AC 2007-1077: INTEGRATED LIBERAL AND PROFESSIONAL PEDAGOGY: AN INTERDISCIPLINARY COURSE

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Assessment of a Multidisciplinary Pedagogy for an Integrated Liberal and Professional Course

Abstract

Managerial decisions made by engineers apply economic theory to assist in solving engineering problems and concepts. They form the basis for many theoretical relationships studied in economics. This makes the perfect setting for our multidisciplinary course: Management Issues for Professionals. The course is an integrated liberal and professional study that teams together upper-class undergraduate students of the School of Arts and Sciences and Business with their counterparts of the School of Engineering.

Full-time faculty of the Industrial Engineering Department and the Economics Department teach the course jointly. The course covers numerous topics that link engineering to economics. One such topic is the production function. While the production function is an engineering relationship that describes the maximum output forthcoming from specified input combinations, it is used by economists in cost minimization problems. It investigates both linear and nonlinear production models in the short and long run. In addition, a linear programming production problem is presented to further demonstrate the link between engineering and economics.

This paper discusses the course development process and assesses the successes and shortcomings of the pedagogy. The paper concludes with a comprehensive assessment of the course using a survey. The survey results of students attending two consecutive fall semesters of the course indicate no significant difference in students' perception of the course. Conclusions are reported along with the authors' recommendations.

Introduction

There were three key factors that led to us creating this course. In the 1990s, there was a growing preponderance towards students rejecting the notion of traditional lectures as the basis for learning process in economics courses. Nevertheless, this approach prevailed in most college economic classes even though class discussion was the leading teaching method overall in college courses[3]. In engineering courses, many of the problems that needed to be solved required a multidisciplinary solution because of their complexity[7]. Students have trouble relating to the traditional textbook discussion of markets in microeconomics courses because many examples used are too hypothetical and are without observable phenomena[1]. This results in students having a difficult time relating what they have learned in the classroom to the real world. The likelihood that economists would benefit from exposure to the engineers' perspective was addressed[3]. The trend toward multidisciplinary research further supports our College's expansion of interdisciplinary courses. Notwithstanding these factors, the final impetus came from our college administration decision to require all undergraduate students starting with the 2007 graduating class to complete a course in "Integrated Liberal and Professional Studies" as part of their degree requirements.

For one of us, this was not the first experience in team teaching or even multidisciplinary teaching. However, this was the first course linking engineering with liberal arts for both of us. The college currently has an enrollment of about 2,500 full-time undergraduate students enrolled in the Schools of Arts and Sciences, Business, and Engineering. In addition, the college has part-time undergraduate programs in each of the three schools and graduate students in Arts and Sciences, Business, Engineering, and Education, as well as a School of Law.

The School of Engineering emphasizes undergraduate and master's level education. It offers B.S. degrees in biomedical, electrical, industrial, and mechanical engineering, and M.S. degrees in engineering and engineering management. One important component of the College's mission is the integration of professional and liberal learning. As a result, the School of Arts and Sciences serves all undergraduate students, those in its own programs as well as those enrolled in the School of Business, the School of Engineering, and students enrolled in certain graduate disciplines and other continuing education programs.

There is some literature relating the experiences of multidisciplinary teaching involving engineering and business courses. The experience in combining a marketing research course with a bio-resource engineering course was assessed[5]. The latter combines biology and engineering to solve problems in a variety of environmentally related fields. The approach of this course was to team together students from both courses to work collectively on a project involving both developing and marketing a new product. The engineering students worked alone or in groups of two over a two-semester period on one project. The engineering students working on a design project were then assigned to work with a group of marketing students to complete the assignment. The course ended with students completing a questionnaire relating to their experiences from the course.

Additional research on the subject includes a paper by Ashford in 2004 where he addresses the question of how multidisciplinary teaching and transdisciplinary and research can coexist in universities when most faculties are neither multidisciplinary nor transdisciplinary[2]. He concludes that there has been some confusion in differentiating the two methodologies. However he reports that there have been some useful advances. Notwithstanding these facts, he believes the amount of research in the subject matter continues to be slow. In yet another study, the capacity of engineers to integrate technical expertise, socio-cultural analysis and professional ethics in analyzing and solving real-world engineering problems was investigated[5].

Another interdisciplinary pedagogy relating to engineering and business is a study involving industrial and biomedical engineering students working as a team with marketing students[4]. The students were assigned to develop a new medical device including the phases of design, production, and marketing of the new product. The authors reported that the interdisciplinary environment greatly facilitated student learning, as well as enhanced mutual accountability and mutual respect.

Course Syllabus

The central points discussed in classroom were:

1. Optimal Decisions Using Marginal Analysis
2. Demand Theory and Analysis
3. Price Elasticity
4. Income Elasticity

5. Production Theory (one-variable input)
6. Production Theory (two-variable inputs)
7. Cost Theory and Analysis
8. Breakeven Analysis
9. Risk and Decision Making
10. Decision Tree Analysis
11. Forecasting Techniques
12. Linear Programming Applications

Course Methodology

Our course differs in several ways. First, we operated in a one-semester three-credit hour course. Our student population came from liberal arts, business and engineering, and included students majoring in a variety of fields within those three general disciplines. Engineering students included both industrial and mechanical engineers. Business students included marketing, management, finance and accounting majors. Liberal Arts students majored in an even wider variety of disciplines ranging from mathematics and computer science to economics and political science. Rather than having students work on one project, we presented students with a variety of topics of interest to engineers, economists, and business managers along with assignments covering these topics. On some assignments, students worked alone and on others students were given the option to work on teams. However, in this case, the students chose the team compositions themselves. Some teams crossed disciplines and some did not. In addition, we tested students with closed book examinations on some of the topics covered in the course. The course concluded with a questionnaire. This ten-question survey related to the students reactions to our course.

The course began with some fundamental economic training. First, a demand function was introduced followed by a discussion of the relationship between demand and revenue. Revenue maximization was discussed. The approach to this and most topics throughout the course was mathematics-based. This was followed by a discussion of cost and profit. Students were directed to consider a number of objectives that a firm may decide upon depending on the prevailing business climate at the time. These include break-even, maximizing sales, (i.e. output, subject to a profit constraint), profit maximization and revenue maximization. The objective of revenue maximization was selected for the first case problems given to the students.

Students learned the basic concepts of revenue maximization, profit maximization, breakeven and cost minimization. They were asked on their first assignment to apply some of their newly learned knowledge to a potential real world problem facing a firm. In this case study, the students were told that the government had decided to place a specific tax on their firm's product, but it had not yet decided on the format for the tax from two possible options; a per unit tax or a percentage of revenue tax. Students were asked to determine which tax they should lobby for if their objective remains one of maximizing revenue. Now of course the firm's revenues become net revenues.

The students were allowed to work in teams of two (an engineering student was included whenever possible), and were given four days, which usually included the weekend, to prepare their recommendations on this and the two following assignments. The rationale for such case studies was to enable the students to apply their analytical skills to solve real world problems. However, real world problems seldom replicate exactly what was learned in the classroom. The per unit tax resulted in a shift in the revenue function that changed the revenue maximizing price and quantity. On the other hand, the percentage of revenue tax simply changed the amount of net revenue to the firm without changing the pricing decision or the estimated quantity that will be sold at that price. The demand functions and tax rates were very carefully chosen so as to show students that the option of not reconsidering the original pricing decision will ultimately result in lost revenues.

A second topic covered in the basic training portion of the course was a breakeven analysis. The traditional textbook examples involved both linear and nonlinear cost functions with the firm producing one output. In this situation, however, the students' assignment was to determine the breakeven output for a hotel they were managing with different quantities of rooms that rented at three different prices. The students were asked to report on the problems associated with this output. To further challenge the students, the variable cost of preparing each room for rent was different for each of the three price levels. Students were reminded that the customers had decided on certain room prices subject to availability. Their ultimate task was to determine a percentage breakeven output, and to demonstrate that even when the target breakeven percentage was met on a given day, the firm could potentially lose money. In addition, the students were asked to consider a situation when the firm's output mix for that particular day included a high percentage of low profit rooms. The final application of the economic training portion of the course dealt with profit maximization. This assignment was consistent with the theoretical textbook example involving price discrimination, even though the lectures were based on a firm selling its product at one price. Those students who completed the reading assignment would have seen an example similar to their assignment.

We covered a number of topics that linked engineering to economics. One such topic was the production function. While the production function is an engineering relationship that describes the maximum output forthcoming from specified input combinations, it is used by economists in cost minimization problems. We investigated both nonlinear and linear production models in both the short and long run. For example, a Cobb-Douglas or multiplicative production function was presented to demonstrate both the concept of diminishing returns in the cost run and optimal input selection in the long run, relating both to cost issues affecting the firm. In addition, a linear programming production problem was presented to further demonstrate the subtle association between industrial engineering and economics.

A major component of economic theory involves modeling. In some sciences, data is available for analysis without the presence of a model, whereas in economic theory, the opposite is usually the case. Economic theoreticians often develop models without data.
We feel this represents strengths for both sides, in that they complement each other; thus providing benefits for both the firm and society. Managerial economics, on its own, helps to clarify the vital roles firms play in society, and to identify methods of improving their operations for society's benefits.

The firm's production function specifies the maximum output forthcoming from specified input combinations. In a simplified model, we utilized a version of the production function found in economics texts, where the firm employed only two inputs: labor and capital. This is referred to as the Cobb-Douglas production function. The function is given by the expression:

$Q = A\, K^{\alpha}\, L^{\beta}$

where Q = Rate of Output

K = Quantity of Capital

L = Quantity of Labor

A, α, β = Constants

It is the most commonly used specification of production in economics. This specification can be used to demonstrate both short run situations and long run situations facing the firm. The short run is defined as the production time period where at least one of the firm's inputs is employed in fixed proportions, whereas in long run situations, all of the firm's inputs are variable.

Another use of production theory common to both microeconomics and industrial engineering that was included in our course involved linear programming. Here, the firm is operating in the short run with both inputs employed in fixed proportions. The firm faces either a situation of cost minimization, or one of profit maximization in applications found in applied economics. These are not altogether dissimilar to problems involving linear programming found in industrial engineering applications.

Risk analysis was yet another topic common to both economics and industrial engineering that we included in our course. The economic-based example we used involved analyzing investment options for profit under conditions of uncertainty, where the standard deviation of the probability distribution measured the absolute risk, and the coefficient of variation measured the relative risk. Students were then assigned a project where, as before, they could work alone or in teams, to compare alternative investment strategies based on relative risk. Students were asked to consider three alternative investment strategies for which historical data were presented. Then, under an assumption of risk aversion, they were asked to make a selection and explain why it was their choice.

Assessment

We conducted an indirect assessment of the course using a survey. Students who enrolled in this course in the Fall 2005 ($n_1 = 19$) and Fall 2006 ($n_2 = 24$) semesters were asked to complete a survey of ten questions. The questions are presented in Table 1. The surveys were administered to the students on the last regularly scheduled session of each semester. The students were strongly encouraged to keep their surveys anonymous, thus ensuring that the responses would in no way have any impact on their final grades. The students' academic disciplines for both semesters are reported in Table 2.

For each of the ten questions of the survey, five potential responses are provided. The responses are: strongly agree, agree, indifferent, disagree, and strongly disagree. Each of the five responses was assigned a numerical weight of 5, 4, 3,2, 1, respectively. Table 3 represents the mean response weight for each of the ten questions given in the survey.

According to the coded survey results, eight of the ten questions show improvements (higher mean response weights). This appears to translate into better student satisfaction when the course was taught in the Fall 2006 semester versus the Fall 2005 semester. The largest percentage improvement involves survey question #9, which relates to student interactions with other students of diverse academic backgrounds. This may be attributable to our ongoing efforts to engage the students in team projects. The most disappointing result involves survey question #2. This question asks the students if the course helped them in realizing any linkage between the fields of economics and industrial engineering. It appears that although the students enjoyed the teamwork concept, we as faculty must do much more to convey to them one of the central messages of the course. This involves bridging the gaps that exist between engineers and non-engineers working together for one firm.

Finally, a t-test of the difference between the survey mean response weight from both semesters was not significant ($t = .65$, $p = .52$). This indicates that there was no significant difference in the perception of the course from one year to the next. While we believe that many objectives of the course were met, a few others must improve (i.e., multi-application of risk analysis techniques, and the subtle linkage between economics and industrial engineering). We strongly believe that such deficiencies would be easily overcome if the proportion of engineering students to non-engineering students in the course would increase from the current 25%. This is rather achievable by further promoting this course, and eliminating macroeconomics as a prerequisite for engineering students.

Table 1
Survey Questions

1. This course contributed in some degree toward making me a more educated and Informed individual.
2. This course assisted me in realizing the linkage between economics and
engineering.
3. After taking this course, I feel that I know more about the general problems facing micro economists in the private sector and how they relate to my major.
4. After taking this course, I feel I know more about the general issues facing engineers and how they relate to my major.
5. This course helped me better understand how to approach issues involving risk in managerial decision-making.
6. I feel that I have learned a lot this semester about the topic of risk analysis.
7. I feel that I have learned a lot this semester about the applications of the production function.
8. I feel that linear programming is a subject matter that is useful to students of diverse backgrounds.
9. This course created an interactive environment with students and faculty from diverse academic backgrounds.
10. This course has contributed positively in preparing me for the real world.

Table 2

Academic Disciplines of Enrolled Students

Fall Semester (2005)	Fall Semester (2006)
Engineering (6)*	Engineering (6)
Economics (3)	Economics (4)
Management (4)	Management (5)
Mathematics (2)	Mathematics (3)
Other** (4)	Other** (6)

*Number of students enrolled

**Disciplines include: Accounting, Computer Science, Finance, and Marketing

Table 3

Mean Response Weight* of Survey Questions

Question	Mean Response Weight	
	Fall 2005 Semester	Fall 2006 Semester
1	3.4	3.6
2	3.2	3.1
3	3.2	3.3
4	2.9	3.2
5	3.8	3.6
6	4.0	4.2
7	4.1	4.1
8	4.4	4.7
9	3.8	4.4
10	4.0	4.1

*Response Weights are: Strongly Agree (5), Agree (4), Indifferent (3), Disagree (2) Strongly Disagree (1)

Conclusion

We believe that the learning process is enhanced through multidisciplinary education. Traditional engineering courses focus on production problems while economics courses focus on problems on the demand or revenue side of the market, and on supply or cost side issues facing firms. The real world necessitates that both groups interact with each other, as well as with their colleagues in the marketing and finance departments. This multidisciplinary course enacts this interaction in a classroom setting, and thus better prepares students for the business environment. Although we recognize that working on a problem with a classmate from another discipline may not provide the complete experience gained in the real world, we believe this multidisciplinary approach will help pave the way to a successful career for our valued students.

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