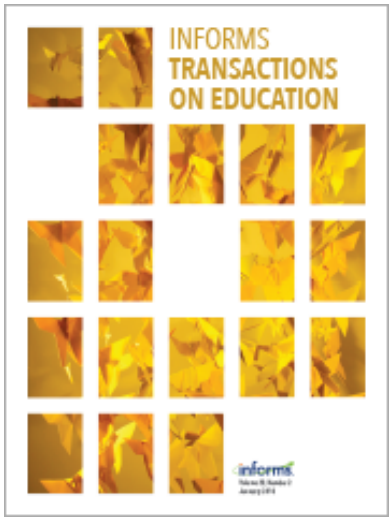

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A Survey of Research in Field-Based Education: A Summary of Process, Best Practices, and Lessons Learned

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Abstract. Field-based education, in which students earn academic credit while working with clients in a live consulting setting, is growing in popularity among operations research/management science educators. This paper provides a survey of over 20 articles on field-based education in operations research, management science, and related disciplines. It presents a common structure of such courses based on that reported in the literature. Furthermore, it captures best practices and lessons learned from over 20 prior articles on the teaching of field-based research.

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

Keywords: field-based education • literature review • practice • pedagogy

Introduction

In recent history, operations research and management science (OR/MS), and more generally, business curricula, have struggled with the perception of diminishing relevance of the materials and reduced value of degrees in the business community. An influential article by Bennis and O'Toole (2005) discusses how business schools have "lost their way," convincingly suggesting that as researchers increasingly focus on theory and math, they lose connection with practical application. More specifically, for OR/MS Grossman (2001) reports that the discipline has struggled to establish relevance and practical application. Sodhi and Tang (2008) point out that research, teaching, and practices are becoming increasingly disengaged from one another, with research increasing in theory while reducing its practical application. In a similar vein, Carraway and Clyman (1997) recently argued that managerial relevance is essential for OR/MS to succeed. This is not a new sentiment; for examples, Reisman (1994) promoted the marriage of theory and practice and Little (1970; reprinted 2004, p. 1841) quips, "The big problem with management science models is that managers practically never use them." If this trend of increasing theoretical focus and disregard for practical application continues, OR/MS might occupy only niche areas and disappear as a distinct field. Moreover, OR/MS programs run the risk of producing graduates with less practical skills (Dubey and Gunasekaran 2015). In short, the practice of cutting edge OR/MS is important to researchers in the discipline and to its graduates.

Field-based education, in which students work in practical, real-world settings under the tutelage of academics and the guidance of practitioners, offers an opportunity for OR/MS specifically, and business schools more generally, to reestablish their position of influence and relevance to the business community. (These field-based courses have also been referred to as "experiential learning," "live consulting projects," "client-based projects," etc.) For the purposes of this article, "field based learning" is defined as any student-led project with a corporate client that addresses a real-world, live issue for that client, and is for academic credit, and guided by an instructor. Such courses offer an opportunity to bridge the gap between theory and practice, and between research and teaching.

This survey discusses the experiences documented by more than 21 prior reports on classes and organizations centered on field-based learning efforts. It suggests a common course structure in field-based education based on commonalities from the literature, including pre-project activities, project kickoff, project execution, and project wrap-up. Furthermore, it reports on best practices, challenges, risks, and lessons learned in such efforts. Finally, it recounts the reported opportunities created for faculty, educational institutions, students, and practitioners and their organizations from such experiences. The intent is to provide a summary overview of such courses and the mechanics

of how they work for existing offerings to benchmark one another, and for new offerings to glean from the experiences of others.

Literature Overview

Table 1 presents the literature on the OR/MS capstone projects surveyed in this article. It updates the Gorman (2010) table with 12 additional articles not covered in that article. In all, 21 articles on field-based education in OR, MS, Operations Management (OM), and Supply Chain Management (SCM) are assessed in this research. Others, with an engineering focus, are also referenced, but the focus is specific to OR/MS education. The earliest articles are Giauque (1980) and Giauque and Sawaya (1982); there were no others until the late 1990s (Eaves 1997). The topic has grown in popularity in the 2000s, with 18 additional articles, including a special issue in 2012, and this one in 2017. The topic has clearly taken off in the last two decades as OR/MS and related disciplines focus more on practical application. See Pembridge and Paretti (2010) for a recent account of pedagogy in engineering capstone projects. Dutson et al. (1997) provides a survey of capstone pedagogy articles in engineering.

Publications on such projects have been roughly evenly split between graduate and undergraduate courses. The courses are most often at the advanced level; only three articles have been published based on application in an introductory course. When offered in an introductory course, the projects typically represent a small portion of the course grade; the advanced courses are usually entirely dedicated to the field project, which is usually three credit hours, but may be as much as six credit hours.

The field-based projects are mostly OR/MS based, though seven are reported to be based on the related topics of OM, and three more on SCM. There are similar field-based courses in related fields such as marketing (see Clark et al. 2012) and Engineering (Mosher 2014).

About half of the articles report the client reaction to varying degrees in qualitative or quantitative ways. In all cases, the client results of a subset of the most successful projects are described. Of course, the client benefits are subjective, and often projected or potential rather than achieved (Handfield et al. 2011), but many authors tout significant client benefits. Surprisingly, only four articles report student reaction to such field-based learning (Ahire 2001, Gorman 2010, Grossman 2002, Handfield et al. 2011).

The remainder of the paper is organized as follows. First, the general structure of field-based projects is discussed, including client acquisition and retention, project procurement, project selection, student team assignment, project requirements and execution, and student team evaluation. Second, the perceived benefits to the constituencies (student, client, faculty, institution) are discussed. Third, widely held critical success factors for such projects are discussed. Fourth, the risks and challenges of such projects are discussed. The article concludes with summary thoughts and comments on such field-based courses.

The Learning Objectives of Field-Based Learning

Some authors discuss the basic objectives of field-based learning. In general, academics hope to get students out of an academic environment, bridging to a practical setting under faculty guidance. Gorman (2010) presents the most concise and comprehensive summary of learning objectives, many of which are cited by other authors. Although some objectives include the ability to apply technical tools in a new environment, these are typically less than one-third of the learning objectives of a field-based course. General business skills and soft skills are rarely covered in OR/MS and OM courses because the situations are difficult to recreate in an academic environment.

Technical skills

- Gain experience using technical and analytical concepts and tools, such as optimization, simulation, and statistical analysis, in a live business environment (Salo 2012)
- Learn the appropriateness of analytics and assumptions in the problem-solving process
- Gain experience with corporate data collection and analysis

General business skills

- Skills in problem identification and value quantification
- Project management skills working against strict deadlines with real-world complications (Kopczak and Fransoo 2000)
- Gain insight into the multidisciplinary nature of business problem solving

Soft interpersonal skills (Kopczak and Fransoo 2000, Gorman 2010)

- Gain experience in informal professional communications
- Gain experience in formal professional communications, including presentations and reports (Salo 2012)
- Gain practical experience in working effectively in a consulting project team (Kopczak and Fransoo 2000, Salo 2012)
- Successfully convince a client organization of the cost and benefits of suggested operational improvements (Salo 2012)

The Unique Pedagogical Contributions of Field-Based Education

Many authors describe the uniqueness of field-based learning. Though team projects and case studies are

Table 1. Summary of Research on Field-Based Education Covered in This Survey

Authors	Year	UG/GRAD	Institution	Course level	Project credit equivalent (approx)	Field of study	Live client?	Client reaction reported?	Student reaction reported?	Client benefit? dollar/ Qualitative; (projects reported)	Number of course offerings reported	Average team size	Number of clients reported	Project source: student or faculty	Total projects	Total students
Ahire	(2001)	UG Grad	Indiana University South Bend	Introductory	0.75	OM	Y	Y	Y	$1,093,000 (6)	2	3 UG 1 Grad		Student	70	130
Armacost and Lowe	(2003)	UG	US AF academy	Advanced	3	OR		Y	N	Qualitative (4)	18	4	20+	Faculty	135	540
Aserkar	(2013)		S.P Jain School of Management	Advanced	3	SCM		N	N	Not reported	7	2.5	50		100	250
Bak and Boulocher-Passet	(2013)	UG	University of Brighton	Advanced		SCM		N	N	Not reported						
Bradley and Willett	(2004)	Grad	Cornell University	Intermediate	1	OM	Y	Y	N	Qualitative	1	5	1	Faculty	12	60
Eaves	(1997)	Grad	Stanford	Advanced	3	OR	Y	Y	N	$150,000, Qualitative (8)	1	4.5		Faculty	8	40
Fish	(2008)	Grad	Cansius College	Introductory	0.45–0.90	OM	Y	N	N	Not reported	16	1		Student	368	368
Fraiman	(2002)		Columbia Univerisity			OM							16	Member companies		60
Giauque	(1980)	Grad	Brigham Young University	Elective	3	OR	Y	Y	N	Qualitative (6)	1		7	Faculty	6	
Giauque and Sawaya	(1982)	Grad	Brigham Young University	Elective	3	OR	Y	Y	N	$212,000 (8)	1		8	Faculty	8	
Gorman	(2010)	UG	University of Dayton	Advanced	6	OM	Y	Y	N	$4,100,000 (8) Qualitative (9)	8	3	22	Faculty	56	163
Gorman	(2011)	UG	University of Dayton	Advanced	6	OM	Y	N	Y		8	3	22	Faculty	56	163
Grossman	(2002)	UG Grad	University of Calgary	Intro, intermed, advanced	3	OR	Y	N	Y	Not reported	1	6		Student	10	60
Handfield et al.	(2011)	Grad/UG	North Carolina State University	Elective/ Advanced	Varies	SCM		Y	N	$1,250,000 (2)	30+		39	Cooperative	331	1,251
Heriot et al.	(2008)	UG	Columbus State University	Introductory	0.45	OM		N	N	Not reported (5)	1	1	0	Student	44	44
Hillon et al.	(2012)	UG	Univeristy of Central Missouri	Advanced	0.75			N	N	Not reported				Industry liason		

Table 1. (Continued)

Authors	Year	UG/GRAD	Institution	Course level	Project credit equivalent (approx)	Field of study	Live client?	Client reaction reported?	Student reaction reported?	Client benefit? dollar/Qualitative; (projects reported)	Number of course offerings reported	Average team size	Number of clients reported	Project source: student or faculty	Total projects	Total students
Milne and Zander	(2012)	UG	Clarkson University	Advanced	3	OR		N	N	Not reported	2	5		Director, faculty, students	8	40
Pilotte et al.	(2012)	UG/Grad	Purdue	Advanced	3	OR		N	Y	Not reported	5		1	Faculty	25	85
Rand and Ranyard	(2013)	Grad	Lancaster University	Advanced/ MS in OR	3	OR		N	N	Qualitative (9)	40	2	9	Faculty		
Salo	(2012)	Grad	Aalto University	Advanced	3	OR		N	N	Qualitative (1)	11	4.5	10	Faculty	48	220
Shearer and Whitaker	(2012)	Grad	Naval Post Graduate School	Advanced/ MS in OR	2	OR		N	N	Not reported	61	1	1	Student		
Speier-Pero	(2017)	Grad		Advanced/ MS in analytics	3	Analytics	Y	N	Y	Not reported	4	5.5	4	Faculty	4	75

commonly lauded as great educational experiences, without exposure to a real-world problem and client, in many ways they cannot deliver a number of real-world experiences (see McCarthy and McCarthy 2006, Hillon et al. 2012).

The unique offerings from a field-based course are many. The most common course elements are listed below, with references to the articles in which they were discussed. Note that many of these claims are just that: Other than Gorman (2010), none of the articles present any hard measures, only observations. In particular, the following list describes the many ways in which field-based learning is different from case-based learning.

- *Exposure to an ill-defined problem*. (Grossman 2002, Armacost and Lowe 2003, Handfield et al. 2011, Milne and Zander 2012, Hillon et al. 2012). Case studies attempt to approach such an experience; however, case studies contain a structure and though potentially vague best course of action, the problem is well framed for a good case study. The real-world nature of the field study is well beyond a fictitious authored problem with a solution key.
- *General consulting skills.* (Fish 2008, Gorman 2010, Handfield et al. 2011, Aserkar 2013, Kopczak and Fransoo 2000, Salo 2012) including client expectation management, leadership, confidence in approach, creativity in problem solving, and compassion for client situation, and the soft skills required in change management. Although a case has some elements of this, students are aware of the artificial nature of a case, which falls short of a field study. Gorman (2010, p. 439) reports student consultants must learn that "The customer may always be right, but the client isn't." Conversely, even if the consultant is right, that is not always enough to enact change. Furthermore, Gorman (2010) reports that as consultants in a real-world project, students learn that the project scope may change unpredictably.
- *Project Scoping* (Armacost and Lowe 2003, Gorman 2010). Too often, students are handed a neatly framed question or case: In practice, such a luxury is rare. What is in and out of scope is a difficult and new challenge for many students. Gorman (2010) reports that getting "The answer" is not as big a problem as establishing the question.
- *Working with large scale, ill-formatted dirty, data.* (Armacost and Lowe 2003, Gorman 2010, Hillon et al. 2012) Students learn that data is not neatly packaged in the most convenient format for their analyses; it can be ill-formatted and incomplete.
- *Interviewing/Question and Answers.* (Eaves 1997, Armacost and Lowe 2003) Students do not have experience collecting information via interview. A well stated question is revealing; follow up questions demonstrate listening. These skills are particularly important in early project stages.

- *Project, risk and time management skills.* (Armacost and Lowe 2003, Handfield et al. 2011, Kopczak and Fransoo 2000). These skills include identifying critical path activities, and those that may become critical path due to uncertain durations.
- *Informal communication skills.* (Eaves 1997, Fish 2008, Aserkar 2013, Hillon et al. 2012) Emails, phone calls, and meetings are critical components of project success. Knowing when to copy a teammate, client or advisor forces the student to balance too much communication with not enough, and is a novel skill for students
- *Presentation skills to a "live" client.* (Giauque 1980, Fish 2008, Aserkar 2013). Students have experience making presentations, but not with interactive discussions and probing questions. The working session style of presentation is unfamiliar to students. Giauque (1980) discusses the value of a "dry run" presentation, where the environment of a client presentation is simulated and students recognize deficiencies in their ability to explain and persuade before presenting to the client.
- *Effective writing skills.* (Giauque 1980, Gorman 2010) Students rarely write to explain, inform, and teach. They learn the difficulty of effective writing. Gorman (2010) discusses the valuable experience of multiple draft writing, which most students have not experienced.

Field-Based Course Structure and Process

Overview: Table 2 summarizes the articles that describe the structure of the field-based learning course. Though researchers describe the process differently, there are generally four broad steps in the process:

- Pre-project preparation
- Project kickoff
- Project execution
- Project wrap-up

Pre-Project Preparation

Pre-project preparation takes place before the project begins. It is generally the responsibility of the faculty to:

- Acquire clients
- Solicit project proposals
- Select the best projects
- Form teams

Some authors include student nomination/recruitment/selection (for elective courses), and student preparation (once the course begins) as steps in this stage.

One might draw a parallel to pre-semester preparations of materials, syllabi, websites, etc., in a traditional course. However, it is not as simple as a repeat class offering because a project course is different every year and there is considerably more risk and effort versus a traditional course.

Client Acquisition. From Table 1, we see that clients and projects are sourced by faculty, students or a formalized entity at the university. Usually, the responsibility falls to the faculty, and client acquisition typically happens one to five months before commencement of a project. Though there is overlap, client acquisition greatly differentiates from project procurement and selection. A client can return year after year, but projects change each year. While a client may originate from many sources, the faculty is solely responsible for the quality and appropriateness of the project. One describes the interest of the client to participate; the other describes the desirability of the project as a vehicle for learning. Table 2 shows that some authors emphasize the difference between the two steps, while others blend the two into one.

In short, clients come from a number of sources; as stated by Eaves (1997, p. 109), "Where does one find clients? Everywhere. We rely on personal contacts, faculty contacts, current student contacts, alumni contacts, affiliate programs, repeat sponsors, and now volunteers who have heard of the course." From the literature, these are roughly and subjectively the most common sources in descending order, and of course would vary by how long the course has been in existence, and by the institution:

- Prior engagements with client
- Faculty contacts and Entrepreneurial behavior
- Existing advisory board contacts (department, school, university)
- Other adjunct faculty/former faculty
- Career planning and placement offices and career fairs
- Formalized outreach centers or institutes in the university
- Alumni
- Students

The best clients tend to be affiliated with the institution (alumni, advisory board members, etc.) or discipline (Council of Supply Chain Management (CSCM), INFORMS, etc.) in some way. Some authors report it is critical to procure local clients for ease of access and logistics (Armacost and Lowe 2003, Milne and Zander 2012), while others are explicitly international in scope (Kopczak and Fransoo 2000, Pilotte et al. 2012, Aserkar 2013).

Giauque (1980) describes the successful yield from a cold-call style letter writing campaign. Roughly 25 letters yielded 7 projects, 16 clients with potential interest in future projects, and 2 that were not interested. However, as that paper describes a first effort at such a course, such a campaign may be necessary. The successful yield rate could be due to Giauque's writing prowess, entrepreneurial spirit or as Armacost and Lowe (2003, p. 2) states, "there is always demand for (free) operations research talent." Though the yield of

Table 2. The Structure of Field-Based Learning Courses

Ahire (2001)	Armacost and Lowe (2003)	Aserkar (2013)	Bak and Boulocher-Passet (2013)	Gorman (2010)	Handfield et al. (2011)	Heriot et al. (2008)	Konrad (2017)	Milne and Zander (2012)	Pilotte et al. (2012)	Rand and Ranyard (2013)	Salo (2012)	Speier-Pero (2017)
					Pre-project execution							
	Pre-course preparation and project solicitation		Client acquisition	Client recruitment	Manage client cooperative organization	Client acquisition	Client selection			Setting up projects	Identification of clients	Partner selection
		Student nomination							Student recruitment/ Selection			
Student training			Student preparation							Preparing the students		
Guidelines and project	Project selection			Project selection	Project identification		Project topic solicitation	Project selection	Project selection		Screening of project topics	Project definition
		Companies select teams	Setting up the teams	Team selection/ Project assignment	Team selection/ Project assignment	*Student team formation*	Team formation	Team assignment		Allocation of students to projects	Kickoff meeting/ Team assignments	
		Projects assigned to teams				*Team organization*		Faculty assignment				Faculty mentor identified
					Project kickoff							
				Company background research		*Preliminary industry analysis/ Client issues*	Problem framing		Develop relations	Supervising projects		
				Site visits		Initial client meeting	Organizational research		Preliminary research		Initial client meetings/ Data collection	Initial meeting
Detailed project proposal	Problem definition and project scope	Teams submit proposal	Define problems	Student proposal		Letter of engagement	Client presentation		Project scoping			Technical training
	Background research					Background reading	Data requirements					Methodology presentation

Table 2. (Continued)

Ahire (2001)	Armacost and Lowe (2003)	Aserkar (2013)	Bak and Boulocher-Passet (2013)	Gorman (2010)	Handfield et al. (2011)	Heriot et al. (2008)	Konrad (2017)	Milne and Zander (2012)	Pilotte et al. (2012)	Rand and Ranyard (2013)	Salo (2012)	Speier-Pero (2017)
						Project execution						
Data collection and analysis		Teams work on project with close collaboration with academic and industry mentors	Establishing contact points	Project kickoff		Project analysis	Data management	Project execution	Mentor lead fieldwork, data collection, and analysis			
	Model and system development		Problem analysis	Project execution		Develop alternatives	Proposal					
			Synthesis and evaluation of the problem									
		Midterm review		Miterm review							Two interim status meetings	Preliminary results presentation
						Project wrap up *Prepare final report*	Final report	Delivery of final report	Final presentation and report preparation			Feedback
				Research symposium presentation		Final presentation to class and client	In class presentation					
Project reporting	Final recommendations and implementation	Final presentation	Presentation of findings	Final client presentation			Model delivery	Final presentation to client			Final presentation	Final presentation
						Evaluations	Evaluations	Evaluations		Assessing projects		Feedback

that effort was high, it is nonetheless a high risk and time consuming approach to cultivating clients.

A letter writing campaign may be less necessary due to existing networks at most institutions. Once a field-based course is established, prior clients are the most common source of projects. Giauque and Sawaya (1982) allude to this fact. Most faculty (e.g., Armacost and Lowe 2003) point out the critical importance of maintaining an on-going, long standing relationship with prior and potential clients to reduce churn and the need to find new contacts. Gorman (2010) notes that over an 8-year period, half the project clients (and well over 80% of the projects) were repeat clients, and some of those for six and seven projects in that span. Furthermore, Gorman cites a 25%–40% churn, implying that 60%–75% of the projects are with the same client as the year before. Bradley and Willett (2004) use the same client, Lord Corporation, for its projects every year, while Shearer and Whitaker (2012) have a built-in repeat client at the Naval Postgraduate School. Others (Handfield et al. 2011) have a formalized relationship with ongoing, paying clients. Despite having a built-in client with the US Air Force, Armacost and Lowe (2003) report using local newspapers to advertise projects.

Other regular sources for new clients can be found at most schools. Gorman (2010) suggests that department and school advisory board members, career planning placement office network of employers, full-time practitioners who are adjunct faculty, and employers of graduates are the primary sources of clients. Milne and Zander (2012) suggest university career fairs and students; Fraiman (2002) suggests alumni.

In four cases from Table 1, the source of the project depended on the student (Ahire 2001, Fish 2008, Grossman 2002, Heriot et al. 2008, Shearer and Whitaker 2012). Of course, student-based projects reduce the load on the faculty. However, students may have difficulty finding a client and an appropriate project of proper scope, subject area, and analytical rigor. The student-based undergraduate projects tended to be for a small portion (15%–25%) of a semester grade, rather than a full semester consulting experience.

In three recent cases, a more formalized entity provides leads on projects (Fraiman 2002, Handfield et al. 2011, Hillon et al. 2012). Handfield et al. (2011) describes a Supply Chain Resource Cooperative at North Carolina State University, with 41 member companies, that makes a $30,000 annual donation to participate. Fraiman (2002) describes the W. Edwards Deming Center at Columbia with industrial partners. Hillon et al. (2012) developed a relationship with a local Small Business and Technology Development Center, which is supported by the federal Small Business Administration. Heriot et al. (2008) leveraged a federally funded Small Business Institute until funding ran out, then leveraged an advisory organization, the Small Business Institute Directors Association on an independent basis. Giauque (1980) refers to an association with the National Advisory Council. Gorman (2010) refers to a business school and OM advisory councils. Such organizations create infrastructure for maintenance of relationships, create program recognition and credibility, and reduce faculty workload, but are costly to operate.

Project Solicitation. Project solicitation looks to existing and potentially new clients for a project proposal with a specific start date, end date, and objectives. Most authors report project solicitation takes place for a few months before projects begin. Such solicitation is often conducted via email with follow up phone calls. Gorman (2010) provides a sample solicitation letter. Giauque (1980) suggested, "Once I was in the manager's office, defining good projects was rarely a problem." On the other hand, Gorman (2010) reports approximately a 60% acceptance rate on proposals to assure a quality experience for students; thus, to get 6 to 8 good projects, 10 to 14 submissions are typically required. (Gorman further notes that a higher rejection rate may discourage resubmission in subsequent years.) Armacost and Lowe (2003) actively solicit projects so that they end up having more projects than they can support. Though it is possible for a single client to support multiple projects, it is important that there is a different client contact for each project to assure quick and quality responses to student queries. This author has found that some clients submit multiple projects, hoping that one (or two) is selected.

Project Selection. Project selection is based on a number of criteria that vary by author. Those most often cited are:

- *Appropriateness of scope.* The project requires sufficient effort to fill allotted time, but is not so broad, ill-defined or technically challenging that it cannot be completed. (e.g., Milne and Zander 2012, Gorman 2010)
- *Academic rigor.* The project should use tool skills appropriate to the level of the student and the subject matter of the course (OR, SCM, OM). Gorman (2010) notes that projects are inherently multidisciplinary, however, and projects that span Marketing and Financial topics are common.
- *Importance to the client.* (Gorman 2010, Pilotte et al. 2012) Front-burner issues with real value to the client incentivize enthusiastic client participation and motivate students. Gorman (2010) suggests a project with financial value to justify a team of three, over 15 weeks, at 20 hours per week, or a consulting project costing $100,000.
- *Quality of the proposal.* The effort expended on the initial client proposal is a good leading indicator of the likely client effort expended during the project.

Speier-Pero (2017) gives a concise list of criteria that tend to yield a good client project: (1) the types of

business problem and analytics methods to be used, (2) strength and ability of the firm to support such projects, (3) the value of the projects to the client, (4) the ability of the client point person to act as a mentor for student teams, (5) ability of the point person to engage top leadership, (6) the appeal of the industry for the students, and (7) potential internship and long-term employment opportunity with the client.

A challenge in project selection is predicting how the project will proceed. Most client proposals are high level, often mis-specified, and are further enhanced and detailed in subsequent meetings with students. Thus, in-person and phone-based interviews are often conducted with clients whose proposals are marginal to gain better understanding before acceptance or rejection. From engineering, Kauffman and Dixon (2011) suggest that project vetting should be a function of how well it matches desired course outcomes. See Magleby et al. (2001) for a discussion of project selection criteria in engineering courses; Maleki (2009a) provides advice for project selection in general business capstone courses.

Some authors have a full-group context session after projects are selected and before teams are assigned. This session is a chance for clients to present their project idea. Often this meeting is the basis for students developing an interest in a project and bidding to work on it.

Team formation and assignment: From Table 1, we can see that projects are rarely carried out by an individual student; exceptions include Ahire (2001), Heriot et al. (2008), Fish (2008), and Shearer and Whitaker (2012). Most project teams have 3–5 students, depending on instructor preference, project scope, and the number of projects relative to the number of students. While Gorman (2010) discusses in detail getting the appropriate number of project submissions to support teams of three students, Milne and Zander (2012) offset this risk by letting multiple teams work on the same project in competition.

Many authors discussed team formation. The criteria for team formation and assignment are:

- *Student preferences.* Students may bid on projects (Armacost and Lowe 2003, Milne and Zander 2012, Pilotte et al. 2012, Gorman 2011, Rand and Ranyard 2013, Salo 2012) based on the proposal, and in some cases client presentation at introductory meetings. Milne and Zander also work on roughly a first-come-first-serve basis, subject to scheduling constraints. Gorman (2011) describes considering non-binding student requests to work with, or not work with specific students in addition to favorite or least favorite projects.
- *Team skills.* Gorman (2011) lists a number of measures for each student: Overall GPA, GPA in major, second and third majors, electives taken, specific tool skill training, prior internship experience. The objective is to assign skill sets appropriate to the project requirements to each client, and balance the talent level across teams. Rand and Ranyard (2013) report the use of a decision support system to assist in building balanced teams that meet constraints.
- *Scheduling feasibility*. Field-based learning is often not at regular class times. In fact, one instructor cannot meet with multiple teams on multiple projects at the same time. Thus, finding windows of time when all students on the team are available is critical (Gorman 2011, Milne and Zander 2012). Gorman (2011) makes available a student survey form for collecting skills and preferences.
- *Client Requests.* Armacost and Lowe (2003) describe accepting client requests for certain students. Such requests are based on limited exposure to the students during initial class meetings, and other contact the students may have initiated with clients before team selection.

Advisor Assignment. Little is written about advisor assignment, yet advisors are an integral part of a project team. Gorman (2010) reports that the advisor acts as a senior partner in a law firm, tracking progress on the project, and offering insights and technical support to teams that require help. Furthermore, because projects are resource intensive, the courses often require more than one advisor. From experience, advisors are often assigned based on industry and domain experience, project topic preference, usefulness of technical skill areas of specialization, and student team preference.

Student Acquisition/Nomination: In some cases, courses are electives, so there is discretion on which students take the course. (This would obviously take place before kickoff meetings and team formation; it is discussed after the other sections because it is not a common step.) Aserkar (2013) discusses nominations of students to work on industry projects. Pilotte et al. (2012) describes 15–20 student acceptances out of 25 to 35 applications in that course. Both of these authors describe international experience, where participation is costly for the students in terms of money and time.

Student Preparation. Some authors write about student preparation as part of the course offering. In any introductory course, (e.g., Ahire 2001, Heriot et al. 2008, Hillon et al. 2012) the introduction to topics obviously takes place before any field work. Bak and Boulocher-Passet (2013) discusses preparing the students for an international experience. However, even if not a major element in their course structure outline, most authors discuss some priming of student skills. For example, Gorman (2010) discusses a two-class "boot camp;" one is the general consulting process, the other is data analysis with pivot tables in

Microsoft Excel®. Data analysis is often critical to such projects, and pivot tables represent a relatively simple and accessible analysis tool with which most students have little or no experience. Speier-Pero (2017) offers students one day training in IBMS SPSS®. The consulting process coverage discusses things such as nondisclosure agreements, the importance of protecting proprietary data, and the elements of a good proposal.

Project Kickoff

In general, the project kickoff has four parts, i.e., the kickoff meeting, background company research, interviews and tours, and project proposal.

Kickoff Meeting. The project kickoff is usually marked by a meeting between the newly-formed team, client representative(s), and the advisor. This critical meeting has three major, and very practical, purposes.

- *Make acquaintances.* The meeting is important to give the student comfort with the client, and vice versa. Students get an idea of the level of formality of discussion and dress of the client and have an opportunity to express their personalities.
- *Interact and share ideas in an open session.* Similar to midterm and final meetings, it is important to get all of the constituencies in the same room to have a common understanding of the general direction and objectives of the project and to minimize potential miscommunication.
- *Discuss logistics.* Resolve mundane issues such as regular client meeting times, and rules or restrictions the students might face. Examples include safety training and equipment, access badges, logins, security clearances (military), and health tests (health care).

***Background* (company/industry/problem) Research.** Heriot et al. (2008) and Gorman (2010) discuss background research on client and industry. Heriot et al. (2008) includes a second "background reading" section after the proposal is submitted. Armacost and Lowe (2003) includes background research, after the proposal is submitted. This is project preparation, but is specific to team and project. It is critical that students have some sense of the current conditions facing the client, ideally before entering the first meeting. Such research gives students confidence and credibility going into their first client meeting.

Interviews and Tours: To have a well rounded understanding of the problem and project scope, students (and the advisor, as appropriate) engage in multiple interviews with client problem owners and receive site tours for a first-hand understanding of the problem (where appropriate). Konrad (2017) suggests peer review of prepared clarifying questions and data requirements as a good way for students to critically evaluate their ability to acquire relevant information from the client. These conversations and tours are critical to building rapport, understanding of client issues, and developing strategies to address them. Speier-Pero (2017) and Konrad (2017) suggest debriefings after client meetings to assure accurate recording of client responses and to encourage open discussions and information sharing.

Proposal Submission and Acceptance: Six of the ten articles in Table 2 describe some sort of "proposal" (Ahire 2001, Gorman 2010, Aserkar 2013) or "letter of engagement" (Heriot et al. 2008), or "problem definition" (Armacost and Lowe 2003, Bak and Boulocher-Passet 2013). The formal document adds depth and detail to the client's original proposal. It offers likely methodologies for the student team to use, anticipated benefits, and, importantly, a project plan for the spring semester.

Gorman (2010) describes the proposal writing and its subsequent acceptance as critical to the project. Demonstrating the proposal's importance, his course structure was modified from a one-semester, four credit course to a single credit "proposal" stage in the fall, followed by a clearly differentiated five credit project execution stage, roughly indicating the time allocation in the two stages of proposal and execution. The proposal is critical as it sets the stage for the spring semester. The course structure is unique relative to the others, as no other course structures separate the stages as definitively into two separate classes. (The time between proposal and execution stages of winter break has the additional advantage of allowing clients time to collect data, schedule meetings, and get required access approvals, etc.)

Somewhat surprisingly, no authors provide a detailed description of the key elements of a proposal. Perhaps it was assumed that these elements are well known. In general, they are:

- *Executive summary.* A brief, one paragraph summary of the project providing enough information that a busy executive need not read the entire proposal. The paragraph includes a statement on background of issue, scope of project, methods to be used, and expected benefits.
- *Introduction*: A background on the company and the problem.
- *Problem statement*: Discussion of the problem or opportunity to be addressed.
- *Methodologies to use*: What approach will the team use to solve the problem?
- *Data requirements*: Data needed to conduct the project (typically electronic)
- *Anticipated benefits*: The value of undertaking the project.
- *Project plan*: Activities, milestones, start and end dates.
- *Resource requirements*: Budget, specific client resources, as necessary.

• *Acceptance*: Formal agreement to commence project.

A typical proposal for a semester long project runs approximately 10 pages, but may range from 5 to 20 pages, depending on the depth of description and the number of figures. In general, more detailed and in-depth proposals lead to more successful project execution.

Project Execution

In general, project execution consists of three broad parts, i.e., data and information collection, analysis, and recommendations or conclusions. Gorman (2011) provides a course schedule in the supporting electronic documents. In all cases, students typically have formal training in each of these areas, but extend it dramatically through practical application. From engineering, Paretti et al. (2011) gives a host of suggestions for managing engineering capstone projects.

Data/Information Collection. Students collect a wide variety of information at the start of the project to support subsequent analysis. Electronic data is the most common data used in such projects. To be fair, in almost all cases, electronic data collection is often conducted by the client on their production systems; the student project plan should show "receive data" as an early milestone, not as an activity.

However, unlike other academic experiences, the electronic data is not defined and formatted in advance. It may be incomplete, stored in unintuitive ways, and voluminous and error filled. In one sense, this is a good first time experience for the students; it can also be painful and a project risk. Working with, cleaning, and massaging data to make them useful project inputs is clearly a task that falls to the students in most cases. Students tend to underestimate the effort of this activity.

Students also collect other sorts of data in numerous ways. Gorman (2011) and Ahire (2001) list three other types of data collection, i.e., interview, observation, and outside textual sources (articles, textbooks, the Internet). Armacost and Lowe (2003) identify interviewing as a critical skill. Some authors have a required "background research" component of the project execution (Gorman 2010, Heriot et al. 2008). Although authors did not often discuss observation and time studies, in many projects these are a critical source of data (e.g., process and flow time analysis, quality projects, line balancing, etc.).

Analysis. The analysis segment of the project is often perceived as the core activity. In analysis, teams apply various tool skills acquired in their academic courses to the problem at hand. Many authors describe the types of tools used in various projects. For example, Ahire (2001) describes "management science" tools such as forecasting, linear programming, queuing, scheduling, project management, inventory control and facility layout, and "quality management" tools including error proofing, re-engineering, and business process re-engineering (though one could argue about the categorization). Gorman (2010) reports that 40% of projects focus on statistical analysis, 40% on process analysis and simulation, and 20% use optimization and heuristics. Bradley and Willett (2004) describe lean methodologies used at Lord Corporation.

Many reports cite examples of the use of advanced analytical techniques and tools. Konrad (2017) discusses using the university technology center's training courses on data management, pivot tables, and data formatting. Gorman (2010) reports that some teams learn statistical analysis systems (SAS), Business Objects, and other techniques. Other authors suggest that students also learn that simplicity is better when possible (Bradley and Willett 2004, Gorman 2010).

Sample Clients and Projects. Most articles describe a subset of clients by name. Clients are in manufacturing and services, and across a large number of industries (see Ahire 2001, Gorman 2010, Kopczak and Fransoo 2000). Sample projects and results are reported by almost all authors to various degrees (Giauque 1980, Giauque and Sawaya 1982, Eaves 1997, Ahire 2001, Bradley and Willett 2004, Gorman 2010, Heriot et al. 2008, others). In most cases, authors describe a problem, a methodology, and a result. Gorman (2010) describes ways he has staged and split projects to create manageable and appropriately scoped student projects.

Recommendations/Conclusions. *Project wrap up.* The project wrap-up includes three key components, i.e., the student team final presentation, a formal project write-up (in most cases), and the student team evaluation.

Final Presentation. A ubiquitous element of field-based learning is the final presentation in which the student team describes the outcomes of their project. Authors do not generally provide guidelines on the length of the presentation, but it is usually one to two hours.

Giauque (1980) and Armacost and Lowe (2003) discuss the value of the "dry run" or practice presentation where student teams get feedback from advisors before presenting to the client. Eaves (1997) provides advice on good presentations:

1. Use the client's terminology to show familiarity with the problem.
2. Use the data you have; if you have no data, show how you could have used it.
3. If the client will learn nothing from a portion of a presentation, leave it out.

Other authors, such as Armacost and Lowe (2003), Ahire (2001), and Gorman (2010) discuss the importance of other presentation opportunities such as academic conferences, business association meetings, and student research symposia.

Write-up. Authors describe a final paper to summarize the project. The length varies from 10 (Gorman 2010) to 50 pages (Milne and Zander 2012) to optional for smaller projects (Heriot et al. 2008). In general, the requirement of a full length document is heavily discounted relative to presentations in terms of importance in field-based training.

Student/Team evaluation. An often discussed topic related to field-based course is student evaluation. Konrad (2017) discusses the importance of blending academic (methodological) requirements and practical (client needs) components of the project in determining the course grade. In addition to technical accuracy, clear and concise communication to the client is a key part of the team performance.

Gorman (2011) provides a succinct list of grading components. Note that as in project objectives, the technical component is a surprisingly small element of the total course grade (one of four graded areas; two of twelve specific grading items):

Technical analytical skill assessment

- Appropriateness of the analytical tool set used to address the problem
- Analytical sophistication of the analytical method used

Business skill assessment

- Accuracy and clarity of problem description
- Quality and clarity of project plan
- Adherence to the project plan and communication of deviations from the plan

Soft skills assessment

- Cohesiveness and professionalism of the consulting team
- Timeliness, accuracy, and thoroughness of all informal communications
- Quality of formal communications, i.e., proposal, midterm and final presentations, and written report

Business outcomes

- Magnitude of the potential and realized dollar impact to the client
- Appropriateness and usefulness of project recommendations for the client
- Effort invested to make the project a success
- Satisfaction of the client and faculty advisors
- Decision support tools in use by the client for future decision making

Milne and Zander (2012) offer a different list, with an approximate descending level of importance (technical skills are listed third in importance and one of six criteria).

- Client satisfaction
- Estimated magnitude of the potential or realized impact of your work (implemented work gets more credit)
- Technical quality of the work (this includes using the appropriate tools/methods for the situation)
- Clarity and efficiency in communications (and for final report and presentation, thoroughness of communication)
- Professionalism in all respects
- Individual contribution

Armacost and Lowe (2003) provide grading guidelines for the course in the appendix to their article. Heriot et al. (2008) provides a rubric for grading oral presentations.

There are a number of issues related to student evaluation, including:

- *Free-ridership.* As with any team project, the possibility of free ridership of one or more students arises. Many authors (i.e., Milne and Zander 2012) propose student peer reviews to help offset this.
- *Effort Level and Project Quality versus Achieved Results.* Projects can have good "results" but be poor projects. Conversely, supreme efforts may be made and top-notch analysis conducted, but the business environment may prohibit implementation or achievement of results.

Apart from the grading process, Speier-Pero (2017) discusses the importance of student self-evaluation, experience sharing, and reflection for the student to fully value and appreciate their learning experience. See Maleki (2009b) for a discussion of student team evaluation in a general business capstone course.

The Risk and Lessons Learned of Field-Based Education

Tellingly, most articles report the risks and lessons learned of field-based learning courses, or their best practices and critical success factors, or both. This is perhaps not surprising, given that these courses have a relatively wide open structure and framework that can lead to dramatic positive results, or sometimes painful lessons learned. The following section reports both. See Bacon et al. (1999) for a report on best practices and lessons learned in general management capstone courses. Often an author will identify a critical success factor or best practice as a result of a lesson learned (risk); as duals of one another, it is sometimes difficult to separate the two. Eaves (1997) reports general lessons learned in the project course, though the lessons are perhaps better related as critical success factors for student teams. They are:

- The critical importance of leadership
- The delicate nature of team spirit
- The trade-offs of modeling simplicity and accuracy

- The importance of question and answer sessions for getting to the root of problems

As well organized by Bak and Boulocher-Passet (2013), who focuses on field project risks, the key risks faced in field-based courses accrue to students, faculty, the client, and the institution. Another risk identified here is risk to project success (Grossman 2002). Though some of these risks are related and may overlap, it is helpful to think of such risks in this partitioned way. With each risk, where possible and appropriate, a suggested critical success factor or best practice from the literature is suggested that has been proposed to help mitigate that risk.

Risks to Student. The table below organizes risks to students as in Bak and Boulocher-Passet (2013). Also, Gorman (2011) describes in detail other risks identified in student surveys based on student surveys. Students identified risks associated with their client who may not be responsive or motivated enough to give them a chance to succeed, their projects which may be too narrow, too broad or not fit with their OM major, and communication and feedback from their professor on their performance throughout the semester.

To be sure, some of these risks are the attributes that create a high value learning experience. So, although they must be managed, they are not to be eliminated: They are what makes field-based learning so valuable and contribute directly to many of the learning objectives described above. High levels of effort drive motivation and solid project management; stress requires certain leadership and team building skills; ambiguity creates sharper problem solving; expectations and scope setting are valuable skills.

Risks to faculty. According to Bak and Boulocher-Passet (2013), faculty face risks in the following key areas:

Risks to Client. As summarized by Bak and Boulocher-Passet (2013), the risks to the client are:

Risks to Project. Bak and Boulocher-Passet (2013) focused on the constituencies; Eaves (1997) focused on project success risks. Eaves (1997, p. 113) highlights risk factors that affect the success of the project: "(The project course) confronts students with a bigger, less-structured environment: the project sponsor, more data, more latitude, and the unexpected. Misunderstandings with sponsors, alienated team members, data matters, and failure to make the most of the progress reports threaten the success of a project." Furthermore, Gorman (2010) discusses the inherent risk of projects that can fail for numerous environmental reasons that have nothing to do with "fault." These may include general economic downturns, layoffs, as well as corporate politics or crises that can disrupt projects and reduce or eliminate the probability of success. Gorman (2011) points out that apparently good projects can falter due to misestimated value to client, bad data, and other issues.

In all of these cases, risks are palpable. Yet in most cases the remedy lies simply in a dose of reason. As the parties responsible for course quality, faculty must be creative, reasonable, flexible, and practical in managing such risks for all parties involved. In short, though

Risk to student (Bak and Boulocher-Passet 2013)	Critical success factor/Best practice
Unknown but high levels of effort (Also Gorman 2011, Speier-Pero 2017). Field learning projects tend to require an extremely high but unknown level of effort from the student.	*Clearly communicated Time Requirements*. Armacost and Lowe (2003) require 30 hours by midterm; 60 hours by final and a detailed hours log required to be kept. Milne and Zander (2012) require 135 hours to be logged as "billable hours" to the client Gorman (2010) describes the project as a 500 hour project (166 hours per student)
Stress from high pressure consulting environment (Also Heriot et al. 2008)	*Create a vision of the final deliverable.* Armacost and Lowe (2003) also discusses the challenge of getting student teams to visualize the end product of their project early on. They relate the importance of the student team defining structure on an unstructured project, and creating an accurate problem statement.
Poor or unresponsive Client (Also Gorman 2011)	*Select Projects of High Importance to Client.* (Gorman 2010, Fraiman 2002, Milne and Zander 2012). Clients with a vested interest in results will be more responsive. *Select clients with relatively few "crises."* (Bradley and Willett 2004, Speier-Pero 2017) A stable client can focus on a project scope for the required 4 to 5 month span. *Establish Contact Protocols.* Gorman (2010) and Milne and Zander (2012) establish clear responsibilities for primary project manager and more senior project sponsors. Aserkar (2013) defines a more holistic organizational structure for projects.
Gaining clear understanding of expectations for project, individual and team (Also Ahire 2001, Armacost and Lowe 2003) *Unclear Grading and Progress* (Gorman 2011)	*Clear criteria for all graded events* (Armacost and Lowe 2003) Students are given through information on graded events; how they are graded and their relative importance.
Frequent frustration from ambiguity of projects Projects too narrow, broad, or mismatch for skills (Gorman 2011) Students identify a fair amount of risk related to the project they receive.	*Accept a subset of projects* (Gorman 2010) A 33%–40% "reject" rate both helps keep project quality high, while not discouraging resubmission. Though students must conduct detailed scoping of the project, the faculty advisor must first select projects that are workable for student skills and time constraints.

Risk to faculty (Bak and Boulocher-Passet 2013)	Critical success factor/Best practice
Client recruitment. (Also, Heriot et al. 2008, Fraiman 2002) Finding and keeping clients is time intensive and uncertain, and requires a fair amount of what Bak calls "commercial awareness," which is a kind of business savvy and the ability to promote the project course to clients.	*External Presentations/Establish an External Identity.* (Armacost and Lowe 2003, Hillon et al. 2012) External presentations, publications, press releases, and some "branding" of external projects helps build a reputation. *Develop or Join a Consortium or Affinity Group* (Gorman 2010, Fraiman 2002, Handfield et al. 2011, Heriot et al. 2008). *Utilize an industry liaison.* (Hillon et al. 2012). A liaison or group of supporting professionals builds credibility and a pool of clients in local industry.
Time and resources constraints. (Also, Gorman 2010, Speier-Pero 2017) Unstructured, open-ended field-learning courses take more time than traditional courses. Gorman (2010) estimates 100–120 hours per semester just in student face-to-face time. (20 hours per project and 5 or 6 project teams) *Case supervision*. (Also Heriot et al. 2008) Management of student consulting team is inherently uncertain; therefore the effort level and results are uncertain.	*Become a "Senior Partner" to your Analysts*. (Gorman 2010, Hillon et al. 2012) Allow students to flounder and learn, for mitigation of faculty effort as well as enhanced student learning, but step in for quality control, project management, and technical support.
Support from university administration. (Also Pilotte et al. 2012) Such courses are resource intensive, and in general the student-faculty ratio is lower. Administration must support that expense.	*Increase Academic Credit.* Gorman (2010, 2011) points out that the capstone course at the University of Dayton has been expanded from 4 to 6 credit hours, allowing additional resources to offer the course.

Risk to client (Bak and Boulocher-Passet 2013)	Critical success factor/Best practice
Understanding the course needs. (Also, Gorman 2010, 2011) Clients are often unfamiliar with the requirements of an academic course, including problem scope and sophistication and course calendar.	*Communicate calendar clearly* Armacost and Lowe (2003) suggest that the client is provided a course schedule, the syllabus, and expectations of the client.
Matching client expectations with student ability. (Also Gorman 2010, Speier-Pero 2017) Some clients expect students to provide professional consulting and to have advanced skills. Others may approach the student project as an academic exercise with no real demands or expectations.	*Establish Client Primary Contact* (Gorman 2010, Milne and Zander 2012). A client employee familiar with the course, the project, the team and facilitates improved understanding and communication of course and project objectives within the client organization.
Resource commitment. (Also Hillon et al. 2012) Clients may be unable to estimate the time required by management to support a project, including needs for a project Sponsor, project lead contact, and often a subject matter expert or experts, and some technical support.	*Make Client fully aware of the extent of the obligation* (Hillon et al. 2012) Hillon estimates almost 100 hours of client time is required to support their course. That works out to over 6 hours a week, which is more than some clients may realize at the outset.

there are inherent risks to field-based learning projects, the risks can be managed to create a positive and remarkably valuable learning experience.

Benefits of Projects to Stakeholders

Many research articles report the benefits to students, faculty, client, academic institution, and discipline from conducting field-based research. Of course, the overwhelming positive reporting could be a function of the "file drawer hypothesis" that suggests failures are under reported. However, the positive reporting is wide spread. See Sawhney et al. (2014) for a report on the value of capstone projects in engineering courses.

Benefits to Students. Authors report that students benefit from the "real-world" experience, hone their skills to a higher level, and become more employable in the process. Although such courses can be nerve wracking and challenging, students typically value the experience a great deal.

Ahire (2001) suggests that with field-based learning, the students attain pragmatic insights, a sense of worth based on tangible accomplishments, and widened opportunities for career advancement based on project experience. Grossman (2002) downplays application of the recommendations, but focuses on the value of students dealing with ambiguity, exercising judgment, and creative problem solving (though, they do not always like it at the time). Handfield et al. (2011) succinctly lists the obvious skills attained by students:

1. Real-world experience
2. Improved project management skills
3. Improved understanding of soft issues
4. Increased ability to work in project teams

Such sentiments are loudly echoed across most articles.

Gorman (2011) provides the most holistic reporting of benefits to students available in the literature. His article reports student course evaluations at the time the course was taken, senior exit interview comments as the course relates to other courses in the major, and

a 10-year cross sectional survey of student reactions to the course, conducted in 2011 of the course attendees for the course from 2002 until 2011. The students themselves dramatically point out that, while they find the course very challenging, with time after graduation they downplay the challenge. According to survey responses, they tend to value the experience more after graduation relative to traditional courses because they realize that the skills developed were helpful in getting their first job, and even more helpful in their career. In particular, students emphasize the "real-world" aspect of the course, as well as the value of team work and project and time management. Many authors allude to higher employability of students after taking such courses; Gorman (2010) and Grossman (2002) mention that students put their projects on their resumes.

In an industrial engineering setting, Hall-Phillips et al. (2017) compares student outcomes under two different Masters of Science level field-learning course designs, i.e., a centralized, structured format at North Carolina State University, and a decentralized, unstructured format offered at Worcester Polytechnic Institute. The authors find no statistical difference between the two structures, perhaps owing to a large number of confounding factors such as difference in faculty advisor, client, institution, composition of student teams, and prior student field learning experience.

Finally, field-based learning is appreciated by students at all levels of education. Gorman (2011) reports extremely high course evaluations from students on their undergraduate capstone course; Eaves (1997) reports that his students find the field-based course one of the most valuable they take in their graduate careers.

Benefits to Faculty. Faculty involvement in field-based learning courses enhances their teaching, research, and connectedness to industry. Ahire (2001) discusses the presentation of student projects at an undergraduate research conference, international research conferences, to regional business associations and to school boards of directors as a benefit to faculty. Ahire (2001) mentions their value as OM examples in other classes he teaches, and as a way to constantly refresh analytical, research, and consulting skills.

Authors report that field-based courses can lead to projects, papers, and presentations. Grossman (2002) reports student projects are a good source for case studies, and sometimes become the basis for future research projects. Gorman (2010) and Handfield et al. (2011) each list a number of academic publications of various authors that have stemmed from field-based courses.

Finally, while many authors mention the difficulty of cultivating and maintaining the relationship with industry for field-based courses, there are ancillary benefits to having such contacts such as increased industry credibility, opportunities for guest speakers, and contacts for student introductions.

Benefits to Clients. Many authors report that clients are impressed with the results of projects. Table 1 shows authors who have reported quantitative and qualitative benefits to clients, though many of these benefits are "identified" and not necessarily realized. Individual letters of recognition written by clients are reported by numerous authors, indicating a wide variety of benefits. Student projects are not necessarily of low quality and sophistication; Ahire (2001), Gorman (2010), and Eaves (1997) cite clients who laud student projects as better than some professional consulting projects. Bradley and Willett (2004) suggest that clients benefit simply from student energy and outside perspectives.

Another measure of the value to clients is indicated by the cost they are willing to undertake to participate. Gorman (2010), Giauque (1980), Fraiman (2002) and Handfield et al. (2011) discuss varying degrees of explicit gifts and membership fees paid by clients (consortium members), though all are careful to not frame the cash transfers as consulting fees. Such dollar amounts range from reimbursement of gasoline and other incidental expenses (Gorman 2010), to $500 suggested gifts to department or university (Giauque 1980), to $30,000 per year consortium membership fees (Handfield et al. 2011). Handfield et al. (2011) further points to client retention as a measure of sustained perceived value, noting that more than a dozen companies have funded the consortium for more than five years. Similarly, Speier-Pero (2017) and Gorman (2010) report 75% retention of clients, a strong indicator of client satisfaction with projects. Hillon et al. (2012) suggests that the cost in client time is thousands of dollars per project; though this is clearly a cost, it is not likely undertaken for projects of little value.

Finally, Grossman (2002), among others echoing students' improved employability, reports that these projects are also a great opportunity for clients to recruit graduates, acting as a 4–6-month interview and demonstration of capabilities, as well as getting students who are more familiar with client operations. See Friesen and Taylor (2007) for a report on client experience with capstone projects in engineering capstone courses.

Benefits to Institution. Ahire (2001) and Handfield et al. (2011) discuss the value of such projects to the university, whose reputation for community involvement is enhanced and improved. Grossman (2002) and Handfield et al. (2011) report benefits to alumni, who benefit from their affiliation with the institution, and vice-versa.

Benefits to Discipline. Interestingly, most of the articles describe benefits specific to the discipline even though a motivating factor for such courses is to demonstrate the value of OR/MS. This lack of reporting

may be because of more parochial focus on the accrual of benefits, or the overlapping benefits of promoting the discipline with those incurred by students and faculty. Though not explicitly recounted in these articles it is clear from the raised awareness of the application of OR/MS that the discipline benefits. Grossman (2002, p. 47) suggests that "Teaching students to be end-user modelers is leading to a renaissance of OR/MS."

Conclusions

This research summarizes more than 20 articles published on field-based research and presents them in a common course structure. Risks and best practice mitigation practices are presented. Finally, the benefits to the constituencies are discussed.

Field-based education is growing in popularity as a means to allow students to apply their academic training in a real-world context. Though such courses are resource intensive and challenging for students, faculty, and clients alike, the literature suggests that the efforts are well spent because all of the constituents are richly rewarded from the experience. In short, field-based education is clearly an endeavor of high risk and reward from taking on such challenges.

Such courses face obstacles, but by being aware of the key risks and challenges, faculty can be better prepared to forestall them and successfully delivery a high-value experience for students. Authors from most or all of the studies reviewed concur that there is no substitute for this "real-world" experience to enhance student learning (Gorman 2011, Ahire 2001, GiaqueandSawaya1982, Armacost and Lowe 2003, Milne and Zander 2012, among others).

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