Baseball Stadium Design: Teaching Engineering Economics and Technical Communication in a Multi-Disciplinary Setting

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Introduction

The Rowan University College of Engineering has a hallmark 8-semester, interdisciplinary engineering clinic sequence, intended to give students practical experience in engineering research and design, as well as technical communication. The full eight-semester sequence has been described previously in detail.[1-4]

This paper describes a Sophomore Clinic module on the economic design of a baseball stadium, conducted in the spring semesters of the 98-99 and 99-00 academic years. Students from all four Rowan engineering disciplines took the module. Pedagogical goals of the project included:

- Developing public speaking skills in a realistic, business setting
- Giving students practical experience with open-ended design problems
- Developing teamwork skills
- Providing instruction in engineering economics and statistics

This paper describes the project in detail and discusses how it addresses each of these pedagogical goals.

Project Description: Students worked in teams of 3-4 to select a new stadium for a local major league baseball team, from the list of options shown in Table 1.

In order to determine which stadium best met the team's needs, students were thus required to project income from ticket sales, which was related to the success of the team by the following specifications, also provided by the instructor:

Attendance Information: In the current stadium, even when the team is terrible, it draws a loyal 20,000 fans per home game. The team draws MUCH better

Table 1: Costs Associated with Candidate Stadium Designs.

Seating Capacity	Cost of Construction	Annual Upkeep
70,000	$350 million	$16 million
60,000	$300 million	$14 million
45,000	$250 million	$12 million
30,000	$200 million	$10 million

Abstract

Rowan University's Sophomore Engineering Clinic provides students with an innovative introduction to multidisciplinary engineering design linked with formal training in technical communication. The course is team taught by faculty from the College of Communications and the College of Engineering. During the past two years, a very successful Sophomore Clinic module on economic design of a baseball stadium was conducted. Student teams were presented with a list of possible stadium designs, in which the major parameters were cost and seating capacity, and were challenged to determine which design best addresses the team's needs. Working in teams of 3-4, they analyzed data to quantify the effect of team payroll on won-loss record, which in turn affected ticket sales and merchandising revenues. Their goal was to produce an optimized economic strategy for running the team, the cornerstone of which was the stadium selection. To support this project, engineering classroom instruction was devoted to introducing the design process (~2 weeks), fundamentals of engineering economics (~6 weeks) and basic statistics (1 week). Concurrently, communications faculty members spent nearly four hours per week training students in public speaking.

At the end of the semester, students presented their design in a simulated business meeting to engineering faculty, who portrayed the owners of the team, and communications faculty, who portrayed city officials. Students were thus challenged to convince two groups who had very different agendas that their design is best. Consequently, the module provided a practical exercise in persuasive speaking that nicely complemented the more familiar technical seminar.

This format also served to connect the engineering economics aspect of the clinic with the public speaking component. Students responded favorably to this experience, rating it above 4 (4.33 and 4.13 in successive classes) on a five-point scale. Comments from students on course evaluation forms indicated that they felt this experience "prepared them for business issues" and "was the most valuable thing they had done this year."

when it is doing well, so for each win above 70, you get an extra 1,000 fans per home game. For the purposes of this problem, we will assume the current stadium can last another season or two, but cannot be used beyond that. The new stadium is expected to draw better, especially for the first couple seasons while it is new:

FIRST YEAR: 25,000 fans per game, plus 1,000 for each win above 60.
SECOND YEAR: 25,000 fans per game, plus 1,000 for each win above 65.
THEREAFTER: 25,000 fans per game, plus 1,000 for each win above 70.

Ticket Sales: There are 81 home games per year. Currently, the mean ticket price is $14. Fans are used to prices increasing by 50 cents per season- you can budget for this increase without expecting any drop-off in attendance. You can increase ticket prices by more than that if you want, but studies show that attendance will fall by 10% for every "extra" dollar increase in ticket price.

Also, note that each ticket holder averages an additional $10 in food, parking, programs, etc.

The success of the team, in turn, was related to the payroll. Thus, students were provided with information shown in Table 2, which are actual team salaries and won-loss records for the 1998 and 1999 major league baseball seasons. Additional specifications provided by the instructor allowed students to project revenues from other sources such as merchandising and TV/Radio contracts:

Television and Radio Money: The team will receive $40 million in the coming season, increasing by $3 million per year for the next 10 years, at which time a new contract will be negotiated.

Merchandising: You can count on $5 million per year, plus another $100,000 for each win above 60.

Thus, the thrust of the design problem was to determine whether or not the increased revenues associated with a winning team would be sufficient to offset the expenses of high payrolls and a larger stadium.

Another important aspect of the project was deciding how the stadium would be paid for. It was specified that the owners of the team had only $30 million in cash available, and that they had the option of borrowing an unlimited amount of money at 6% annual interest. Further, it was specified that the city could be asked to make a contribution of any size to the construction of the stadium.

At the end of the semester, each student group presented its design in a mock business meeting. Meetings were conducted in a conference room with appropriate

Table 2: Payrolls and Won-Loss Records for all 98 and 99 Major League Baseball Teams.

Team	1999 Salary (In Millions)	1999 Record	1998 Salary (In Millions)	1998 Record
New York Yankees	$92.0	98-64	$66	114-48
Texas Rangers	$80.8	95-67	$61	88-74
Atlanta Braves	$79.3	100-62	$62	106-56
Los Angeles Dodgers	$76.6	77-85	$63	83-79
Baltimore Orioles	$75.4	78-84	$72	79-83
Cleveland Indians	$73.5	97-65	$60	89-73
Boston Red Sox	$72.3	94-68	$59	92-70
New York Mets	$71.5	97-66	$59	88-74
Arizona D-Backs	$70.0	100-62	$32	65-97
Houston Astros	$56.4	97-65	$48	102-60
Chicago Cubs	$55.4	67-95	$50	90-73
Colorado Rockies	$54.3	72-90	$48	77-85
Anaheim Angels	$51.3	70-92	$48	85-77
Toronto Blue Jays	$48.8	84-78	$34	88-74
San Diego Padres	$46.5	74-88	$53	98-64
St. Louis Cardinals	$46.3	75-86	$44	83-79
San Francisco Giants	$46.0	86-76	$49	89-74
Seattle Mariners	$45.3	79-83	$44	76-85
Milwaukee Brewers	$43.0	74-87	$32	74-88
Cincinnati Reds	$38.0	96-67	$21	77-85
Tampa Bay Devil Rays	$37.9	69-93	$27	63-99
Detroit Tigers	$37.0	69-92	$19	65-97
Philadelphia Phillies	$30.4	77-85	$29	75-87
Oakland A's	$25.2	87-75	$22	74-88
Chicago White Sox	$24.5	75-86	$35	80-82
Pittsburgh Pirates	$23.7	78-83	$14	69-93
Kansas City Royals	$16.6	64-97	$36	72-89
Minnesota Twins	$15.8	63-97	$25	70-92
Montreal Expos	$15.0	68-94	$8.4	65-97
Florida Marlins	$14.7	64-98	$15	54-108

professional attire. Engineering faculty members portrayed the owners of the team, and public speaking faculty members portrayed officials of the city. Each student group was required to present the following:

- Their selection of the stadium, and the rationale for the choice
- A detailed cash flow diagram of revenues and expenses for a planning horizon of at least 10 years
- Specification of how the cost of the stadium would be divided between the city and the team owners
- A detailed, realistic time frame for paying back the loan, if any
- A decision on who would own the stadium- city or team- upon its completion

Students were advised that both the city and the team had an absolute veto on any stadium plan, so their design must appeal to both groups to be effective.

Issues for Discussion

This unique, open-ended problem provides many relevant topics for discussion and/or subsequent lectures. Among these potential questions are:

? How can one raise capital for such endeavors?

? What are the uncertainties in this problem and how should they affect decision making?

? How does one balance conflicting needs? For example, the city managers want a winning ball team, while the owners want to maximize profit. No single outcome optimizes the wishes of both groups, yet they must agree on a proposal

? What information is relevant enough to warrant presentation in the business meeting?

? Are there valid alternatives beyond the scope of the project that should be considered? (sell or move the team).

Public Speaking Skills

In recent years, many engineering educators have recognized[5-7] that technical communication is a vital component of engineering practice and have sought ways to develop these skills in their students. In addition, the new ABET criteria mandates that this will be a priority for all accredited engineering programs[8]. In general, most of a student's experience with public speaking follows the seminar format: a prepared speech of a predetermined length followed by a couple of questions. The authors certainly do not dispute the value of this experience; indeed, each student gave three graded speeches (on topics of the student's choice and unrelated to the Baseball Stadium project) during the course of the semester in Sophomore Clinic. However, the business meeting format of the final presentation was intended to complement this experience, as it differed from the seminar in several important respects:

- It was persuasive, rather than informational, in nature
- It was a team presentation, rather than a seminar given by an individual
- The "audience" participated actively throughout rather than waiting passively until the end

Development of Design Skills

Another recent trend in engineering education is the integration of design experiences into the lower levels of the curriculum, in addition to the traditional senior capstone design course.[1,3,8-12] Such integration is desirable because it provides more time for these crucial skills to develop, and because it provides a practical context that helps students appreciate the significance and interrelationships of the many topics covered in their technical education.

This project was not technically esoteric; it was readily understandable and manageable for sophomores. However, it provided a substantial design challenge because of the conflicting agendas. It was stated in class that the team's primary agenda was to make money, regardless of team success. The given specifications were crafted so that a design with minimal payroll and small stadium would prove to be most profitable. However, the city's primary agenda was to foster commerce in the area around the stadium and enhance the prestige of the city, and these ends were best met by a winning team. This motivated the students to approach the problem in a spirit of creativity and compromise, and insured that the design problem would be open-ended with no provably optimal solution.

To support the students' design efforts, the first two weeks of lab time were devoted to engineering design principles and miniature design problems, as well as techniques such as the House of Quality.[13]

Developing Teamwork Skills

An important feature of the problem is that the decisions that needed to be made (size of stadium, source of funding etc.) were too closely interrelated to be divisible. This helped insure that students would go through a true team experience. The teams certainly identified many tasks, such as specific calculations, which could be assigned to an individual. However, the team had to interact and compare notes in order to make the critical decisions; there was no real way for members to simply work independently on separate aspects of the problem and then combine their efforts at the end.

Exposure to Engineering Economics and Statistics

In order to compare meaningfully the four possible stadium designs, students needed to possess a working knowledge of such engineering economics principles as present worth and rate of return, and techniques such as sensitivity analysis. Six weeks of classroom instruction were devoted to instruction and problem-solving exercises in engineering economics. Each meeting was concluded with a discussion of how the new principles introduced could be utilized in the baseball stadium design project.

As indicated in the Project Description section, the instructors contrived most problem specifications for simplicity and convenience. However, it was considered desirable to include one aspect to the problem that required engineering approximations, and this was quantifying the relationship between team payroll and won-loss record. One week of class time was devoted to basic statistical techniques such as linear regression. The College of Engineering does not require students to take a full course on statistics, but recognizes that basic statistics are frequently employed by engineers,

and thus inclusion of this instruction into a multi-disciplinary sophomore course is a benefit to the program.

Summary and Conclusions

The Baseball Stadium Design project described here proved to be a popular and highly successful vehicle for introducing principles of engineering economics, engineering design and technical communication into the sophomore year for students of all engineering disciplines. Student feedback on the module was very positive. When asked to rate the module overall on a scale from 1-5, two classes of students gave mean ratings of 4.33 and 4.13. Specific student comments included that the project was enjoyable and that the business meeting format of the final presentation was a very realistic and useful exercise.

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