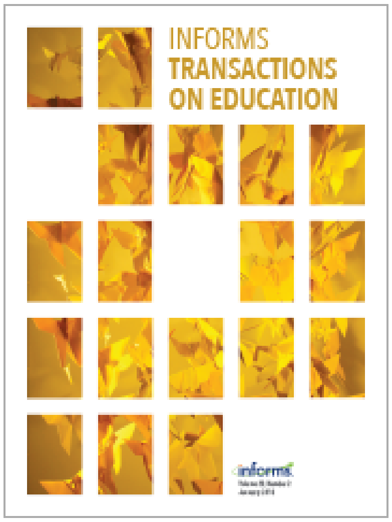

INFORMS Transactions on Education

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

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informs
http://pubsonline.informs.org/journal/ited/

INFORMS TRANSACTIONS ON EDUCATION
Vol. 18, No. 3, May 2018, pp. 174–182
ISSN 1532-0545 (online)

Effectively Engaging Industry Partners Within the Classroom

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Received: August 27, 2006
Revised: March 24, 2017; September 15, 2017
Accepted: September 28, 2017
Published Online in Articles in Advance: March 14, 2018

https://doi.org/10.1287/ited.2017.0189

Abstract. Student projects with an industry partner provide a meaningful way for students to translate abstract knowledge into practice, and to develop the data management and communication skills desired in industry. This paper provides suggestions for engaging an industry partner in a classroom and improving the classroom project experience. Set up as a competition, a single industry partner works with a multitude of student teams on the same problem. The project design aims to develop students' project framing, data management, and communication skills. The paper covers general considerations for field-based course projects, and provides suggestions on how to address these issues. In general, students have given exceptionally good feedback ratings for the project. Learnings from the student, faculty, and industry partner perspectives are discussed. Although based primarily on experiences in a simulation class, instructions and practitioners can apply many of these observations more widely in an operations research or analytics curriculum.

History: This paper has been accepted for the *INFORMS Transactions on Education* Special Issue on Field-Based Education.

Keywords: group projects • teaching with projects • project-based learning

1. Introduction

Operations research (OR) is an applied discipline for solving decision-making problems using analytical methods. Most OR curricula involve a methodological focus on specific OR methods, such as simulation and optimization. However, classroom examples and assignments tend to be less complex and ambiguous than real problems, which typically require collaboration to fulfill client expectations in relation to an open-ended problem (Cheng et al. 2013). Moreover, in the classroom setting, systematic structuring and management of the problem-solving process is necessary to avoid violating time, budget, and quality constraints (Salo 2012). As a result, many students struggle with the ambiguity and complexity of the workplace after graduation. Researchers have recognized that students need to develop skills in applying OR in the real setting (Behara and Davis 2010, Cherney 2008). Students should be able to effectively interact with a client, structure complex problems, organize a coherent work plan, and work as a team (Salo 2012). The importance of communicating analytical work to a client or an organization in nontechnical terms cannot be understated; yet, as Grossman et al. (2008) point out, many OR students struggle to effectively communicate analytical content. Projects that partner with industry provide a meaningful way for students to develop such skills.

Student projects with an industrial partner offer practical learning experiences for students to translate abstract knowledge into practice. The experience students gain in solving real-life problems goes a long way toward building a solid base for their future careers (Aserkar 2013). Students who accumulate hands-on experience tend to be better prepared to recognize obstacles and solve problems in a real setting compared to students with only abstract knowledge (Grandin and Johnson 2010, Hillon et al. 2012). A faculty group from various institutions assessed students business intelligence and analytics skills and recommended that, at a minimum, students need to understand data management, a business functional area, quantitative analysis, and communication (Wixom et al. 2014). We can assume that OR graduates should show similar proficiencies.

This paper describes a project designed to help undergraduate students at Worcester Polytechnic Institute (WPI) to improve their skills in applying OR methods to real problems by working in teams on problems posed by industry. In addition to using OR methods to solve an open-ended industry problem, in this project, students create an abstraction of the problem as a simulation model, interpret results in a meaningful way, and learn to pitch their work to a client. Throughout the project, students solidify the methodological aspects of the simulation course as well as concepts broached in a number of courses throughout the OR curricula, i.e., data analysis, modeling, and statistical analysis. They also develop the new skills of effective communication and problem framing. Such a project adds palpable benefits for the student, especially those without prior industrial experience, as it helps to contextualize the material they learn in the classroom.

In addition to the benefits for the student, the project design helps faculty to prepare a meaningful context and directly address an organizational problem. By having a single industry partner working with a multitude of student teams on the same problem, the partner is provided with several, often viable, solutions. The single partner setting also provides a unique educational opportunity for students. In this paper, I give an overview of an approach to engage an industry partner so that the project experience is beneficial for the industry partner, students, and faculty. In this approach, the project is designed as a competition in which student teams submit proposals and final reports, along with their recommendations to the partner for judging. The assessment uses a sliding scale based on the industrial partners evaluation and the technical completeness of the project. This study includes focus groups with students and industrial partners to assess the educational experience and improve the project experience for subsequent course offerings.

The uniqueness of this approach in the OR curriculum is that industry engagement is with a single client, and a competition is set up among student teams. Student team competitions have shown to be effective in promoting academic performance (e.g., Beersma et al. 2003, Threeton and Pellock 2010), and developing interpersonal and intrapersonal attributes (Tauer and Harackiewicz 2004). Academic contests have successfully been integrated into the business course curriculum through semester-long, competitive, team projects (e.g., Özpolat et al. 2014), yet not in the OR curriculum. Similarly, team-based, competitive, single-industry projects have been deployed in computer information systems course projects (e.g., Wong et al. 2013), and undergraduate business strategy courses (e.g., Hillon et al. 2012). Yet few examples of successful similar projects can be found in the OR curriculum. The majority of field-based, teamprojects in the published OR education literature engage multiple industry partners in the same course offering (e.g. Handfield et al. 2011): As such the benefits of a single partner have not been well documented. In this light, this paper provides general considerations and learnings from a project design with a single industry partner and is a team-based competition.

2. Simulation in the OR Curriculum

Although a simulation course is part of the typical OR curriculum, it can include many perspectives, such as business, engineering, computing, and mathematics/statistics. The OR curriculum typically covers discrete-event simulation (DES) methods, Monte Carlo simulation methods (MC) and perhaps agent-based modeling (ABM) or system dynamics (SD). Graphical simulation packages, such as SIMUL8 (DES), Arena (DES), and AnyLogic (DES, ABM, and SD), as well as spreadsheet-based versions, such as @Risk (MC) and Crystal Ball (MC), facilitate teaching and learning because of their relative ease in constructing, running, and accessing statistical summaries. Yet, as reflected in the title of one of the earliest texts on simulation, *The Art of Simulation*, simulation is a tool that requires skill in its application (Tocher 1967). Effectively constructing a simulation model and using it to extract interesting and useful information about a real system is a challenging task (Conway and McClain 2003). This is in line with Robinson's view that the practice of simulation requires skills in "problem solving, computing, statistics, project management, people management and communication" (Robinson 2014, p. xviii). Hass (Cheng et al. 2013) argues that the only real way to learn these skills is "by doing" through project classes with real clients, summer internships, practicums, and the like.

Although the focus of this discussion is implementation of an industry-sponsored project in a simulation class, instructors could apply the project design to other courses in the OR curriculum.

3. About Worcester Polytechnic Institute (WPI)

Worcester Polytechnic Institute (WPI) is a private research university in Worcester, MA. The university has a student body of just over 4,000 undergraduate students and 1,000 graduate students. As a polytechnic center, it is devoted primarily to instruction and research related to technical arts and applied sciences. DES is offered by WPI's Industrial Engineering (IE) program, which is part of the Foisie School of Business. This unique organizational structure benefits IE students, as they take business courses that help contextualize the methodological aspects of their curricula. The Accreditation Board for Engineering and Technology (ABET) accredited IE program has an undergraduate population of approximately 60 students; it awards BS degrees in IE to approximately 15–20 students each year. The program requires all students majoring and minoring in IE to pass the OIE 3460—DES course. For perspective, the class meets for two hours, twice a week, for seven weeks, and has an enrollment of about 35 undergraduate students with different engineering majors (predominately IE). The students are typically in their third year of study, and one-third come from abroad. OIE 3460, in its current form, has been offered five times.

4. The Project Explained—The Pedagogical Sequence

The project includes a single industry partner and has a competition design. Student teams submit proposals and final reports; moreover, they present their recommendations to the industry partner for judging. Assessment uses a sliding scale based on the industry partner's feedback and the instructor's evaluation of the technical completeness of the project. Since the project introduces an element of competition, students exhibit high motivation to complete the project, and view its importance as substantial. The partnership increases students' awareness of the significance of effective communication and the feasibility of their proposed solutions. The project is designed to run for the duration of the course and is divided into three parts, as follows: Part 1: Problem Framing, Part 2: Data Management, and Part 3: Project Deliverables. Figure 1 depicts the three parts of the project for a seven-week course offering. See appendix for a sample course outline illustrating how the project is used in addition to methodological concepts covered in the course. Below, I describe each part of the project and provide advice and examples related to implementation.

4.1. Part 1: Problem Framing—Understanding the Industrial Partner's Needs

Problem framing is an important "soft skill" for simulation modelers (Cheng et al. 2013) and OR practitioners in general. Researchers have found educating students in problem-structuring methods to be beneficial in helping them to develop problem-framing skills, such as determining simulation study objectives (Rosenhead and Mingers 2001, Kotiadis 2007).

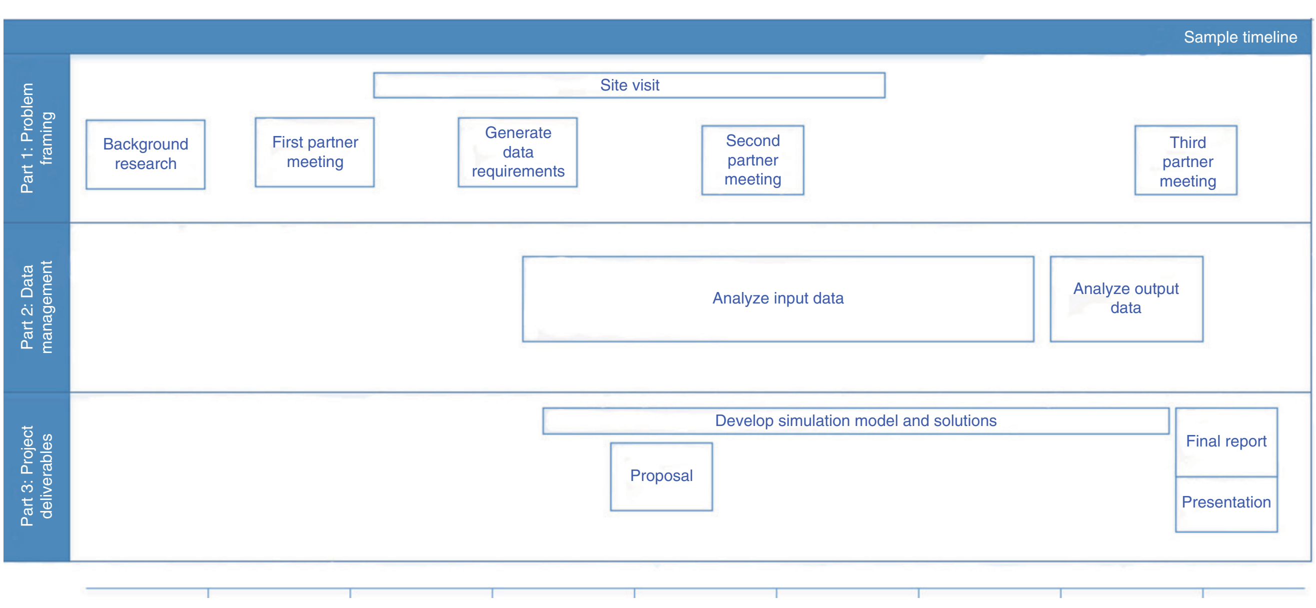
As students need to address a real-word problem that is riddled with uncertainty, the start of the project is designed to focus on the problem (as opposed to the model). Before the first class meeting, the instructor introduces the industry partner to the class and directs students to carry out the following steps:

- research the organization,
- prepare questions,
- read any preassigned materials from the partnering organization, and
- read preassigned materials focused on interviewing and gathering information.

In the early weeks of the course, the industry partner presents the organization's background and introduces the project. The involvement of the industry partner at this stage serves to motivate students and validate their experience as relevant to industry.

As students learn about the partnering organization and begin scoping the project, the instructor asks them to generate a data requirements list for submission to the partner. Inevitably, the list also contains questions related to the process or organization. The instructor consolidates questions and data requests for the partner for two reasons. The first is to avoid overwhelming the partner with copious, likely related, questions. The second is that when the instructor reviews requests from students, they can then be coached on how to ask clarifying questions. For example, one team asked for "data for the year 2014 for comparison." This was not specific, and thus became a talking point during a classroom discussion to illustrate the importance

Figure 1. Project Timeline



of well-formulated questions with clarity of purpose and proper framing, e.g., Which data—staffing data, cost data or arrival data? The instructor also provides examples of well-formulated questions.

Midway through the course, the industry partner returns to the classroom to answer questions and explain the available data. If possible, students have the opportunity to visit the partnering organization. In my experience, it is best for students to visit the site as early in the term as possible to help them contextualize the problem, understand the feasibility of the proposed solutions, and build ownership and excitement about the project.

Lessons Learned. There are several actions an instructor can take to make project framing more effective. These actions include:

- Handing out materials on how to solicit information from clients and structure a problem: For example, these materials can cover how to ask clarifying questions. As a result, students will have some basic guides they can follow to effectively understand the problem context and seek appropriate data.
- Having students peer review data requirements: Teams can post their data requests and questions for the organization on a course content management site, such as Blackboard, for other teams to review. Peer reviews force teams to think critically about how to ask clarifying questions.
- Holding debriefing sessions after interactions with the partner: Depending on the size of the class, these sessions can be whole-case discussions, small group sessions or online discussions. The goal is to help students identify effective communication skills.

4.2. Part 2: Data Management

Hass (Cheng et al. 2013) makes a compelling argument as to why simulation practitioners need to become more data friendly. The ease of obtaining massive amounts of useful data means that such practitioners can use simulations to tackle even broader problems and not merely for model calibration. Students need to develop the ability to exploit data and master the interplay of data and models (Cheng et al. 2013). Not only are data management skills increasingly necessary for simulation modelling, or even more broadly, for OR, but the ability to make decisions with incomplete information has been cited as desirable to employers (Gloeckler 2008). Most textbook examples and cases presented in OR classes are unrealistically small-scaled and basic compared to what graduates will encounter in industry.

To help shape students' data-management skills, instructors should expose them to data sets that reflect those in industry. Because students use data from the partner, they encounter the complexity and ambiguity that they will likely face after graduation. For example, in one project, students received over 10,000 rows of daily arrival data and were surprised that this only constituted six weeks of data. As in the real world, data files contained missing data or data entry errors, something that students rarely encounter in the classroom. In another example, students received data in several .csv files, such that they needed to link data fields. In one project offering, although several months of arrival data were available in electronic format, to parametrize the simulation model, students needed to engage in manual data collection, fostering their understanding that the desired data are not always available. For many students, this part of the project is their first introduction to industrial data, and some are overwhelmed by the processes of data management. For example, one student made the following comment: "*This aspect of the project was incredibly time consuming, and I found it rather difficult because so much of the data was inaccurate or not useable. With that being said, that is the reality of data collection, and I think it is important to practice with real, raw data. Most other classes would give a fictional set of data that did not need to be worked with. Although difficult, it was incredibly helpful as a learning tool.*"

Lessons Learned. An instructor can help with data management in the following ways:

- Offering data management tutorials by partnering with a university's technology center: In my experience, tutorials on pivot tables and data formatting are the most helpful. Attending additional tutorials outside of assigned classroom time makes students more comfortable and less frustrated when working with large data sets. Students also have an opportunity to develop additional skills.
- Working with the partner to ensure that the data reflect the real world but can still realistically be studied in an academic term: Students will lack a contextual understanding of the data, as they do not belong to the organization. Reviewing the data with the students before releasing any data files eases this knowledge gap.
- Incorporating data management skills across the curriculum: Clearly, the task of promoting data management skills extends beyond an individual simulation class and represents a desirable skill for employers. At WPI, during course curriculum planning meetings, faculty map opportunities for students to develop experience with large-scale, complex data sets.

4.3. Part 3: Project Deliverables

Project deliverables include a proposal, final report, in-class presentation, and the simulation model and accompanying data files required to reproduce the project results. Combined, these deliverables account for more than one-third of the students' class grade. The proposal is designed to help frame the project: Students submit it approximately one-third of the way through the course. The proposal describes how teams perceive the topic and how they intend to carry out the project. It also helps to ensure that the team has begun working and is making progress. The proposal should include a clear problem statement, project scope, anticipated data needs, validation plan, proposed alternatives the team seeks to evaluate, and specific metrics the team will use to compare alternatives (e.g., wait times). The instructor clarifies that students' proposals need to convince the partner to "hire" their team, and thus should convey a sense of credibility and confidence in their team's ability to address the partners' needs.

In the final report, students provide recommendations to the partner. In addition to the recommended course of action, students document the technical details of their simulation study, such as the warm-up period, run length, number of replications, experimental design, model parameterization, statistical analysis, model assumptions, and limitations, validation, and sensitivity analysis.

The partner attends the in-class presentation. Teams have seven minutes to present their recommendations and convince the partner of the quality of their solutions. In many course offerings, the partner debriefs the class after the presentations, providing feedback on students' presentation skills, "war stories" from the industry, and the actual solution to the problem (if there was one).

Proposals and final reports are submitted to the partner and the instructor. Each party independently evaluates the deliverable. The partner is asked to select a "winning" team that the company would hypothetically hire to build a simulation model. Without knowing the partner's decision, the instructor concurrently grades the reports. The team that the partner selects is guaranteed the highest mark in the class, and the remaining teams receive an adjusted grade. For example, if Team A is selected by the partner, but the instructor awarded that team a 7/10, the highest grade in the class for the proposal will be 7/10. If the instructor initially gave Team B a grade of 9/10, representing a higher grade than that of Team A, Team B's grade will now be 7/10. Teams with an original grade that is lower than that of the winning team will have their grades normalized (e.g., if Team C received a 6/10 from the instructor, the grade is adjusted to a 4.2/10). The grading scheme for the final report follows the same logic as the proposal, and the "winning team" for the final report does not have to be the same as for the proposal.

The grading scheme outlined serves three purposes. First, it emphasizes the importance of understanding the partner's needs and real-world practicality and feasibility. For example, a team could propose insightful but completely impractical alternatives, achieving a high grade from the instructor but failing to secure the industry partner's selection. Second, the grading scheme balances academic expectations against those of industry. Third, the competitive aspect of the grading scheme has been found to appeal to students' desire to produce good work.

Early iterations of the course project illuminated differences between academic exercises and industry expectations for the instructor. Although the instructor always informed students that a nonexpert decision maker would assess the content of their deliverables, in early course offerings, the format of the deliverables was not amenable to industry practice. Initially, teams submitted a four-page proposal plus appendices and a ten-page, plus appendices, final report. Discussions with industry partners showed that these two documents were rarely read in full, and it was decided that presenting deliverables in a format similar to that used at the partner organization would be more beneficial to the partner and serve as a learning experience for the student. In a subsequent offering, the partner suggested that team proposals should be a single page in length and include project documentation tools, such as A3 diagrams. However, this conflicts with typical student report formats. As a result, students initially found it difficult to concisely present their proposals, as they are more used to lengthy reports; however, at the end of the exercise, the feedback from students indicated that they valued the experience. Similarly, teams submitted their final reports in the form of well documented slide decks, which are typical for the industry partner. Students were surprised to learn that their final report was a four-slide presentation, but they gained the experience of designing informative slides and learning to document their work in footnotes, additional slides, and the "notes section." These two examples of deliverables formats reflect industry demands. Many lengthy reports are valuable only in the most basic of their results; most of the report goes unread.

Lessons Learned. While project deliverables and grading details may vary from course to course, there are number of actions the instructor can take to ensure that the deliverables provide a learning experience for the student while balancing the trade-off between academia and industry. These actions include:

• Designing a grading scheme that considers industry and academic requirements: Clearly, students working on industry-sponsored projects can reap a number of benefits. Providing a well designed and clearly explained grading scheme will benefit students, avoid frustration, and assist the industry partner.

• Identifying industry-specific deliverables: An important part of an OR education is effective communication. While there is merit in having students write a typical scientific report (e.g., introduction, methods, findings), it is also valuable for students to learn to communicate recommendations in alternative formats.

- Providing teams with feedback directly from the partner: For students, hearing how their projects deliverables were received from the client is a more valuable, and credible, experience than hearing it from the instructor.

5. Project Logistics

To operationalize project-based learning, instructors must consider a number of logistical issues. Below I cover general considerations for field-based course projects. Moreover, based on my experience in running the project, I provide suggestions on how to address these issues.

5.1. Choosing a Partner

The instructor can select the partner in a number of ways. First, the instructor could proactively approach companies, through new or existing relationships, and propose a partnership. In addition, the instructor could contact course alumni working in organizations with problems that may be amenable to particular course contents, such as simulation. I have created a course group on LinkedIn that allows me to contact course alumni when I am looking for a course partner. Second, the instructor could seek out partners in the university, such as in food services, the health center or the technology help center. Campus partnerships offer advantages in that students are familiar with the business context and can easily observe the process and problem under study. Finally, the instructor could contact the state Small Business Administration offices to solicit potential partners.

The instructor typically selects a partner four to five months before the class begins. This provides sufficient time to approach a potential partner, conduct initial meetings explaining the goals of the project, and work with the partner to develop an appropriate project scope. For example, one project topic with a partner was turned down because the scope was too large for a single term. Working with a partner in advance also prevents unexpected delays in the acquisition and delivery of data. Unfortunately, in one project offering, students were very discouraged that their projects could not proceed as intended because of problems of data availability that were beyond their control. Advanced planning also ensures that the partner can schedule time for classroom and site visits. One cannot overstate the importance of engaging a committed contact person who is prepared to collaborate with the class. Student feedback indicates that the partner interaction is the most valuable aspect of the project.

With multiple partners, students do not have a common frame of reference to discuss shared learning points. However, in classes with more than 40 students, having a single partner is not practical and poses a diminishing rate of benefit for the instructor and the partner.

5.2. Partner Preparation

The seven-week time frame is short enough to maintain a high level of partner and student engagement, yet realistic for the deliverables. The industry partner commits to three in-class meetings (see Figure 1), i.e., the first to present the problem, the second to clarify questions, and a final meeting for student presentations. Students have opportunities to ask follow-up questions at pre-specified dates. As teams often have similar questions for the partner, questions are submitted to the instructor who then compiles the questions before emailing the partner. The partner evaluates and ranks the proposals and final reports. Travel to campus is also required. In addition, the partner may host an on-site visit session for the students.

Although there is no specific industry partner training, early, open, and honest communication is the key to successful projects. A partner's sincerity in supporting student learning, and willingness to work with the students are key criteria for a successful collaboration. Partners who have experience working with students through co-ops, internships or research projects typically have a good understanding of the time and energy investments required as well as the potential benefits.

5.3. Project Topic Solicitation

To ensure a meaningful, real-world experience, the partner proposes the project topic. However, not all proposed project topics are amenable to the course. The topic should fulfill two criteria: The project topic must be (1) feasible, i.e., the instructor needs to ensure that a student team, mainly comprising those with no previous simulation experience, can understand the context, model the problem, and generate constructive recommendations over the duration of the course; and (2) it must be relevant, i.e., the problem must be a real issue faced by the client. Although the instructor and the client could modify the topic slightly to account for time constraints and student learning, some degree of ambiguity is necessary for the project to be educational. Because repeat partners understand what they can expect from the project teams, the instructor needs less time to screen the topics proposed. The approach of collaborating with repeat clients was particularly successful in one course offering, where the partner and instructor used the same general topic as in a previous session (i.e., process redesign for blood draws at a cancer treatment site) but clearly stated what was out of scope (e.g., facility layout) and provided additional data-management seminars to facilitate data analysis techniques, such as using pivot tables.

5.4. Team Formation

Before the first day of class, the instructor informs students about the project through email. Students self-form teams of three or four individuals. The instructor discourages the formation of larger teams to avoid task division and diminished learning, but also discourages smaller teams because the amount of work required of each team member may become excessive. Instructors may wish to form teams that would more closely reflect real-world assignments, and they can use open-source team-formation tools, such as CATME (Layton et al. 2010).

5.5. Evaluations

Throughout the project, students complete two self-evaluations of their performance, their contribution to the team, and the function of the team as a whole. Here, the instructor emphasizes accountability and self-reflection, giving students an opportunity to recognize effective practices, team dynamics issues, and potential barriers to success. The instructor reviews these evaluations with each team to determine whether managerial interventions are necessary.

5.6. Costs and Compensation

For the university, the costs of the course are negligible, as students can complete the project using available software. As a courtesy to the partner, the instructor bears the costs of travel for the partner and hosting the partner on campus. Travel costs to the project site are borne by the students, although in the past project partners have validated parking. Projects are carried out pro bono without payments to the students or to the university. Note: It is important to communicate to the students that neither the professor nor the university benefits financially from their labor.

6. Typical Results

In general, students have given exceptionally good feedback ratings for the project. The instructor collects feedback at the end of the course through anonymous surveys, and almost all students appreciate the project experience and skill gains. Beyond skill development, students have reported that the project helped them in job interviews. For some international students, the project is their first exposure to American industry, and they find the experience invaluable. Finally, one team placed second in the Institute of Industrial and Systems Engineers (IISE) Annual Simulation Competition, partially attributing their success to the preparation from this course.

As to the *student learning experience*, I can make several observations. Students begin to appreciate the impact of effective communication, which is increasingly important when dealing with nontraditional consumers of OR results. Because all teams have the same project topic, to remain competitive, the instructor encourages students to present their approach and findings succinctly while emphasizing the significance of their results. Students are eager to showcase all of the technical details related to the work they have completed, but in the real word, such details are lost on the client or management. Although students struggle with presenting their proposal in an A3 format or their final report in four PowerPoint slides, feedback from course alumni has described this as a valuable learning experience.

At the outset, students perceive a lack of structure in the projects; this is primarily because they are unfamiliar with the partners organization and processes. Students may also struggle to adapt their skills to a broader context beyond the course content. More commonly, students have difficulty seeking the right information. They are accustomed to having all the "necessary details" of a problem prescribed, and therefore have difficulty developing clarifying questions. To circumvent this, the instructor moderates class discussions on how to frame a problem and solicit information from a client.

Most teams tend to underestimate how much time they will need to spend on data analysis. Actual large data sets present a stark contrast to homework problems in which model data are prescribed. One student made the following remark: "*I enjoyed the real-world data we were given. It was nice not to have 'cookie-cutter' data where the solution was simple. The data made us think and explore different ways of distributing the information. At my internship, I do work with data*." Unlike most of the textbook examples, a project does not have a unique right solution: Some students have trouble letting go of stereotypical solutions. The open-endedness of a real-world problem lends itself to different approaches; for example, some teams choose to focus on a particular aspect of the problem, such as scheduling, and go on to develop algorithms to address that problem. Others take a much more holistic approach. In one case, two teams had contradictory results, and the partner asked them to compare and contrast their approaches. Many teams struggle to complete elaborate models of the current problem, and may lose sight of the need to generate recommendations. Such teams are often disappointed that their elaborate model is not selected by the partner when, in fact, they did not produce anything of value to the partner. Indeed, Balci (1994) observed that a key shortcoming in many simulation studies is developing overly elaborate or even incorrect models. Finally, students can appreciate the effect of their recommendations on operations.

As to the *industry partner experience*, partners noted that students were engaged and motivated: One partner observed that for a number of students "the project was not just a deliverable for them." Asked whether the solutions offered practical value to the organization, all partners surveyed agreed that there were some projects that were of value. Some projects provided evidence to support an alternative a partner wished to explore further, while in others, students proposed solutions that were coincidently implemented. The partners identified the largest barrier to implementation as organizational change management, something that is beyond the scope of the course. Partners also observed that working with a group external to their organization forced them to think about how to present and communicate the details of the problem. In addition, partners commented that they are interested in providing employment offers to students. Finally, one partner noted that the overall experience was "great fun."

From the *faculty's perspective*, running a competitive industry-based project offers several benefits. First and foremost, this approach helped instructors to understand the nuances of skills desired by industry. For example, in the early years of the course offering, projects that the instructor rated highly tended to be rated low by the partner. While the instructor was grading for technical completeness, the partner was considering feasibility. Second, instructors can proactively identify interesting topics that could become research projects. Third, on a more personal note, it is very rewarding to coach student teams, particularly those that are highly motivated, through this process. Furthermore, it was satisfying to hear how students have used the skills obtained in this project in an internship or after graduation.

7. Concluding Remarks

The project design outlined in this paper was devised to help students, working in small teams, improve their skills in applying OR methods to real problems posed by industry. If the project is designed and implemented well, a local organization receives a useful service, students develop skills valued by employers, and faculty has an opportunity to learn how to coach students for post-graduation success. While the project design presented in this paper relates to a typical simulation course, this design is likely to work in most theoretical and methodological OR courses towards the later stages of a degree.

For instructors wishing to implement a similar project in their classes, material for recent project offerings is available as supplemental online material. This includes handouts for each step of the project, project evaluations, guides for written and oral presentations, and sample projects.

Acknowledgments

We would like to thank several project sponsors for their continued support in project sponsorship. The author also thanks Anita Vila-Parish for her suggestions during manuscript preparation.

Appendix. Sample Course Outline

Session	Topics	Material due
1	Course overview Introduction to Simulation	
2	Overview of a Simulation Study Introduction to Project	Lab 1
3	Elements of a simulation model Building a simulation model in Arena	Lab 2 Homework
4	Input analysis: Specifying distributions	Homework
5	Modeling: Logical structure and schedules	Lab 3 Homework
6	Exam 1	
7	Guest Speaker Project Update	Questions to Sponsor
8	Data Structure: Variables and expressions	Lab 4 Project Proposal Due
9	Input/Output Intermediate Modeling: Sequences	Lab 5
10	Modeling spatial aspects	Lab 6 Homework
11	Output analysis for terminating simulations: confidence intervals, comparing scenarios, optimizing	
12	Steady-state modeling and statistical analysis: warm-up and run length, batching	Homework
13	Exam 2	
14	Project Presentations	Project Presentations
Post course		Project Report Due

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