

## A Supplemental Resource for Teaching Engineering Economy

Joseph C. Hartman  
Lehigh University

### Abstract

We report on the use of *The Wall Street Journal* as a supplemental source of information for teaching Engineering Economy at the undergraduate level. While the *Journal* is often associated with reporting information concerning financial markets, it also provides a plethora of information on engineering firms, or firms that engage in engineering activities, and their capital investment decisions. Articles that focus on these decisions (e.g. plant openings and closings, equipment replacement, and product design and development) can be used as examples to enhance classroom teaching. We illustrate ways in which articles can be used in the classroom and provide student feedback from implementation in the Spring of 2001. These include the use of an open-ended exam that was motivated by an article. Conclusions from use of the open-exam format are also provided.

### Introduction

This author has promoted the teaching of Engineering Economy in a decision-making context in hopes that students learn the necessary steps to make decisions about capital investments for engineering problems<sup>4</sup>. While teaching in this framework may help students understand the decision-making process, concrete engineering examples are required such that the students can appreciate its application.

Schmahl et al.<sup>5</sup> recently published a study in which they examined end-of-chapter problems of three leading textbooks for undergraduate Engineering Economy. The results showed that unless authors “make an effort to increase emphasis on engineering applications through problem selection, students completing engineering economy courses will still lack the skills they need to apply economic principles to many engineering decisions.”

To partially address this issue, we report on an idea that is commonplace in many business and/or finance curriculums in higher education: using *The Wall Street Journal* to enhance teaching a course. This is not to say that we advocate utilizing the *Journal* in the same way that a business or finance course might. Rather, we focus on the reporting of activities by firms that are directly related to Engineering Economy. For example, if a company decides to close a plant (abandonment), select a new vendor for machinery (equipment replacement) or install a new line in a plant (capital investment), relevant information is generally published in *The Wall Street Journal*. This information allows an instructor to supplement teaching with real-world, engineering examples.

This paper reports on the use of *The Wall Street Journal* in an undergraduate Engineering Economy course taught in the Spring of 2001. We discuss three ways in which the *Journal* was utilized and analyze feedback from students in the course. This includes reviewing the use of an open-ended exam format motivated by use of an article concerning capital investment.

### Implementation and Potential Applications

We used *The Wall Street Journal* in three specific classroom formats:

1. *Provided articles and asked students to answer related questions.* In this format, articles supply information that can be used as the basis for examples, homework problems or quiz questions. The questions asked are only limited by the information given in the article.

For example, in March of 2001, Maytag Corporation announced that it was increasing its manufacturing capacity for its washers and dryers and opening a research and development laboratory<sup>3</sup>. As the article provided numerical data concerning investment and operating costs and revenues, the students were asked to find internal rates of return and payback periods for investment in the additional capacity. They were also asked to how to evaluate investments in capacity expansion versus the use of overtime. Finally, they were asked about the risks involved with expanding in a slow economy and to provide an analysis to address these risks.

2. *Provided various articles and asked students to “find” relevant engineering economy topics.* As opposed to asking students to answer pointed questions, as in the previous application, students are asked to discover the engineering economy subject matter present in a given article. This forces students to interpret the articles and examine them from a “bigger picture”, or topical, perspective.

For example, in April of 2001, Midwest Express announced that it was purchasing new jets from Boeing and Embraer<sup>2</sup>. The students found topics concerning equipment replacement, technology choice, capacity expansion, risk analysis and cash flow analysis in the article.

3. *Tested students with an open-ended final exam based on an article.* This course emphasized topics in engineering economy and decision analysis. Thus, it was believed that the use of an appropriate article would force students to apply both engineering economy and decision analysis techniques under conditions of risk and uncertainty. The chosen article provided numerous data, but it was clear that many of the estimates were uncertain. More about this application is discussed later.

The article described a possible investment in a liquefied natural gas facility and pipeline being considered by Enron<sup>3</sup>. The article may be summarized as follows: Enron Corporation announced that it is strongly considering the development of a liquefied natural gas (LNG) terminal and facility in the Bahamas. The facility, which would cost between \$300 and \$400 million, is expected to service the Florida market, where gas demand is forecasted to double between 2000 and 2009. Plans are to build a 90-mile pipeline to move product to a location north of Miami. While shipping LNG is generally more expensive than moving natural gas delivered via pipeline in the US, recent surges in natural gas costs have opened the door for

this possible expansion. It would be the first facility built to feed the U.S. market since 1978. Enron still requires permits and applications from the Federal Energy Regulatory Commission, Florida and the Bahamas, but it hopes to begin construction early in 2002 and start shipping product in the second half of 2004. 80% of the funding is to be financed through capital markets. Long-term contracts with utilities or gas contractors are expected to defray project costs.

Specifically, the exam asked the following:

The following page contains an article recently printed in *The Wall Street Journal* concerning a possible investment in a liquefied natural gas facility. As a new hire to the engineering department, you are to determine whether the investment should be made. Your presentation will be made to the Board of Directors, who have been known to ask a lot of tough questions, so be prepared. Specifically, you should be able to make a recommendation (whether to invest or not) and defend your decision with rigorous analysis that considers economic and non-economic factors while addressing the risk and uncertainty inherent in the project. All assumptions made should be explicit and again, you should be able to defend them.

If possible, the data for your analysis (or analyses) should be extracted from the article. However, if data that you require is not given in the article, assume a reasonable value (or values) to continue your calculations. In addition to defending your assumptions for any data created, you should also state possible sources for the data. The company uses a 12% rate of interest for all discounting purposes.

Take time to think about your answer thoroughly before you begin writing. You have 3 hours.

There are obviously other ways in which to utilize stories that are reported in the news. One could construct examples for class or homework problems with realistic background information and data. The point of this article is to illustrate that this information is readily available. It should also be noted that this information is in many locations and in many forms of media. Finally, the amount in which these articles are integrated into a course is entirely up to the instructor.

In our application we used a total of two classroom hours for discussion and the final exam period (three hours). One could reserve some time for class discussion or just insert small examples into a normal lecture -- to the point that one may not even notice a change in format -- just that the examples have been "livened" with real, engineering applications. It is believed that the best application of these articles is the basis of open-ended problems. This is because, in many instances, the articles provide a lot of data, but are still incomplete (one must remember that these are very large and complicated investments). Thus, it is up to the student or team to fill in the gaps either with additional research or validated assumptions. This is truly decision-making in the real world, as not all information is readily available.

## Student Reaction

We implemented these ideas in an undergraduate Engineering Economy course in the Spring of 2001. The class consisted of 56 undergraduates, most of which were second-semester junior Industrial Engineering students. After the semester, the students were surveyed about use of the *Journal* in the course. The questions and survey results are presented in Tables 1, 2 and 3. Table 1 focuses on responses to questions concerning the use of the articles in classroom discussions. Note that “Agree Strongly” receives a score of 5 while “Disagree Strongly” receives a score of 1.

Table 1. Student responses concerning use of articles in classroom discussion(s).

Question	Agree Strongly	Agree Somewhat	No Opinion	Disagree Somewhat	Disagree Strongly	Avg.
The discussions were interesting.	6	30	2	3	0	3.95
The articles contained relevant Engineering Economy topics.	13	24	3	0	0	4.25
You would be interested in having more of these types of discussions.	9	25	2	3	0	4.03

As Table 1 shows, the students were generally enthusiastic about using *Journal* articles as the basis for classroom discussions. Additionally, they were able to identify relevant Engineering Economy topics in the articles.

Table 2 focuses on the student responses concerning using an article as the basis of a final exam question. As noted earlier, students were given an article describing a company’s possible investment in a liquefied natural gas facility and asked to determine whether the investment should be made. The article provided a lot of data, but required that the student fill in many gaps with explained assumptions.

Table 2. Student responses concerning use of article in final exam.

Question	Agree Strongly	Agree Somewhat	No Opinion	Disagree Somewhat	Disagree Strongly	Avg.
The final exam was comprehensive.	10	14	1	12	5	3.29
The exam tested your comprehension of Engineering Economy topics.	9	16	2	12	1	3.50
The content of the exam made you feel like you were addressing a real problem.	12	13	4	8	3	3.58

The conclusions about the exam were mixed in that some students did not feel that the exam tested their Engineering Economy skills. One must note that the course focuses on Engineering Economy and Decision Analysis. In retrospect, we should have asked if their decision-making skills were tested. It is important to note that most students thought they were solving a “real problem”.

It is clear that the final exam given to the students was not “typical” in that it did not follow a specific question-answer format. The students were also asked to comment on the use of an open-format for an exam, as these types of questions are often relegated to projects or case studies. Of the 40 students answering the survey, 38 said they had never taken an exam with that format before. As this author stresses decision-making with Engineering Economy, the goal of the exam was to see whether the students could make a decision in light of incomplete information, as would be expected in a real situation. The responses are provided in Table 3.

Table 3. Student responses concerning final exam format.

Question	Agree Strongly	Agree Somewhat	No Opinion	Disagree Somewhat	Disagree Strongly	Avg.
The exam was easier than an exam with a question/answer format.	3	6	5	15	11	2.38
The open-ended format is preferred to a question/answer exam format.	4	7	5	15	9	2.80
You were prepared for the exam.	10	14	4	8	4	3.45
The exam was fair.	6	12	9	10	2	3.26

A majority of the students felt that they were prepared for the exam and that it was fair. It is worth noting, and as a point of reference, that the students answered the question “The grading procedures for the class were fair” with regards to the entire course (before taking the open-format exam) with an average score of 3.70 and standard deviation of 1.23.

It is also clear from the data in Table 3 that students would rather take exams in a more specific question/answer format. This may be due to a variety of reasons, including the fact that they are more accustomed to structured formats. This alludes to a more troubling point that goes beyond the scope of this article, in that students do not seem prepared to tackle open-ended problems. This is troubling because once they leave their institution of higher learning, it is reasonable to assume that most problem-solving situations which they face will be defined as “unstructured”.

The students were also asked to provide their comments (in addition to the survey questions). While only a few students provided comments, they spanned a variety of topics. Concerning the exam, many comments were positive:

- It was a good exam.
- Exam was more challenging and it also tested application skills.
- Hard to prepare for exam but it was a good exam.

Many students focused their comments on the “open-ended” nature of the exam. These comments included:

- The exam left too many assumptions and guess-work for the student. A lack of information was provided for analysis.
- No data provided.
- It made the test easy for all to look intelligent and knowledgeable on the subject matter by incorporating everything they knew, even if they know 3 out of 15 concepts.

- Exam was real but it took more time to justify assumptions than use engineering economy techniques.
- Found it vague and hard to effectively answer the questions. Questions were not clear.
- The format was good but it should have more numbers (available for analysis).

These comments are to be expected by those that face *real* problems, as not all of the necessary data is provided and thus, assumptions must be made. While this may have been discerning to a number of students, it aided in this instructor's goal of putting the student in a realistic decision-making situation where they had to apply the techniques of Engineering Economy.

It is interesting to observe the solution techniques used in the open-ended format, as none were specified with the problem and students were free to choose their analyses. Table 4 provides a list of techniques utilized by the students and their frequency (number of students). Recall that 56 students took the exam, thus, the average number of analyses performed by a student was just under three. Note that this count provides no reflection on the quality or accuracy of the answers.

Table 4. Student analyses utilized in final exam.

<b>Analysis</b>	<b>Number of Students</b>
Before-Tax Cash Flow Analysis	44
Non-Economic Factors Discussion	23
Expected Value Analysis	20
Payback Period Analysis	15
Cost Estimation	13
Benefit-Cost Analysis	8
After-Tax Cash Flow Analysis	7
Decision Tree Analysis	7
Non-Economic Discussion and Analysis	6
Sensitivity Analysis	5
Scenario Analysis	5
Project Balance Analysis	4
Breakeven Analysis	3
Economic Life	2
Decision Making under Uncertainty	1

As can be seen by the table, a majority of the students included some basic (before-tax) cash flow analysis before using an analysis that accounts for risk and/or uncertainty. The most popular risk analyses included expected value analysis and payback period analysis.

There are two troubling conclusions that come from this data. First, the students did not utilize sensitivity analysis extensively. This is despite the fact that the article states that the investment is attractive to the company due to the current price range of natural gas (with numerical data given). This is a situation where sensitivity analysis is useful as natural gas prices are subject to fluctuation and there clearly is a price range where the investment would not be feasible. This information would be quite helpful in making the decision.

The second troubling point, which is tied to the first, is that students do not readily engage in risk analysis unless they are asked. That is, in a structured exam format, a student may be asked to determine which parameter is most sensitive with respect to an investment decision. In this type of format, most students will answer using sensitivity analysis. However, it is clear from the data in Table 4 that the students do not readily utilize sensitivity, scenario, breakeven or decision-tree analysis in a less structured exam, even though it is clear that the given data is uncertain.

This analysis illustrates that it is critical that students not only understand *how* a method works, but that they must also understand *when* and how it is to be applied. Otherwise, teaching the appropriate analyses is in vain. This skill can only be attained through practice. Thus, to address this problem, it is suggested that more of these open-ended formats are provided to the students in order to condition the unprovoked use of appropriate analyses. The articles described in this paper provide a means in which to construct these types of problems.

### Aid in Implementation

An instructor might be discouraged from integrating these ideas into an Engineering Economy course because it will further drain their precious time in preparing for class. However, Dow Jones and Company (publisher of *The Wall Street Journal*) provides resources for professors in order to encourage use of the *Journal* in classes. More information is available at <http://www.professorjournal.com>. Information is provided for a variety of topics, including Accounting, Microeconomics, Finance, and Engineering Economy. This is not to say that an instructor needs this service or that this is the only service available, but merely a report on this author's use of the service. Any news source or company contact could be used in a similar manner.

### Conclusions

Teaching engineering economy in a decision-making context requires the use of engineering problems and examples in order for students to appreciate the application of techniques. As noted in an earlier study, Engineering Economy textbooks may not provide enough of these types of examples. We reported on experiences from using *The Wall Street Journal* as a supplemental source of information, mainly for providing real examples of engineering firms or firms engaged in engineering activities, in an undergraduate course. Articles were used to promote discussion of Engineering Economy topics as well as the basis for computational problems. A survey of students discovered that the students found relevance between Engineering Economy topics covered in class and those reported in the news (i.e. *The Wall Street Journal*). They also felt that problems derived from news articles appeared to be "more realistic" than typical Engineering Economy textbook problems. In addition to use of articles in teaching, conclusions were also provided concerning the use of an open-ended exam that was motivated by an article concerning an investment decision. It was clear from responses of the students and the analyses utilized that they are ill prepared to work on open-ended problems which unfortunately await them in the real world. It is suggested that educators try to incorporate more open-ended formats in their teaching in order to help educate students on how to appropriately apply analysis techniques.

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## Author Biography

JOSEPH C. HARTMAN is an Assistant Professor in the Department of Industrial and Systems Engineering at Lehigh University. He received his Ph.D. and M.S. in Industrial Engineering from the Georgia Institute of Technology and B.S. in General Engineering from the University of Illinois at Urbana-Champaign. He is a member of ASEE, IIE, and INFORMS and currently serves as director of the EED of ASEE.