

Learning across Disciplines: A Case-study Approach to Teaching Engineering Economics and Business Policy

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Introduction

For engineering students in disciplines other than industrial engineering, the required engineering economy course is sometimes considered to be uninteresting or even irrelevant. In an attempt to increase the appeal of our economics course, we have successfully introduced two elements. First, we build a large portion of the course around a case study that requires a simple product design, a manufacturing plan, and a marketing plan – all of which must meet a tight time schedule and a specified budget. Second, we require our engineering students to work with marketing and accounting students from a business policy class, creating a multi-disciplinary team with the task of developing a solution that is technically feasible, financially viable, and appealing to the target market.

This course structure exposes students to problem-solving techniques in real-world situations, while also providing a natural platform for relevant classroom discussions. In terms of real-world exposure, the case study is based upon events that occurred in the writing instrument industry during the World War II era, giving students an opportunity to investigate real companies, real decisions, and even real failures. After completion of the project, the students can compare their solution to the historical one and speculate upon how events could have been different. Another aspect of the course that simulates the real world is its cross-disciplinary nature, which introduces students to the challenges of developing a solution that simultaneously satisfies criteria in several different areas. In terms of classroom discussions, the World War II setting provides an excellent foundation, since many modern industrial engineering practices have roots in that era. To build upon this foundation, students are required to present intermediate progress reports related to specific issues. Preparation for these checkpoints provides a logical framework for classroom discussions centered on economic issues related to product design and manufacturing.

Our initial experience with the case-study approach has resulted in positive feedback from the eight students and two professors directly involved with the project, as well as others in the engineering and business departments who participated indirectly. This paper outlines the details of our approach, including a brief description of our case study, an overview of project goals, the logistics of making project assignments and relating them to the overall course, an assessment of the project's effectiveness, and ideas for future improvement.

Description of Case Study

Based upon one author's personal knowledge as a pen collector and supplemented by information from a fascinating web site on the writing instrument industry,⁴ the authors developed a case study to describe a critical period in the corporate life of Eversharp, Inc. After presenting a general background of the history of writing instruments, the case study focuses on the development and rapid dissemination of the fountain pen. The authors describe the technical advances that marked the rise of the fountain pen, as well as marketing techniques that contributed to the ever-changing competitive landscape. The case culminates with the anticipated introduction of the ballpoint pen in the mid-1940s.

More specifically, the end of the case informs students that Eversharp has just purchased a patent for the ballpoint pen. The students are told that they are members of a project team charged with developing a workable pen design, an affordable manufacturing process, and a viable marketing campaign. Senior management expects the project team to establish Eversharp as a leader in the emerging ballpoint pen market. Industry insiders believe that the first company to successfully introduce a ballpoint pen will control the highly competitive writing instrument industry for many years into the future, so the case sets up a high-stakes situation with considerable time pressure.

To give students a starting point for their work, the case contains appendices with drawings and specifications of the new ballpoint pen patent purchased by Eversharp, sample drawings from fountain pen patents for comparison, and representative industry advertisements from the appropriate era. A separate handout provides students with annual financial reports for Eversharp, Inc., from 1940 – 1942.

Overview of Project Goals

A cornerstone of the project is that it requires engineering and business students to work together. Cross-disciplinary work is increasingly recognized as an important component of effective education,^{1,3} and the collaboration between business and engineering is particularly relevant to engineering students.⁵ Thus, a major goal of this project is to introduce students to the challenges and benefits of working with people from entirely different fields of expertise.

A second goal is to give students an opportunity to develop and practice communication skills, another widely recognized element of both effective education and career success.^{6,7} The project involves three oral presentations and one written report. To emphasize the importance of good communication, 30% of the overall project grade is derived from the students' performance on the presentations and grammar/style elements in the written report.

Two additional goals are somewhat interrelated. The case requires students to consider three specific areas: design, manufacturing, and marketing. Engineering students are primarily in charge of design and manufacturing, while business students spearhead the marketing plan. In

terms of design experience, a goal of the project is to give students exposure to authentic patent drawings and allow them to build upon the patented idea to come up with a workable design. However, ballpoint pens are now ubiquitous, and technical aspects of their design that were challenging in 1945 have been largely solved by now. We purposely use a product with relatively low design requirements so students can focus on a fourth goal, project management issues, rather than the details of design. In other words, we direct students to focus on the processes necessary for economic design and manufacturing, along with the timetable required to meet the desired project schedule.

To summarize, major goals of the project are listed below.

- Exposure to cross-disciplinary collaboration
- Development of communication skills
- Practice in making the transition from an idea to a workable design
- Introduction to project management

Logistics of Project

There are two areas of project logistics that merit discussion. First, we will describe how we assigned and directed the case study. Second, we will describe how elements of the case study were used to instigate and enhance class discussions.

We made the initial assignment during the first week of the course, and we devoted a full hour of class to introducing and discussing the case. After a brief introduction to the writing instrument industry, we gave the students a written copy of the case study. We conducted the remainder of the class as if it were a company meeting, with Professor Nance as Chief Executive Officer and Professor Russ as Vice President of Design and Manufacturing. We explained the situation at Eversharp at the time of the case, which is briefly outlined in the Description of Case Study section of this paper, and we discussed ideas about how to handle the challenge. We laid out a project timeline that established two intermediate checkpoints and a final presentation at the end of the semester.

The manner in which we assigned the case study set the stage for accomplishing our project goals. The students were quite concerned about knowing exactly what we expected from them at each checkpoint, and they were rather frustrated by our insistence that *they* must decide the specifics regarding what should be done and the order in which tasks should be performed. We deliberately refrained from setting detailed guidelines so that they would be forced to work together to come up with a plan. Working together provided the students with an opportunity to develop communication skills and practice cross-disciplinary collaboration, while formulating a plan gave them practice in project management. Of course, the work itself accomplished the final goal of gaining practice in design.

The checkpoints were a particularly effective element of our strategy. As with the initial assignment, we ran the checkpoints like company meetings during which the CEO and VP

provided input on ideas and plans presented by the students. We required the first checkpoint to be relatively early in the semester, so that we would have time to redirect the students' efforts and provide additional guidance in project management, if needed. Fortunately, this particular group of students rose to the occasion and did an excellent job from the very beginning. They continued to express concern about the ambiguity of the project, but we continued to emphasize that "real world" assignments do not generally come with a complete list of specifications and expectations.

We attempted to introduce reality into the checkpoints by providing the students with new information, rather than simply giving them feedback on what they had done. For example, at the first checkpoint, we told them that the competition was moving more quickly than expected on its own version of the ballpoint pen, and we needed to adjust our timeline accordingly. After some initial surprise and frustration, the students settled down and came up with a good plan during the checkpoint to meet the new schedule.

After the final project presentation, we informed the students of the historical outcome for Eversharp, Inc. The discussion allowed the students to compare their solution to the actual one and to consider how events might have unfolded differently if they had been the project team in charge of designing, manufacturing, and marketing the ballpoint pen.

Of course, to be fair to the students, the grading criteria were not as ambivalent as the project expectations! During the initial assignment, we informed students that the project grade would constitute 50% of the overall course grade, with the high percentage reflecting the importance of the project. To ensure that the checkpoints were taken seriously, each intermediate checkpoint contributed 15% to the course grade, and the final presentation contributed 20%. We also told students that grades would include a significant style/grammar component to assess communication skills, as described in the Overview of Project Goals.

One final note on the logistics of directing the project is related to the time period of the case. The business students were restricted to using advertising methods available during the World War II era, but the engineering students were allowed to investigate and use current materials and processes. We made this decision so that the project would not become an exercise in researching the availability of desired materials and processes during the period of interest. We wanted the students to focus on coming up with the best possible plan without undue regard to historical feasibility. We also allowed both business and engineering students to make financial estimates in current dollars and then use a constant economic deflator to calculate an equivalent amount in 1945 dollars.

Once the case study was off and running, our challenge was to find ways to integrate information from the case study into the standard course material. Of course, the case study could have been conducted entirely apart from the rest of the class, but there is recognized value in synthesizing different aspects of a course.² The most direct method of synthesis we used was to devote a full section of the course to the economics of design and another section to the economics of

manufacturing. The design portion of the course was taught just prior to the first checkpoint, and the manufacturing portion of the course was taught just prior to the second checkpoint. We invited a guest lecturer from an area industry to speak to the class on each topic, and we discussed current trends using information from the Internet and other sources. These sessions were designed to train students to recognize that every decision has an economic impact and to introduce students to proven methods and to new ideas for minimizing cost while maintaining quality. We also used the sessions to address related questions about the project and to discuss progress informally between checkpoints.

A less direct method of synthesis involved using examples from the project in class discussions whenever possible. The World War II era of the project lent itself to inclusion in various discussions, since that era was the beginning of many modern industrial engineering practices. However, we found some more specific ways to inject information learned through the project into class discussions. For example, the students correctly determined that it would not be financially feasible to make any drastic changes in the manufacturing process, such as retrofitting the existing factory with full-scale automation. The impossibility of suddenly introducing 50 years worth of manufacturing and process improvements was a small nugget that fit in nicely with discussions of continuous process improvement.

To summarize, project logistics in terms of assigning and directing the project are listed below.

- Provide the written case study, current scenario, and timeline for project completion.
- Conduct the assignment session as a company meeting, with the professors as managers and the students as a newly formed project team.
- Simulate reality by providing general expectations without giving specific guidelines; force students to come up with project requirements and a plan to accomplish them.
- Set up intermediate checkpoints to exchange information. Again, conduct these sessions as if they were company meetings.
- Make the project dynamic rather than static by introducing new requirements or adjusting the time schedule during checkpoints.
- Have a wrap-up session to discuss historical events and compare them to team decisions.
- Provide definite grading guidelines.
- Communicate decisions about the era in which the students are expected to work.

Logistics in terms of integrating the case study with the remainder of the course are listed below.

- Devote a section of the course to economics of design.
- Devote a section of the course to economics of manufacturing.
- Invite guest lecturers from industry to provide insight into how their companies perform design and manufacturing tasks economically.
- Use examples from the project to tie into class discussions wherever possible, especially in cases where they illustrate classroom theory.

Assessment of Effectiveness

At the end of the semester, the eight students involved in the project filled out an evaluation form with two quantitative assessments and several qualitative assessments. For the quantitative assessments, students were asked to rate the project in two different areas on a scale of 1 (low) to 5 (high). Most of the responses were either 4 or 5, with two responses of 3 on the first question (regarding enjoyment of the project) and only one response of 3 on the second question (regarding learning value of the project). Results are shown in Table 1.

	Overall Response	Response of Engineering Students	Response of Business Students
Rate the overall project experience in terms of your enjoyment of the project.	4.00	4.25	3.75
Rate the overall project experience in terms of how much you learned.	4.25	4.25	4.25

Table 1. Student responses to quantitative assessment items.

We were pleased with the relatively high ratings, but the responses to qualitative questions were even more encouraging. We asked the following general questions:

- What did you like best about this project? What did you like least?
- What one thing would you change to improve the project? What one thing would you leave the same?
- What did you gain by working with students outside of your discipline? What frustrated you most about working with students outside of your discipline?

With the exception of the last question, none of these assessment items were directly related to the project goals. However, most of the student responses can be related to three of the four goals, suggesting that the project was mostly successful in achieving its specific goals. The following list of selected comments supports this assertion.

Comments related to cross-disciplinary collaboration:

- From a business student: “I liked teaming up with the engineering department.”
- From an engineering student: “It was fun working with the business department. This brought forth a more real-world atmosphere – something that I have not experienced here at school.”
- From an engineering student: “It was eye-opening to observe their different point of view ... they have no concept of ‘engineerability.’”

Comments related to communication skills:

- From a business student: “I realized how people don’t speak the same ‘language’ and you have to explain things. This will help me if I ever work on a project like this again.”
- From an engineering student: “The business students have a different way of thinking – something to get used to.”

Comments related to project management:

- From a business student: The project “felt overwhelming [and] gave me a sense of real-world teamwork, [along with an] overall better grasp of what needs to be known in similar projects.”
- From an engineering student: “The checkpoints were extremely valuable! We couldn’t put everything off until the last minute.”

The one goal that did not receive any positive comments was the one about making the transition from an idea to a workable design. However, it did receive the two negative comments listed below, which at least suggest that it was a recognizable component of the project. (Both comments are from engineering students.)

- We “needed more time for innovation.”
- We “could not be very creative.”

Aside from the frustration of engineering students regarding the lack of time to do more meaningful design work, the only completely negative comments on the evaluations were related to the ambiguity of the project and the difficulty of knowing exactly how to proceed. Since we were purposely vague in the project assignment, and since other comments suggest that the overall project approach was successful, we are not terribly concerned with this area of negative feedback. Thus, in terms of both quantitative and qualitative feedback, we feel that the case study approach to teaching engineering economics and business policy was a success.

Limitations

We currently have a small group of engineering students, so we conducted this project with only one team of four engineering students and four business students. This small sample size might bias the project assessment toward favorable student and faculty reaction, making it difficult to generalize the results to a larger group of students. However, two observations possibly help to offset this limitation. First, the authors led a team of three students (two from engineering and one from marketing) to work together on a different project with similar goals in a previous semester, and the results were not nearly as favorable. Second, successful integration of the project into course material is largely independent of class size.

As the engineering economics class grows larger, we will need to adjust our approach so that the case study is set up as a competition, either with different teams representing different companies or with different teams representing the same company and vying for the best internal solution. We might also want to consider using smaller teams to ensure that each student is participating

fully. While we did not observe any slackers among our first group of students, we realize that the potential for individual non-contribution to a group project tends to increase with group size.

Ideas for Improvement

One of the biggest difficulties with this project was the 50-year gap between the case study and the present day. Although the engineering students were allowed to use current materials and processes, they were somewhat tied to the middle of the twentieth century by the impossibility of suddenly making huge changes on the manufacturing floor. A present-day project might prove to be more educational. Of course, setting the project in the present day eliminates the previously mentioned advantages of learning from the World War II era in general and from the historical events of the writing instrument industry in particular. However, we do need to carefully consider the tradeoffs associated with each option.

We would also like to increase the opportunity for engineering students to meet the goal of taking a project from the idea stage through the design and manufacturing stage. It will be challenging to find a product that is simple enough to be done in a semester, while still allowing the other three goals to be met. We will continue to search for workable options!

On a logistical level, the business policy class and the engineering economics class met at different times, making it very difficult to schedule checkpoints. Since the business policy class is large and has several teams working on different projects, one possibility is to set up a special session of business policy for the students assigned to the engineering project.

Conclusion

This case study collaboration between the business policy class and the engineering economics class was a success in the eyes of both students and professors. Given the opportunity to collaborate across disciplines, students from engineering, marketing, accounting, and management ranked the experience 4.25 out of 5 in terms of learning value and 4.00 out of 5 in terms of enjoyment. Qualitative student feedback supports the professors' observation that the project goals were largely met. We will continue to work together to refine the case study and its implementation, because we believe it has tremendous educational value in terms of preparing our students for jobs after graduation.

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