Session 3654

Student Experiences with the Financial Basis of Entrepreneurship

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Abstract

The fourth offering of a Junior level course aimed at stimulating engineering student's entrepreneurial interests in the interplay between engineering decisions and business economics has been completed. In the course, students increasingly experience (1) market identification; (2) plant design; (3) staffing, and (4) the generation of basic financial statements. A novel grading scheme incentivizes the learning of engineering economics for use as an embedded tool in the preparation of financial statements. Projects are usually worked in teams of four and become differentiated as the teams compete for the best market ideas, volume targets, marketing strategies and manpower decisions. After their plans are integrated into multi-layer financial spreadsheets, the teams perform IRR-sensitivity analyses of the underlying assumptions to determine the best ways of operating the business or to alter unsound assumptions. For the most IRR-sensitive parameters, students must define the engineering implications of the dependency . The aim is to create a mindset that sees engineering practice in the context of its economic justification. Final team presentations are made to local financial officers, such as bankers, CPA's, etc., to both motivate high performance and to have the students gain their first experience interacting with bottom-line, oriented decision makers. Course background materials have credibility because they have been evolved with the help of varied representatives of industrial management.

Introduction

When engineering students enter their final year of study, they often receive heavy exposure to the economic aspects of engineering. Prior to this, and for nearly a decade, they have been concentrating on mastering the theories of the sciences they intend to practice, giving very little thought to issues of economic justification, which is at the heart of engineering. We sought to broaden the perspectives of our ceramic engineering students so that they might graduate with greater interest in and knowledge of the controlling economic factors in the practice of engineering. The course we developed could be easily adapted to other engineering disciplines. The overarching aim of the course is to instill in the new graduate an active concern for the engineering implications of business-economic factors. The course is presented in a series of topical, parallel modules, which merge after two-thirds of the course (Table 1). The novel aspects of the topics and approaches will be discussed under their headings.

Table 1 – Parallel Topic Sequence

Design Path Topics	Engineering Economics Topics
Defining Design Objectives (2)	Interest (1)
Local Plant Trip	Cash Flow Diagrams/ Time Value of Money (1)
Case Study Background (1)	Equivalence: PV/FV, Pmt. Series (1)
Market Analysis & Identification (1)	Uniform Series (1)
Preliminary Design (1)	Rates of Return (1)
Presentation of Markets (1)	Depreciation Concepts (1)
Technical Design (1)	Internal Rates of Return (1)
Manufacturing Design & Safety (2 labs)	Payback Period, Breakeven, Perp. Ann. (1)
Manufacturing/Staffing & Layouts Pres. (1)	Mock EIT Test (1)
Income Statements	
Cash Flow & IRR	
Sensitivity Analyses	
Team Presentations and Individual Reports	

Parallel Module Sequences

The course is offered in two, seventy-five minute periods per week. At times, the class meets in a lab format at a computer center. For roughly the first two-thirds of the course, the lecture topics are divided into two paths: Design and Engineering Economics (E$E). We found this arrangement preferable to linearly continuous topical treatment. Periodically, homework or presentations are required along the Design Path, but homework and quizzes are always required on the Engineering Economics "days". Near the last third of the course, the paths are merged and both design and engineering economics are co-mingled for the final phase of the course.

Different philosophies are applied to the two sections. The Design Path is a broad survey and introduction to topics very new to the engineering students. Small individual exercises are given until the case study is introduced and teams are formed. No teaming occurs in the E$E path, except for unofficial working together on problems. The philosophy of the E$E path is to empower these mathematically gifted students in the fastest possible way to use E$E formulae. This means, the E$E principles are presented conceptually, financial calculators are required, and short-cuts and rules-of-thumb approaches are encouraged. One reason for developing E$E skills only qualitatively, is that trained business personnel are generally required by industry to authenticate business proposals. It is not realistic to expect engineers to hold equal footing with the finance departments; yet, they can work together more effectively toward financial goals with this background.

These naturally competitive students are graded for this section in an unusual way. They are challenged to earn a superior grade for this section by out-performing their school peer-group and national norms in mock EIT E$E exam sections. Being naturally competitive, this metric has resulted in a great improvement of our students in this EIT test area. In three years, all have outperformed the national averages for this section. E$E topics are shown in Table 1.

The Design Path Modules

Defining Design Objectives: In this module, the students learn the importance of the unambiguous statement of the design objective. They look at how product "need" arises, i.e., surprise, informal declaration, discovered need, legislation and felt need. As an exercise, they use these principles to determine the need met by the building's coffee vending machine.

A local plant trip is made and the students are required to submit a diagram of the plant and material flow paths. This experience is drawn upon later in the plant design phase of the course.

Case Study Background: A case study is prepared in advance by the responsible faculty member. At the core of this case is some product concept for which there may be a market need. To date, we have used a tomato stain-resistant microwaveable container and a high performance coffee mug as the potential products. The case study creates a universe for the students to think in, and to begin to see the range of competing requirements and trade-offs.

Market Analysis and Identification: Before any economic estimates are made, in teams, the students are asked to estimate what price the consumer would be willing to pay for a solution to the problem identified. They are then asked to determine how big the market is for this solution. This market selection becomes the basis for their projected five-year sales and their subsequent plant design. They are reminded that they must have a recurring market to justify a plant. Initially, they are asked to keep their target markets secret from other teams until the time of group presentations. Using a forced ranking system, all teams are asked to rate the different choice of markets selected by the individual groups. The teams enter their sales projections into the first level of a multi-layer spread sheet for use in generating other financial statements.

Technical Design: This component serves as an occasion to introduce the students to the design and selection criteria of Ashby (1). They are not actually asked to do any detailed design at this stage, but essentially select a reasonable material choice and manufacturing technique. Their decision becomes the basis of another technical presentation to the groups.

Manufacturing/Staffing Layout: Based on the expected sales, the teams lay out a plant that can meet the production requirements determined for their market analysis. A great deal of estimation is used in this section. An industry advisory committee has assisted us in making realistic estimates of the costs of new and used equipment, which could serve the designed factory. Office furniture, tool costs, etc. are all student estimated. Knowing that their designs will be presented and critiqued by peers, lends a heightened sense of realism to this phase. Students will frequently visit office suppliers or call equipment suppliers so that they can justify their estimates. Team enthusiasm often reaches a peak in the layout phase as they debate space usage, staffing and staff salaries. They, of course, hire engineers of their own discipline and it is encouraging to see a sense of reality pervade their deliberations over staffing and pay levels. This is perhaps the first time they see the big picture regarding manpower levels, compensation and equipment costs.

The plant layout is also entered into a number of spreadsheet layers. The precise numbers are left up to the teams, but they are persuaded to use multiple spreadsheet layers rather than complicated cell formulas in a single table so that changes are easier. Some of the layers that they generate are Land and Building Costs; Equipment Costs (new and used options); Raw Material Costs; Utility Costs; Manpower Levels and Wages (Direct and Indirect), etc. In nearly all tables there are assumptions made, such as worker productivity, annual raise rates, receivables, manpower, etc. All assumptions are asked to be entered on a separate spreadsheet layer called the Table of Assumptions. It is from this table that changes will be made to conduct the sensitivity analyses.

Income Statements: The income statement is the second major financial statement the students produce. The organization of this statement is not intuitive, so the students are heavily guided by the course notes developed by the co-author, who is a financial specialist. While they construct the spreadsheet table in a fill-in-the-blank approach, once they enter formulas relating key financial information to its source data, they become keen to understand why the numbers are treated as they are in the Income Statement. In fact, it has been observed that these engineering students do not like to work with numbers unless they know from where they come. In this table and in some of the others, extensive use of the E$E topics, particularly time value of money is used. Here they begin to understand the effects of taxes and overhead costs.

Cash Flow - Internal Rate of Return: The foundational statement of the whole course is the Cash Flow Statement. Data from the rest of the sub-layers flow into this table and generate the bottom line from which the internal rate of return may be calculated. This is the hardest of the tables to understand, but the students seem determined to understand the non-intuitive flow of numbers in this table. Once the cash flow is established, they use spreadsheet financial functions to determine the IRR. By this time, and with their success in the E$E part of the course, they are very interested in whether they are making money or not.

Sensitivity Analyses: The sensitivity analyses determine how the internal rate of return (IRR) of their business depends on the assumptions made in other tables. They then adjust the assumptions where it is feasible, or change the design approach to improve IRR. The results of the sensitivity analyses usually come as great surprises to the students. In particular, the effects of receivables and inventory are usually seen to have great impact on profitability.

Economics - Engineering Integration: It is after the sensitivity analyses are completed that the business economics and engineering design functions become integrated in the minds of the students. For the items of greatest sensitivity, the students are asked to indicate what the engineering implication of the particularly sensitivity is. For example, when the students see that IRR is strongly dependent on inventory level, they are asked how many ways they can think of to reduce inventory. With some coaching, they begin to think more broadly and creatively. One idea that eventually emerges is to consider a design with fewer parts, fewer mold pieces, more versatile forming equipment. When they are engaged at this level, they began to see that economic issues often create engineering challenges instead of engineering interference.

Concluding Presentations: The generation of the financial statements and sensitivity analyses are carried out in team privacy with the instructor frequently called on for consultation. The aim of these deliberations is to fine-tune the operation to maximize profitability. The final configuration is then presented to an enlarged audience for review and evaluation. To ensure the students are "up" for these semester-end presentations, local representatives of financial institutions are invited to the final presentations. These have been bankers or CPA's to date. Their presence has always raised the performance level of the presenters. Depending on the guests, the presenters are sometimes asked to conclude their presentations with a request for some action on the part of the visitors. For example, one year the groups were to justify a request to the bankers for a loan to fund the proposal. Of course, the guests are informed of the preparation level of the students and asked to stimulate, but not intimidate the teams.

Business Plan: Each team member is asked to prepare a final report in the form of a business plan, which includes the data common to their team members. This activity along with the results of their E&E testing allows for grade differentiation in the course, as well as forcing all team members to become familiar with the financial data. This report is to include their own opinions on the engineering implications of the sensitivity analyses.

Course Dissemination Potential

The concept of the course is simple enough that it could be ported to most engineering disciplines provided a qualified financial advisor could be enlisted to assist in setting up the financial tables. In recruiting guests for the financial presentations, it has been our experience that most community financial professionals would be willing to assist in such a program. The burden on the instructor is to conceive of simple, product ideas, which can be designed and implemented by the basic skill set of the engineering students. The students are not asked to perfect the design, just to define the general manufacturing cost envelope. The necessary planning and business skills will be learned and experienced in the course, albeit in a limited way.

Student Response

Student evaluations have been above average. Unexpected, but welcomed is a significant shift upward in student interest in careers in management after this exposure, as indicated by simple post-course student surveys. We equate this increased interest with greater interest in leadership, in the sense of wanting to champion and carryout their own ideas. The students acquire the confidence to campaign for their ideas from a combined engineering/financial perspective. We expect the “I can do this” mindset to not only help them become better team players when they interface with the financial support staff, but to expand their horizons, their organizational ambition and initiative. Students returning from Co-op experiences after this course have said they were surprised how much business and finance discussion dominates the work place. For them, such experiences reinforce the importance of this course.

Bibliography

1. M. F. Ashby, Materials Selection in Mechanical Design, Pergamon Press, NY (1992).

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