Development of Business Skills in Engineering Students through Collaborative Engineering-Business School Activities

O.A. Ezekoye, T.S. Patil and S. Nichols
Department of Mechanical Engineering

J.S. Butler, J. Nolen, J. Doggett
Red McCombs School of Business
The University of Texas at Austin
Austin, TX

Abstract

Most engineering graduates pursue positions in existing businesses. Generally, for an individual to advance in a business firm, it is required that he/she focus on the central purpose of the firm; this most often is maximizing shareholder equity. As has been widely quoted, the business of business is business. Leaders of technology-based firms should have technical competence and business savvy. There have been notable cases of engineers who have risen to the top of major corporations. In recent history, Jack Welch, Andy Grove and Lou Gerstner are widely known as engineers who have leveraged their technical capabilities while also clearly succeeding in business. There are unfortunately many more counterexamples of engineers who have entered corporations with strong technical capabilities and interest in promotion within the corporation, but who have failed to advance as a result of shortcomings in their business skills and sophistication.

This paper describes an ongoing collaborative effort between the Colleges of Engineering and Business at the University of Texas at Austin to create a business short-course for engineering students to familiarize them with business concepts. The objective is not to teach the students all they will ever need to know about business, but instead to teach them the importance of understanding the business implications of technology transfer in commercial ventures. To accomplish these goals in a two week short-course, the faculty members involved are packaging a set of electronic business tutorials of relevance to engineering students. The two week short course culminates in a simulation where the students start a business and run it over several years with the objective of maximizing shareholder equity. The details of implementing this collaborative program are provided in this manuscript.

Introduction

The evolution of a collaborative project between the Colleges of Engineering and Business at the University of Texas at Austin with a goal of creating a business skills short course for engineering students is discussed in this manuscript. The project is one piece of a larger project formulated within the mechanical engineering department at the University of Texas on implementing project based learning into the curriculum. One of the tenets of project-based learning is the direct application of engineering ideas and concepts to practical problems. It became evident in the development of the project based curriculum that one aspect of project based learning that is not typically addressed in engineering curricula is the integration of

engineering ideas into a larger business framework. The disconnect between the coupling of business/market forces and engineering training is often seen in the product design process. Engineering training often times leads young engineers to believe, incorrectly, that the vision and requirements specified by the engineering designer are shared by the market. This is generally not true, and the ability for young engineers to recognize that design must be customer and market driven is important. This is one example of the need for a project of the type discussed.

The vast majority of engineering graduates of the University of Texas are employed by a commercial venture for some part of their careers. This is typical of most engineering colleges (NSF SESTAT). While these graduating engineers have solid training in applying engineering principles to analysis, product design, testing etc., they are often times not adequately prepared for understanding the nature, characteristics and goals of the very ventures that employ them.

Demographics of U.S. Engineers

The National Science Foundation assembles detailed demographic data on U.S. engineers and these data are summarized below. The most recent data available to us was from 1997. Of the nearly 2 million degreed engineers working in 1997, approximately 72% had a terminal bachelor's degree, 23% had a terminal Master's degree and 5% completed a doctorate. Interestingly, 34% of these engineers were not employed in science or engineering occupations. Business and industry employs 82% of all trained engineers while government employs 13% and educational institutions hire the remaining 5%. Perhaps the most interesting demographic data relates to the primary and secondary work activity of trained engineers. Approximately 49% of all people trained as engineers spend some major part of their work in a research and development capacity. 58% spend some major part of their work in management, sales and administration. 25% spend some part of their work in computer applications. 21% contribute to professional service work. Less than 5% spend any time in teaching. This last statistical information is important because more engineers spend some portion of their time at work performing business functions rather than what would be considered engineering functions.

We generated a questionnaire for industry to determine industry specific demographic data and also to gauge the receptiveness of industry engineers to business skills training. The questionnaire is shown in Appendix A. Results of the questionnaire are discussed below.

Questionnaire Results

A sample of 22 engineers at Ford Motor Company took part in a survey designed to determine the perceptions of these engineers to business skills training. The engineers ranged in tenure at Ford from 17 years to new hires. 64% of the respondents have been with Ford more than 2 years. A range of engineering disciplines was covered by the respondents. Primary work areas included finance, design, manufacturing, marketing, project management, product development and testing. Approximately 36% of the respondents indicated that they have worked in multiple types of job functions since arriving at Ford.

Approximately 45% of the respondents have enrolled in formal technical training/courses since joining Ford. Nearly 32% of the population has enrolled in formal business training/courses since joining Ford. 68% of respondents claim to read Ford's annual report, and 45% claim to understand the significance of the numbers i[1]n the annual report. The fact that less than half of the respondents understand the significance of the numbers in the annual report suggests that there is a requirement for additional business training. More detailed questions revealed that 50% of the surveyed engineers were responsible for a budget in their work.

[1] NSF Scientist and Engineers Statistical Data System

Interestingly, this response should be correlated to responses about the relative importance of additional training in accounting and economics. 45% felt that a basic knowledge of economics would significantly help them in their work and 45% felt that it would help moderately. The remainder (10%) indicated that it would not help at all. For accounting, 25% indicate both that accounting would significantly help them and also claim that it would not help at all. Half of the respondents claim that it would help them moderately.

Of the respondents, 27% have supervisory responsibilities. Nearly all of the supervisors understand the annual report and view knowledge of economics as a significant resource in performing their work. They also all are responsible for budgets and all analyze financial projections for their groups. 50% of supervisors note that accounting knowledge significantly helps them in their work compared to 19% of non-supervisors. About half of the supervisors have received additional business training since joining Ford. Interestingly, supervisors who received additional business training are often the same people as who receive additional technical training. This is not the case for non-supervisors. While nearly all supervisors claim to think about marketing implications of their work, they in general rarely contribute to marketing reports. Half of the supervisors frequently write plans and proposals as compared to only 25% of the non-supervisors. Nearly all respondents believe that management skills can be taught. Nearly all respondents believe that spoken communication skills are more important for advancement than written communication skills. A somewhat strange response between supervisors and non-supervisors is the importance of statistics in their performing their duties at Ford. Nearly 67% managers felt that their statistics background was inadequate for performing their duties while only 6% of the non-supervisors indicated that their statistics training was inadequate for performing their duties. Behavioral science was judged to be important by 50% of the respondents in performing their duties. Approximately 25% of respondents judged it to be only moderately important or not important. These percentages were identical between supervisors and non-supervisors.

Using some general results from this survey, we were able to identify some business areas where there would be benefit to industry-based engineers.

Course Topics

The following topics were chosen to cover the course requirements.

Topic	**Nominal Days**
Accounting	1.5
Finance	1.5
Marketing	1.5
Management	1.5
Intellectual Prop.	0.5
Entrepreneurship	4.0

Certainly, the topics presented above are quite general and are mastered only after many years of formal training. The challenge in the proposed course is to glean the essential concepts from these broad areas and present these concepts to non-experts who have no prior training in the areas.

Accounting: The objectives for the accounting modules are that the student should be able to identify a balance sheet & income statement, recognize that there are ratios that can be extracted from a balance sheet and income statement, describe the sections of an Annual Report, describe financial information required in a Business Plan.

Finance/Economics: The learning objectives in the finance/economics area are: Understanding how prices are set in the marketplace, knowing the basics of the monetary system, understanding the basis of stocks and bonds, describe the simplest ways that a business venture can be structured, recognize the relationship between interest rates and loans, and recognizing the financial requirements in a proposal and/or business plan.

Marketing: The basic concept to be conveyed in the marketing segment is the process of mapping customer wants into products and services. Other core topics to be covered in marketing are an understanding of promotional strategies, the notion of distribution channels, and the recognizing the impact of competitive forces on pricing and creation of market share.

Management: In management, the fundamental notions of organizational behavior and operations will be presented

Intellectual Property: This module includes introductions to patents, copyrights, trademarks, trade secrets, employment contracts and other concepts related to intellectual property. The material will focus on developing a students understanding of intellectual property as "property", that is, how to develop and protect manifestations of intellectual concepts (inventions, writings, machines, devices, etc.). From the material, students should develop an understanding of the various classifications of intellectual property and how to best protect their "property".

Entrepreneurship: The glue for the various sections will be the process of exploiting an opportunity through entrepreneurial activity. The separate sections of the course will be related to each other within an entrepreneurial context.

Layout of Course

Overall, a case study approach was identified as being the most appropriate format for delivering the course. Some ideas that were developed include presenting both entrepreneurial and entrepreneurial cases to highlight the core subjects. Industries to extract cases from include auto, consumer products and knowledge/software. For the auto industry there was discussion on the issues that would accompany a decision by an automaker to use a direct sales model like Dell's. The challenges of presenting a case study format were discussed, and these include the need for a facilitator and the limitations in technology for distance based case study lecturing.

Another concept that is being discussed as a mechanism for delivering the course is a "business simulation" where an opportunity is identified and subsequent decision making proceeds based upon business theory. Figures 1 and 2 provide schematic details of the course layout. Just-in-time theory is delivered to explain the simulation's response to a student's choices and decisions. Metrics for evaluating success and failure within such a simulation would be measures of shareholder equity and/or ability for the founders to cash out. A challenge in developing the simulator is that the example should have general appeal to various engineering disciplines. A benefit of the business simulation model for delivery as compared to the multiple case study model is that it can be distributed in a stand-alone format. Several business simulator codes exists and we are going through a buy vs. build decision process.

Process for Developing Course Modules

The content for this course ultimately comes from the business school faculty members. The instructional design and multi-media expertise comes from the Univ. of Texas College of Engineering Faculty Innovation Center (FIC). The FIC has participated in similar projects

within the College of Engineering and has developed tools and expertise for instructional course design.

Faculty Developers

Faculty developers were asked to provide content and problem sets to teach the basic concepts

Lecture

1. Furnish a Table of Contents for developer's contribution to the lecture format.
2. Deliver in electronic format (Power Point) a draft version of developer's lecture contribution.
3. Deliver homework problems and solutions to support developer's electronic lectures.
4. Complete voice recording accompanying lectures (FIC interaction required).
5. Deliver a storyboard (plan) with notes on augmenting the base lecture electronic files with pictures, graphs, animations and video.
6. Deliver final electronic form of lecture series compatible with voice and graphical resources.

Simulation

7. Deliver layout for simulation (scenarios, decisions, evaluation of decision)
8. Deliver scripts for dialogue in scenarios.
9. Complete voice recordings accompanying simulation.
10. Deliver electronic files for scenarios (case information, data, etc.).
11. Deliver decision possibilities/branches in electronic format.
12. Deliver scripts for impacts of decisions.
13. Deliver a storyboard (plan) with notes on augmenting the base simulation files with pictures, graphs, animations and video.
14. Modify simulation (as needed) following evaluation of simulation.
15. Present roll-out course.

FIC

Lecture

16. Furnish alternative plans for presenting lectures that include electronic notes, voice and graphical resources.
17. Develop graphics and animations. Generate video clips to augment lecture notes.
18. Incorporate graphical resources into electronic lecture format.

Simulation

19. Furnish alternative plans for delivering simulation.
20. Furnish programming support and environment to deliver simulation with associated scenario-decision-evaluation components.
21. Develop graphics and animations. Generate video clips to augment simulation.
22. Incorporate graphical resources into simulation environment.
23. Deliver Lecture and Simulation in a CD format compatible with Windows 98/2000 OS.

Schedule/Calendar

	10/12	10/26	11/9	11/23	12/7	12/21	1/4	1/18	2/1	2/15	3/1	3/15
1		**X**										
2		**X**	**X**									
3				**X**								
4						**X**						
5						**X**		**X**				
6								**X**				
7			**X**									
8				**X**								
9						**X**						
10								**X**				
11								**X**				
12								**X**				
13									**X**			
14											**X**	
15												**?**
16			**X**									
17								**X**				
18								**X**	**X**	**X**		
19			**X**									
20					**X**	**X**	**X**	**X**	**X**	**X**		
21								**X**	**X**	**X**		
22										**X**	**X**	
23											**X**	**X**

Evaluation of Course

Basic ideas have been considered in the evaluation of the course. Testing of the students is one option for determining the effectiveness of the course. While this traditional method for determining student progress is relatively easy, it may not be the most appropriate evaluation method for a course of this type. A less stressful (for the students) approach might be entrance and exit surveys where more general perception type questions are posed. This may clarify if the exposure was able to create a shift in the student's perception of business issues as compared to knowledge of specific business details. Clarification of the evaluation process is an ongoing part of this project.

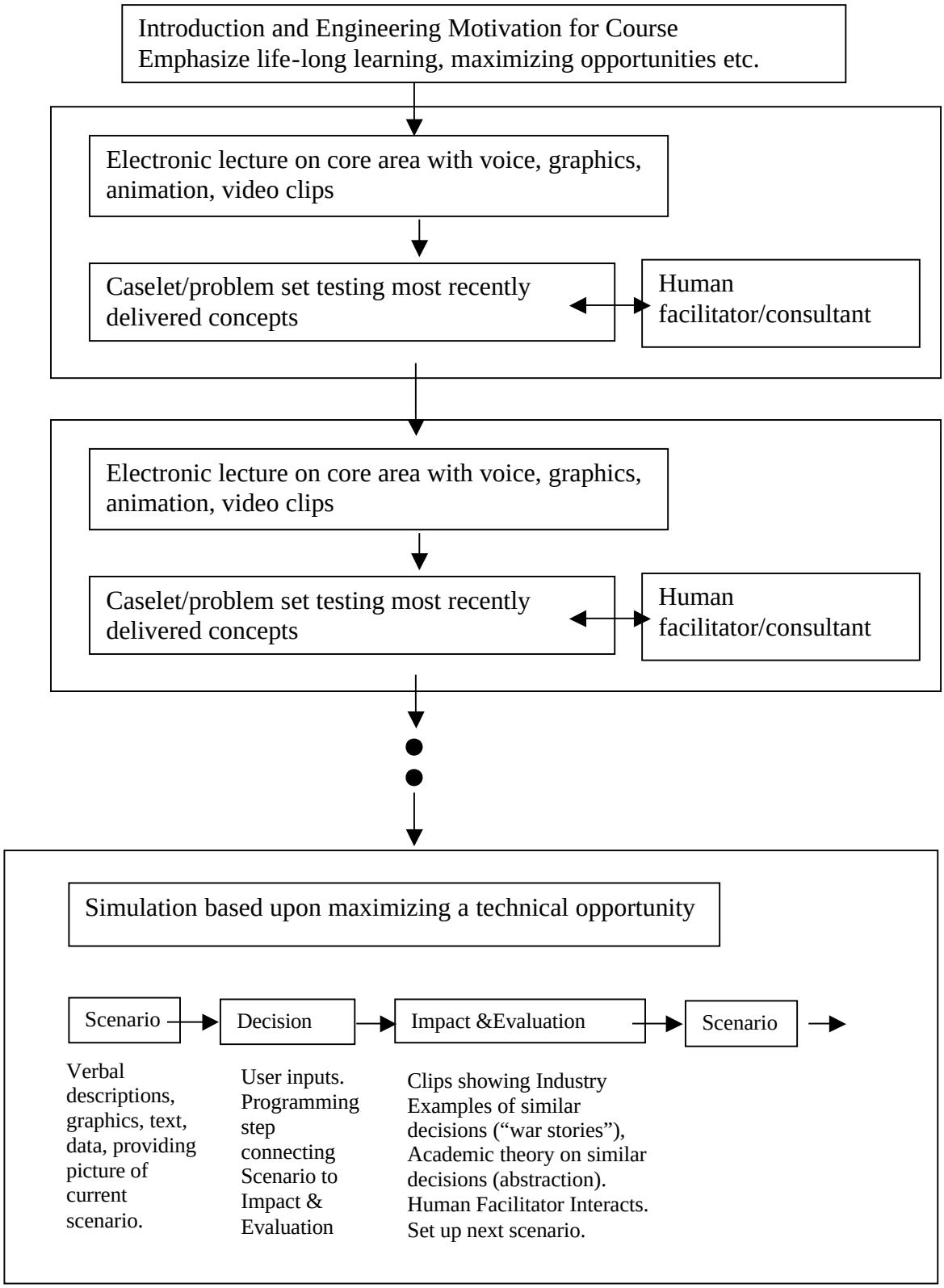

Figure 1. Course layout in schematic form.

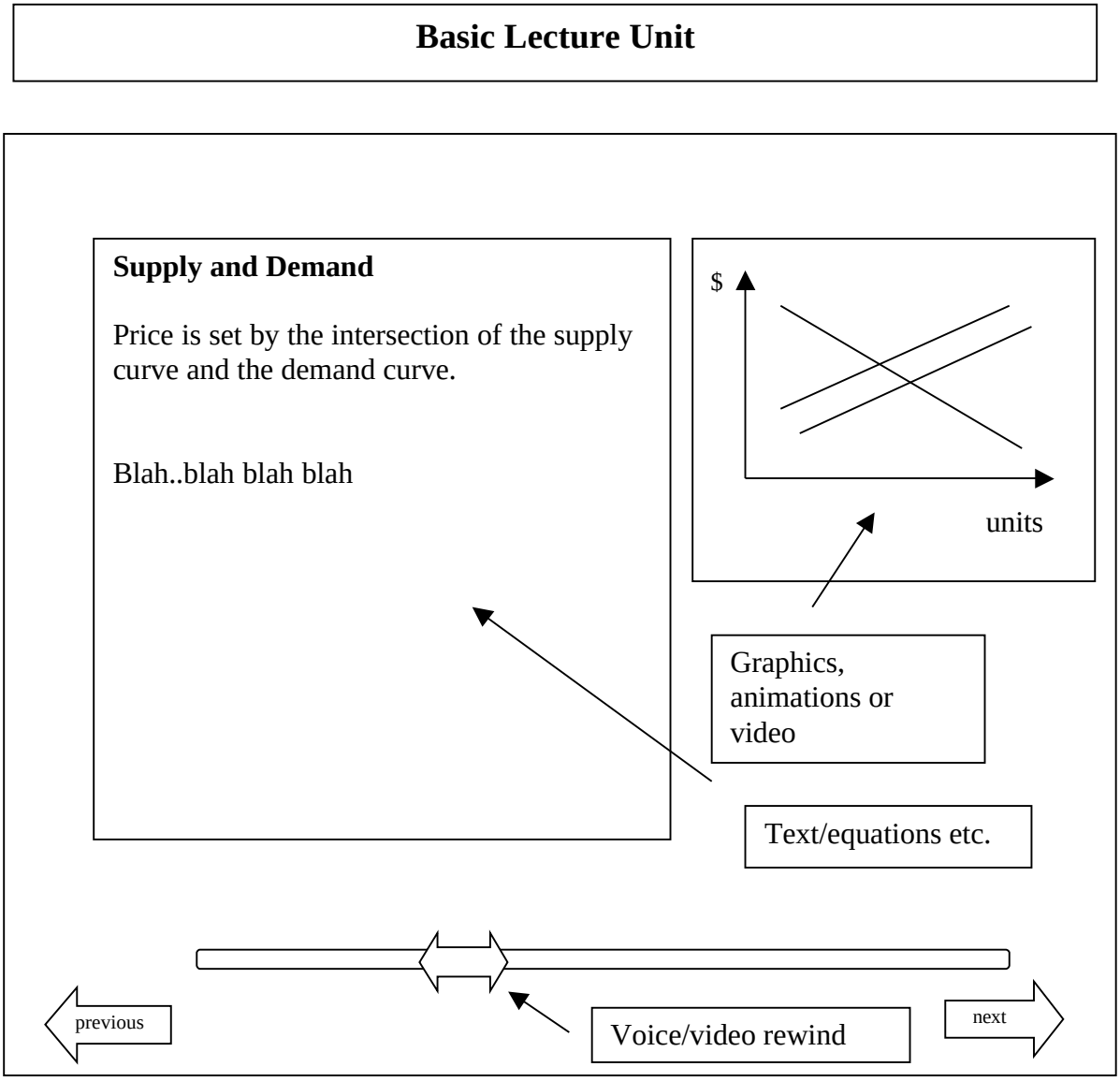

Figure 2. Schematic of basic lecture unit.

Appendix A
Ford-UT Proceed Engineering and Business Skills Questionnaire
*Either mark the choice the makes the most sense or fill in the blanks. Thanks for your time.

What is your primary work area manufacturing, design, testing, facilities, research & development or other_____?

Have you always worked within this area at Ford? Yes No

What percentage of the engineering and technical skills that you acquired in your last degree do you use on a daily basis now?____%

What year did you complete your final technical degree? _____

In what discipline was your degree conferred? _____

Have you enrolled in technical education since completing your UT degree? Yes No

Have you enrolled in business education since completing your UT degree? Yes No

Which form of communication is more important for professional advancement (spoken or written)?

Would it have helped you to have made more presentations while at UT? Yes No

Is it (very necessary, necessary, not necessary) to understand the impact of engineering solutions in a global, political, regulatory and societal context?

Are you aware of the regulatory issues affecting your industry? Yes No

Would you be more or less likely to take additional technical or business training?

Would a basic knowledge of accounting help you in your work (significantly, moderately, not at all)?

Are you responsible for a budget at work? Yes No

Have you ever read Ford's annual report? Yes No

Do you understand the terms and figures in Ford's annual report? Yes No

Would a basic knowledge of behavioral science help you in your work (significantly, moderately, not at all)?

Have you received any management training at Ford? Yes No

Do you think that management skills can be taught? Yes No

Would a basic knowledge of economics help you in your work (significantly, moderately, not at all)?

Was the statistics background that you acquired in your previous degrees (adequate or inadequate) for performing your duties at Ford?

Do you perform statistical quality control? Yes No

Would it help to understand quality control better? Yes No

In your duties, are you required to perform financial reporting and analysis (frequently, rarely, never)?

Do you ever analyze financial projections for your group or division? Yes No

Do you contribute to market analysis reports (frequently, rarely, never)?

In your engineering responsibilities, do you think about the marketing issues?

Do you supervise (0, 1-8, 9-20, >20) people?

Have you ever participated in a time and motion study? Yes No

Do you think that operations (industrial engineering) issues help the bottom line? Yes No

Do you participate in writing internal proposals/plans to fund projects that you champion (frequently, rarely, never)?

Have you ever received training in writing proposals? Yes No