OR/MS Content and Visibility in AACSB-Accredited US Business Programs

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In 1997, an INFORMS task force published the results of a study measuring the damage done to operations research/management science (OR/MS) content in business schools after the Association to Advance Collegiate Schools of Business (AACSB) removed OR/MS from its requirements in 1991. Their results were not encouraging. To investigate the current status of OR/MS, we conducted two related analyses to profile both the overall visibility of OR/MS in AACSB-accredited business schools and the content and delivery of existing MBA courses. Our results show small visibility (less than 10 percent) in terms of departments, programs, and concentrations. Approximately 40 percent of the schools studied, however, show one or more courses devoted to OR/MS. We found evidence of widespread use of computer modeling in MBA courses by both instructors and students. MBA students, however, appear to have low levels of involvement in constructing OR/MS applications and presenting their results. Finally, we found instructors' attitudinal responses regarding their MBA teaching experiences to be remarkably positive.
(*Professional: OR/MS education.*)

Over time, operations research and management science (OR/MS) courses and content at both the undergraduate and graduate levels have decreased in business schools throughout the United States (INFORMS 1997, Powell 1998). Powell (1998), however, points out that OR/MS appears to be increasingly pervasive in business applications. One can certainly find an example by examining the OR/MS models embedded in prominent enterprise resource planning systems. Further, with enhanced tools and technology, OR/MS has never been so easy for novice modelers and analysts to use (Liberatore and Nydick 1999, Powell 1998). Ironically, the OR/MS content in business schools has decreased just when business relevance and user accessibility have apparently increased.

In April 1991, the Association to Advance Collegiate Schools of Business (AACSB), the standards board for business school curricula and the accrediting agency for bachelor's, master's, and doctoral degree programs in business administration and accounting, relaxed its requirements on business schools and adopted new "mission-linked" accreditation standards and procedures that support institutional diversity in management education (AACSB International Online 2002).

Previously, the AACSB had required business schools to provide students with a "common body

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of knowledge." To maintain accreditation, business schools had to offer courses in the key business disciplines, including operations research and management science (INFORMS 1997). In the interest of fostering business school diversity, the AACSB gave accredited business schools the freedom to define their own missions and to set forth their own curricula.

The change in AACSB standards is not generally regarded as the only factor contributing to the diminished visibility of OR/MS in business school curricula. Powell (1998) hypothesizes other possible causes, including the absorption of OR/MS into functional area courses (Gallagher 1991), an increased focus in MBA programs on business strategy, and a pedagogy for OR/MS that may not have communicated its practical relevance. In addition, Powell (1998) suggests that colleagues in other business disciplines may not appreciate the relevance of OR/MS for business education, giving the example of a colleague who "is convinced that I teach the simplex method to our MBA students . . . and no amount of evidence seems to convince him otherwise" (p. 14). A lack of appreciation by colleagues in traditional functional areas certainly would not have increased the chances of survival for OR/MS courses once the AACSB lifted its constraint on removing them.

Intense discussion among OR/MS business school faculty followed the AACSB decision. The general consensus was that OR/MS courses and content would decline drastically in business schools across the United States. In an effort to gauge the status of OR/MS in MBA programs following the AACSB accreditation changes, ORSA and TIMS formed the INFORMS Business School Education Task Force. The task force surveyed business school faculty members teaching OR/MS and conducted structured telephone interviews with top US MBA program administrators. Based on the evidence it collected, the task force concluded that the role of OR/MS in MBA curricula had declined significantly in the five years following the AACSB decision. Further, its analysis did not provide optimism for improvement in the near future (INFORMS 1997).

More than five years have elapsed since the INFORMS task force's study. Partly to satisfy our own curiosity, we decided to obtain a current snapshot of the status of OR/MS in US business schools, and we developed a two-pronged approach. We first investigated the visibility of OR/MS in the undergraduate and graduate courses and degree programs offered at AACSB-accredited schools. Second, we surveyed business school faculty teaching OR/MS content at the MBA level to better understand their course content and delivery.

Methodology (Study 1—Courses and Degree Options)

We analyzed the Web sites of 342 AACSB-accredited business schools to understand how OR/MS currently fits into undergraduate and graduate programs. We evaluated those Web sites included in McBane's List of AACSB International Accredited Schools Online (mkt.cba.cmich.edu/aacsbmkt/alphlist.htm), a list of all accredited AACSB school Web sites (McBane's List 2002). According to AACSB International Online (www.aacsb.edu/accreditation/standards.asp), there are 394 accredited business programs in the United States. McBane's list thus represents approximately 87 percent of AACSB schools.

We answered the following questions based on each school's Web site: (1) Is there an OR/MS department? (2) Does the school offer an undergraduate OR/MS degree program or major? (3) Does the school offer an OR/MS master's degree program or MBA concentration? (4) Does the school offer an undergraduate OR/MS course, and if not, what quantitative courses does it offer? (5) Does the university offer a graduate OR/MS course, and if not, what quantitative courses does it offer? (6) If it offers undergraduate or graduate OR/MS courses, does it offer multiple courses?

Methodology (Study 2—MBA Course Content and Delivery)

We distributed a Web-based survey to instructors of MBA level OR/MS courses in US universities. We constructed our sample of instructors by examining AACSB-accredited business school Web sites. We included faculty members if their vitae or teaching backgrounds included OR/MS instruction, and we

compiled a final list of 693 e-mail addresses. We contacted these instructors by e-mail and asked for their insights into the status of OR/MS in MBA programs and for the content of their MBA courses.

Of the 693 instructors we approached, we obtained 126 usable responses for a response rate of 18.2 percent. The survey did not include an area for additional comments. Instead, we invited respondents to send us remarks by e-mail. We received comments from 37 instructors. Of these, 27 came from people who chose not to respond to the survey. Their e-mails explained their decisions not to respond. Seventeen of the nonrespondents stated either that they do not currently teach OR/MS courses at the graduate level or that their universities offer no graduate level OR/MS courses. The remaining 10 nonrespondents stated either that their backgrounds were in OR-related disciplines with no coverage of OR/MS or that their teaching and research backgrounds were not aligned with the focus of the survey.

This feedback gives us useful insight into the low response rate. In many business schools, there is a significant overlap of OR/MS with other business disciplines. Consequently, we approached faculty members who are not members of our target population of instructors teaching OR/MS at the MBA level. Some do not teach OR/MS but rather teach in a related discipline (for example, business statistics) or an unrelated discipline. Others teach OR/MS only to undergraduate students. The comments led us to believe that the degree of potential nonresponse bias was not serious enough to distort the results significantly.

On the survey, we asked instructors to rate on a Likert scale the degree of coverage (1 = no coverage, 7 = extensive coverage) they give to specific subtopic areas in their graduate OR/MS courses (for example, linear programming formulation). We chose this format because it would give us two types of information: (1) an indication of whether they cover a broader topic area at all, and (2) the intensity of coverage for subtopics within the area. We ascertained whether a general topic, such as linear programming, receives coverage by recoding the responses on subtopics. A response between 2 and 7 on the Likert scale for at least one subtopic constitutes coverage of the broader topic, allowing us to compute the percentage of responding faculty who cover the topic at all. We also used a seven-point scale to inquire about instructors' satisfaction with various aspects of teaching MBA OR/MS courses. Finally, we gathered some data on pedagogical details, such as student presentations, in Yes/No format.

Results (Study 1—Courses and Degree Options)

In our inquiries into the existence of OR/MS departments, programs, and concentrations, we found that 9.6 percent of these AACSB-accredited schools have OR/MS departments that offer coursework in the area (Table 1). A relatively small number of schools in our sample (five percent) offer master's programs or MBA concentrations, with only 4.1 percent of them offering undergraduate programs or majors.

In our results for course offerings, we labeled courses as "OR/MS" only if the course name clearly specified operations research or management science (Table 2). In the case of courses labeled "quantitative analysis" or "quantitative methods," we indicated whether a statistics course also exists in the program. If not, the quantitative analysis or methods course would likely contain some blend of traditional statistics topics and OR/MS.

The undergraduate and graduate offerings are similar for the three categories that show the greatest OR/MS course content. Between 34 percent and 35 percent of programs have one or more courses clearly labeled as OR/MS. Adding in schools with both statistics and quantitative analysis or methods courses, approximately 40 percent of the school Web sites show at least one course that seems to be dedicated to

OR/MS Visibility	Number of Schools	Percentage
OR/MS department in business school	33	9.6%
Undergraduate program or major offered	14	4.1%
Master's program or MBA concentration offered	17	5.0%

Table 1: A small percentage of the 342 AACSB-accredited schools studied offer an OR/MS department, program, or concentration for their undergraduate and graduate students.

OR/MS Courses	Undergraduate	Graduate
Two or more OR/MS courses	26 7.6%	23 6.7%
One OR/MS course	94 27.5%	94 27.5%
Statistics and quantitative analysis or methods courses	19 5.6%	21 6.1%
Only quantitative analysis or methods course	49 14.3%	125 36.5%
Only statistics course	33 9.6%	17 5.0%
No OR/MS course or no quantitative course found	121 35.4%	62 18.1%

Table 2: We found that the typical number of OR/MS courses offered by business schools was small, with few schools providing multiple OR/MS offerings to their students. At the graduate level, OR/MS content is frequently packaged with statistics into an aggregate quantitative methods or analysis course.

OR/MS. A sizable number of graduate programs (36.5 percent) offer single quantitative analysis or methods courses without separate statistics courses. This likely reflects the recent practice of shrinking the courses required in MBA programs by combining separate OR/MS and statistics courses. We did not find evidence of any type of quantitative course for over a third of the undergraduate programs (35.4 percent).

Results (Study 2—MBA Course Content and Delivery)

The top topics respondents cover are optimization (broken into linear, integer, and network programming), simulation, and decision theory (Table 3). Each of these topics is covered in at least two thirds of the MBA courses our respondents teach. The next five topics are project scheduling, inventory management, forecasting, queueing models, and nonlinear programming. These top 10 topics overlap extensively the topic areas ranked by Gunawardane (1991) in a survey of undergraduate topics and by Gallagher (1991) in a study of executive MBA coverage.

OR/MS Topic	Percentage of Instructors
Linear programming	92%
Integer programming	84%
Network models	78%
Simulation	78%
Decision theory	67%
Project scheduling	54%
Inventory management	53%
Forecasting	53%
Queueing models	48%
Nonlinear programming	41%
Multicriteria decision making	27%
Game theory	18%
Data envelopment analysis	15%
Markov processes	15%
Dynamic programming	14%
Search heuristics	10%
Neural networks	4%

Table 3: With fewer course offerings, faculty must be selective in choosing OR/MS topics to include. Beyond linear programming, integer programming, network models, simulation, and decision theory, we found significant variation in instructors' selection of key topics for MBA courses.

Fewer than 60 percent of the responding instructors included the majority of these OR/MS topic areas. MBA-level OR/MS courses are usually survey courses for which faculty must choose a subset of topics. Because MBA programs frequently devote one course or less to OR/MS content, instructors tend to choose topics that maximize their scarce exposure time. While one would expect the majority of courses to include optimization, simulation, and decision theory, our evidence indicates significant variation in selection beyond these topics.

For the most popular topic areas (linear programming, integer programming, network models, simulation, and decision theory), the percentage and intensity of coverage for subtopics varies (Tables 4 and 5). In some instances, the subtopics contain both content and software use.

Linear programming subtopics seem to have dominated OR/MS course coverage for at least 10 years (Gallagher 1991, Gunawardane 1991). Respondents include LP formulation, sensitivity analysis, and graphical method at markedly higher rates than more technical topics, such as the simplex method.

Main Topic Area	Percentage
Linear Programming (LP)	
Formulation	91%
Sensitivity analysis	83%
Graphical method	79%
Spreadsheets for modeling	76%
Commercial software for modeling	34%
Dual solutions/duality	33%
Simplex method (manual)	19%
Parametric programming	18%
Integer Programming (IP)	
Formulation (general integer variables)	78%
Formulation (binary variables)	77%
Commercial software or spreadsheets for modeling	76%
Branch and bound method	25%
Network Models	
Transportation and assignment	77%
Network flow	52%
Simulation	
Monte-Carlo simulation	72%
Risk analysis modeling/spreadsheet simulators	54%
Discrete event simulation	52%
Decision Theory	
Decision tree analysis	60%
Bayesian analysis	53%

Table 4: Organized by main topic area, instructors reported OR/MS subtopics they cover in their MBA courses. We indicate percentages for each area of coverage.

	Intensity of Coverage		
Subtopic Area	Median	Mean	Std. Dev.
Linear Programming (LP)			
Formulation	6	5.25	1.83
Spreadsheets for modeling	5	4.45	2.35
Sensitivity analysis	4	4.21	2.03
Graphical method	3	3.21	1.72
Commercial software for modeling	1	2.42	2.21
Dual solutions/duality	1	1.84	1.49
Parametric programming	1	1.45	1.17
Simplex method (manual)	1	1.44	1.20
Integer Programming (IP)			
Commercial software or spreadsheets for modeling	4	3.89	2.19
Formulation (binary variables)	4	3.71	1.98
Formulation (general integer variables)	3	3.50	1.88
Branch and bound method	1	1.54	1.20
Network Models			
Transportation and assignment	4	3.60	1.91
Network flow	2	2.67	1.93
Simulation			
Monte-Carlo simulation	4	3.91	2.27
Risk analysis modeling/ spreadsheet simulators	3	3.25	2.37
Discrete event simulation	2	2.56	1.86
Decision Theory			
Decision tree analysis	4	3.53	2.37
Bayesian analysis	2	3.03	2.21

Table 5: OR/MS professors rated from 1 to 7 the degree of coverage for several subtopic areas in their graduate-level courses (an intensity of 1 corresponds to no coverage, while a 7 indicates extensive coverage). Our results reveal a fairly high degree of variation among professors in terms of the degree of inclusion of linear programming, integer programming, network models, simulation, and decision theory subtopics in their courses.

For linear programming, we asked respondents about their use of commercial LP software and spreadsheet modeling in two separate questions. They reported using spreadsheet modeling at over twice the rate of commercial LP software. A detailed analysis (not in Table 4) indicated that 88 percent of the respondents used either spreadsheets or commercial LP software, with 22 percent using both, and 66 percent using only one of the two. We found a similar tendency in integer programming coverage toward formulation over explanation of methodological details (Table 4).

We also ordered subtopics based on mean intensity (Table 5). Naturally, the subtopics with 50 percent or less coverage have median intensities of one ("no coverage" on the scale). It is conceivable, however, for subtopics covered by more than 50 percent of the respondents to have low median or mean intensities even if the percentage of coverage is fairly high. Consider LP sensitivity analysis and the LP graphical method. The respondents reported coverage for sensitivity analysis at 83 percent, making it the second-highest subtopic. Yet the median intensity is four, the midpoint on the scale between no coverage and extensive coverage. Seventy-nine percent of respondents cover the LP graphical method, but the median intensity is three, indicating rather shallow treatment.

Both LP formulation and spreadsheet modeling for linear programming have especially high median intensities. Looking at LP formulation more closely,

we found that 71 percent of respondents indicated a level of coverage of 5 or higher, with 31 percent giving formulation the highest possible score (of 7), indicating extensive coverage. A similar examination of the distribution for spreadsheet modeling shows 57 percent of the scores were 5 or higher, with 25 percent indicating extensive coverage.

With respect to OR/MS pedagogy in MBA curricula, we wished to investigate the pervasiveness of computer use (both in and out of class) as well as activities that might connect students with real applications of OR/MS (Table 6). Computers clearly are part of class time for most of our respondents (86 percent) as well as in student work (89 percent). Significantly few respondents are asking their students to involve themselves actively in gathering data (32 percent) and presenting their results to others (38 percent). The use of field trips or visiting practitioners (31 percent) to bring real applications to life does not appear to be common.

Respondents generally have a positive level of satisfaction with aspects of the MBA teaching experience that include resources as well as student enthusiasm and skills (Table 7). We were especially interested in the questions about faculty members' enthusiasm and their perceptions of student enthusiasm. Respondents exhibited a high degree of enthusiasm for teaching the MBA OR/MS course (67 percent responded with a score of 6 or 7) compared to other courses. In addition, 57 percent responded positively (5 or higher) regarding their perceptions of student interest. Not surprisingly, the lowest median response is associated with student analytical skills, with the median being 4 ("Neutral" on the verbal scale).

MBA Course Pedagogy	Percentage
Students use commercial OR/MS software or spreadsheets	89%
Computers are used during class	86%
Students make presentations	38%
Students gather data	32%
Field trips or local practitioners for real-world application	31%

Table 6: An analysis of OR/MS MBA course pedagogy reveals a strong degree of computer use, with the majority of professors indicating that commercial software or spreadsheets are an integral part of their courses.

	Intensity of Response		
OR/MS Instructor Attitudes	Median	Mean	Std. Dev.
Enthusiastic about teaching OR/MS (compared to other courses)	6	5.78	1.13
Satisfied with instructional and technological resources	6	5.43	1.40
Satisfied with course text	5	4.72	1.65
Satisfied with level of student enthusiasm	5	4.71	1.54
Satisfied with student communication skills	5	4.67	1.32
Satisfied with student analytical skills	4	3.98	1.52

Table 7: Professors rated from 1 to 7 their degree of enthusiasm and satisfaction with OR/MS graduate-level courses (an intensity of 1 indicates an extremely negative response, with 7 an extremely positive response). We found instructors' attitudinal responses regarding their MBA teaching experience to be remarkably positive and encouraging.

Discussion

Previous research has focused on the diminishing status of OR/MS in business schools (INFORMS 1997, Powell 1998). While unsolicited comments from our survey respondents seem to support a general feeling that OR/MS is continuing to lose priority in terms of curriculum focus and school resources, we did not attempt to test this trend. Rather, we profile the current visibility and content of OR/MS in business schools more than 10 years after the sweeping changes in AACSB accreditation standards and five years after publication of the INFORMS task-force results.

Our findings on the visibility of OR/MS in business schools indicate that OR/MS departments, programs, majors, and MBA concentrations are rare. In terms of course offerings, approximately 40 percent of our sample of AACSB schools list one or more courses that appear to be devoted solely to OR/MS topics (true at both the undergraduate and graduate levels). The most common format for MBA programs (36.5 percent), however, appears to be a required course that combines OR/MS with statistics under the label of quantitative analysis or quantitative methods. Finally, the list of topics most commonly covered in MBA courses seems to have remained stable over the past decade. The depth of coverage may well

have shifted downward, however, with the packaging of OR/MS with other related disciplines. While we measured extensiveness of coverage, we were not able to make a comparison with coverage 10 or more years ago.

The suggested remedies for the diminished status of OR/MS in business schools (and MBA programs, in particular) have included increased emphasis on modeling, use of spreadsheets, relevance to business contexts, connection with real OR/MS successes (small as well as large), and active student learning (INFORMS 1997, Powell 1998). Because discussion continues on the appropriateness of spreadsheets (Gass et al. 2000, Liberatore and Nydick 1999), we investigated the use of both commercial special-purpose software and spreadsheets instead of restricting our focus to spreadsheet modeling.

We found strong support for an emphasis on formulations as opposed to mechanics and the use of computer-based modeling. Students seem to be actively involved in computer modeling at a much higher rate than the 31 percent reported by the task force (INFORMS 1997). We are less convinced, however, that students are hearing about OR/MS successes or actively building their own OR/MS successes. Fewer than a third of the instructors reported requiring their students to gather data. Even fewer report contact with practitioners, either through field trips or guest lectures. Finally, although oral presentation is an important part of the MBA skill set, fewer than 40 percent of the instructors indicated that they require student presentations. While the profession has made strides toward improving MBA content and delivery, a gap worth filling may exist between the classroom and real experiences with OR/MS.

The responses to our questions about teaching enthusiasm and satisfaction are surprisingly positive compared to the responses to similar task-force questions (INFORMS 1997), although we acknowledge the possibility for framing effects (Tversky and Kahneman 1981) because we stated our questions more positively than those in the task-force survey. Nevertheless, the differences are pronounced in several areas. First, 76 percent of the INFORMS task-force respondents found student motivation and recognition of the importance of OR/MS to be a principal problem in teaching OR/MS. Only 21 percent of our respondents report dissatisfaction with student enthusiasm for the course (scores of 3 or less). Second, the task force reported lack of mathematical background or fear of mathematics as a major problem (77 percent) while 41 percent of the instructors in our study were dissatisfied with their students' analytical skills.

Last, the overall positive tone of responses to the attitudinal portion of our survey may provide a clue as to the current mind-set of faculty teaching OR/MS at the MBA level. Two of the three authors of this paper have taught OR/MS at the MBA level for a number of years. We've lived through the coverage shrinkage and course title changes. We've also continuously encountered a receptive MBA audience whenever we've been successful in connecting these students with the power and applicability of OR/MS methodologies. Perhaps the enthusiasm exhibited in our results bodes well for the health of OR/MS in MBA curricula.

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