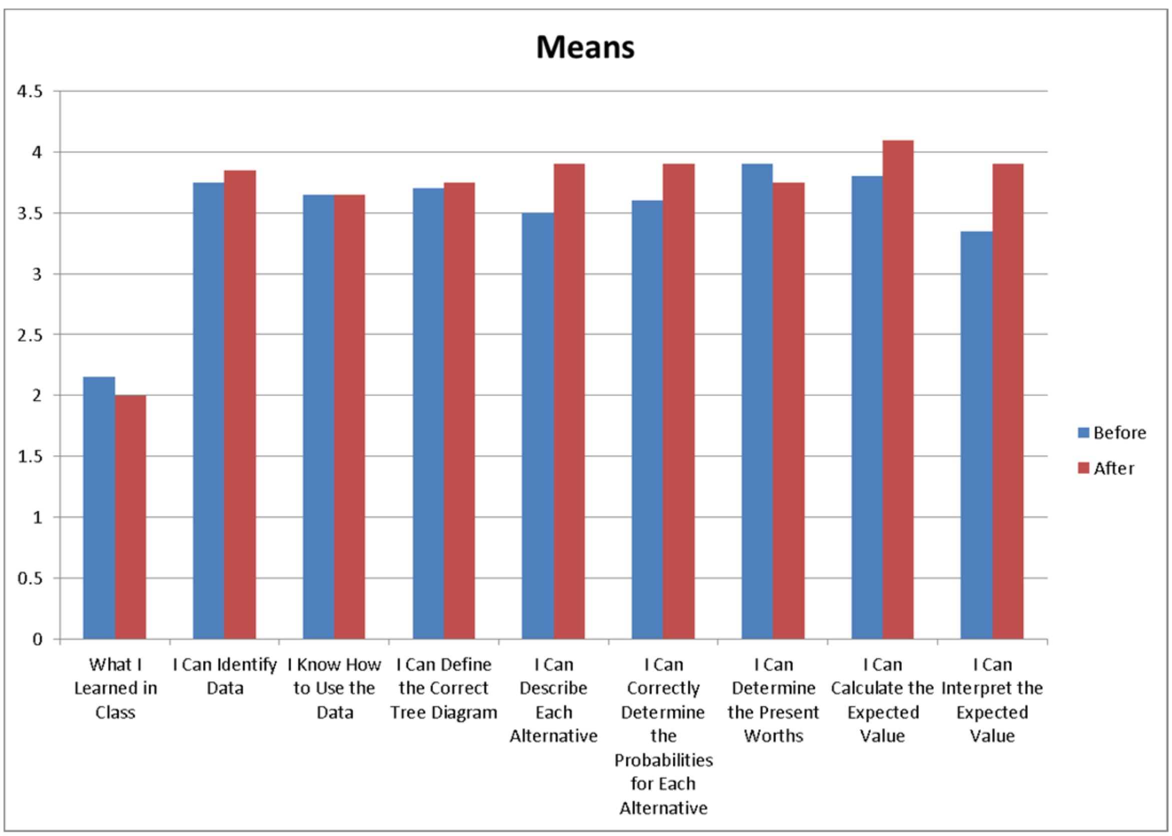

Figure 1 Mean Response to Survey Questions

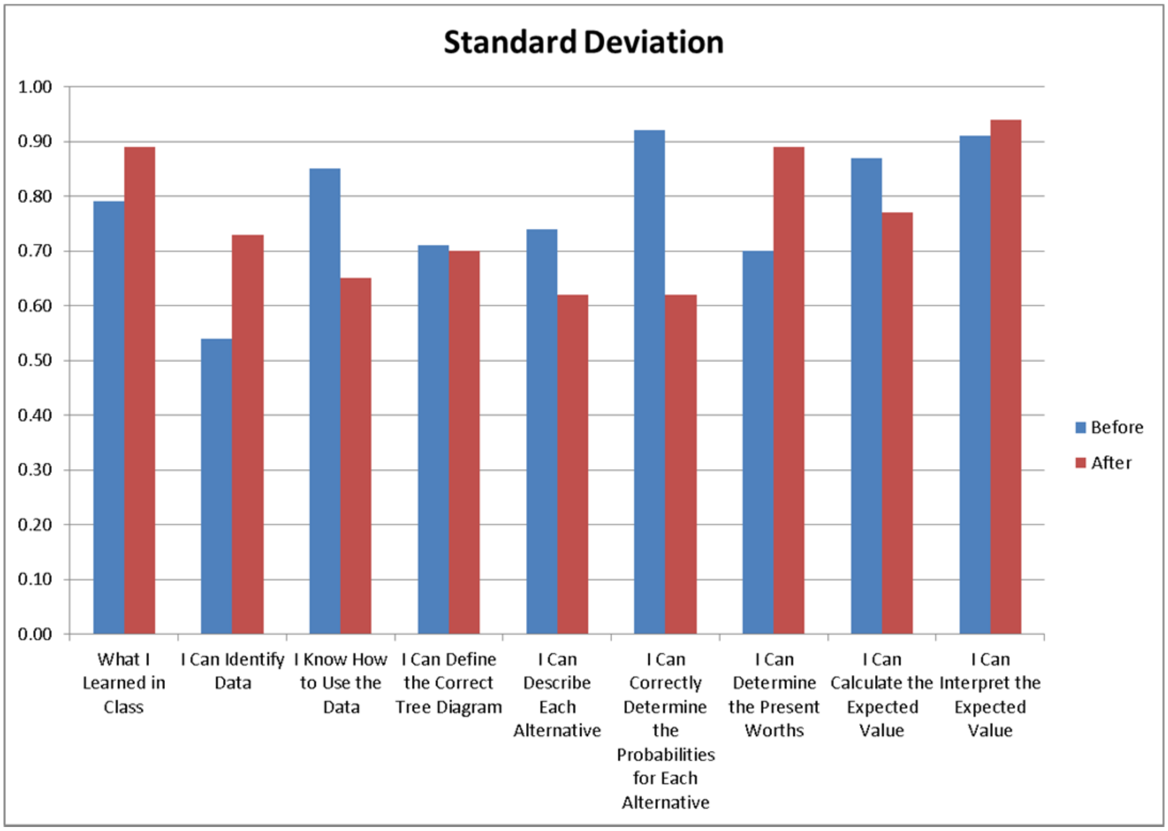

Figure 2 Standard Deviations for Each Survey Question

Analysis

To perform our analysis, we looked at both the mean of the students' responses as well as the range of the responses. Each was evaluated individually and then re-evaluated together. The mean of the responses from before and after moved primarily in the direction that we had hoped they would. The mean for question 1 decreased from 2.15 to 2.0. This means that on average, the students felt better about how to use the tool in real life. With the exception of question 3, which had the same mean before and after the case study was implemented, all of the remaining responses improved. This leads us to believe that the students felt more comfortable that they could utilize decision tree analysis if presented with a similar problem in real life.

There were several responses in which we found that the standard deviation is smaller after teaching with the case study. These responses included the students knowing how to use the data, the students' ability to describe each alternative, the students' ability to correctly determine the probabilities for each alternative, and the students' ability to calculate the expected values. The standard deviation of the responses for defining the correct tree diagram and interpreting the expected value were similar after teaching with the case study. Lastly, the standard deviations for the responses for what students learned in class, students can identify data, and determining the present worth grew larger after teaching with the case study.

As both the mean and their standard deviations for the responses are evaluated, we can see what the perceived impact of the case study was for the students and for the class. For question 1 the standard deviation indicates that there are students who did not feel that they could actually use the tool. The strength of the mean shows that the class, taken as a whole, felt that they could use this tool in the real world. Evaluating all of the other questions shows that, in general, all of the students felt that they understood the materials better after the case study than they did before.

Though it was felt that the surveys showed a positive change in how the students learned the material, it was decided that statistical testing should be performed to determine if the perceived changes in the students' views of the materials were real. A paired-samples t-test was conducted to compare the means for the students' responses. It was determined from this test that there was not a significant difference at $p \leq 0.05$ in the scores for the responses before the students were exposed to the case ($\mu = 3.4$, $\sigma = 0.49$) and after the students were exposed to the case ($\mu = 3.64$, $\sigma = 0.59$); $t(8) = 1.901$, $p = 0.094$. The p-value obtained for each question displayed in table 2 supports the previous statement. With this in mind, the next step would be to evaluate the assignments that the students worked to compare against their survey responses as is planned in future work.

The Case

A simulation for a mass casualty event caused by a tornado hitting the community was planned and executed by the Nursing department at TSU. The initial goal was for the Nursing department to provide a simulated experience in mass casualty treatments for their students. As the Nursing staff proceeded to plan for the event they came to the point where they asked for help from other areas to support their activities. Faculty and students from the Engineering Technology department participated in the simulation that was run in real time and using real resources. One of the needs that became apparent was to help calculate the materials and costs that the activity would consume as the nurses were expected to use supplies as they treated their patients. Since the simulation was run with multiple locations on the campus, where the different locations would treat different categories of patients, it was important to know what amounts of resources would be used in each location. Instead of just performing the calculations for the Nursing staff, we realized the event could be used as a case study to help while teaching as part of our simulation course. All of the students in that course had taken engineering economy and should have been proficient in the work that was needed.

Decision Tree Problem from Case

A hospital is planning for anticipated costs for different types of mass casualties. The have found through their research that they are highly likely to deal with the impacts of a tornado over any other type of event. The hospital has to plan for the types of injuries that they will have to treat and find the following information.

Of the patients that arrive, 98% will be alive. Of that 98%, they know that 34% will require simple first aid while 66% will need further treatment. The 66% breaks out into 32% that will be classified as Category 1, 12% that will be classified as Category 2, and 56% that will be classified as Category 3. The hospital has planned to have a triage center to determine the patients that need first aid vs the patients that need more specialized treatment. They plan to have a second triage center to determine if the patients that need more specialized treatment fall into Category 1, Category 2, or Category 3.

The hospital has anticipated the costs of treating each category of patient. They find the following costs per patient.

Table 3: Cost Centers and Costs for Treating Patients

Cost Center	Cost
Death	$146.86
Triage	$9.24
First Aid	$333.54
Category 1	$926.11
Category 2	$472.99
Category 3	$454.08

The hospital does not know the exact number of patients that they would expect to see in the event of a tornado but they are interested in determining the average cost per patient.

a. Determine the decision tree for this problem.
b. Determine the expected value at each decision node.
c. Determine the expected value for the costs associated with treating each patient.

Observations, Conclusions and Future Research

In the teaching of the cost analysis, mathematical procedures are involved. A common problem is that at times students may be able to find the numerical solution but fail to understand what that solution represents. Once again, the gap between the theory and practice happens as students are unable to relate to real world problems. The teaching of cost analysis involves mathematical calculation and use of formulas. Many times these formulas and numerical procedures as explained by Townend (2001) have been perceived by the engineering students “as a collection of abstract techniques.” In their research, case studies have been introduced to eliminate that perception. Future research includes the application of specific sections within the case to avoid the “abstract” effect. Raju and Sankar (1999) explained the need to develop cases for classroom instruction. Although, their main focus was the interdisciplinary aspect of including other areas when teaching with cases. Understandably, it is becoming more important to provide students with several sets of skills other than the ones corresponding to the engineering profession. Previous research indicates that the use of cases provides a win-win situation. Multidisciplinary cases need to be developed in order to more effectively teach these classes. This research has shown us a reason to continue using cases in class and why it is important to implement cases in class. It is only a first step in the current motivation the authors have to make the teaching of engineering economy more in touch with reality and more satisfying to students. Therefore, future research needs to be done while using cases in the classroom and more specific analysis such using test and assignment results in the evaluation. The first step to this research was accomplished. We think we achieved some improvement in teaching decision analysis. The focus of the next step of our research is to evaluate the students' calculations in order to evaluate how the students performed in conjunction with how they though the performed.

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