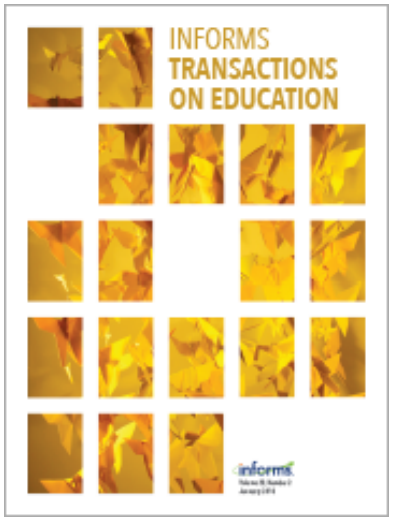

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Optimal Mix of Operations Management Contents for a Blended Course for Teaching Healthcare MBA Students

Sanjeev K Bordoloi
Opus College of Business, University of St. Thomas, Minneapolis, Minnesota 55403, sbordoloi@stthomas.edu

Use of technology is rapidly advancing in online teaching, especially in working-professional MBA programs. MBA programs for special student categories are continuously trying to customize content delivery methods to suit student lifestyles, while meeting accreditation requirements. This paper develops a mathematical model that helps to devise an efficient use of a mixture of classroom and online platforms for covering the necessary Operations Management material for a specialized group of healthcare students. The primary contribution of this paper is not a new use of technology in teaching Operations Management, but an elegant method to organize the materials for teaching a course in an innovative setup that better fits student lifestyles. This method is generic and can be applied to other disciplines.

Keywords: operations management; blended course; hybrid method; online teaching; mixed-integer programming
History: Received: December 2014; accepted: November 2015.

Introduction

Use of technology is rapidly advancing in online teaching, especially in working-professional MBA programs. Kellogg and Smith (2007) offer interesting findings on student-to-student interactions for an online working-professional MBA program. McHaney (2007) discusses use of a video grid for distance learning to encourage exchange of successful distance education techniques, ideas, and methodologies. Davis and Wong (2007) use the flow model and the technology acceptance model to understand and measure user experience of eLearning.

Use of online technology in teaching is common across business disciplines. Hannah and Venkatachary (2010) discuss a hybrid model to teach organizational theory. Ross and Rosenbloom (2011) share a personal experience on teaching an undergraduate strategic management course in a blended format. This paper offers a model for organizing the contents for teaching an Operations Management course in a hybrid format for a healthcare MBA program.

The primary contribution of this paper is not a new use of technology in teaching Operations Management, but an elegant method to organize the materials for teaching a course in an innovative setup, by formulating and solving a mixed integer program (MIP).

Application of mathematical models in the education field is not new. As early as 1967, Bowles (1967) offered a model for efficient resource allocation for educational planning. More recently, Zhang (2015) offers an optimization model for university management teams to improve teachers' skills. Hays et al. (2007) offer a new framework using collective causal mapping to group and sequence operations management topics for effective teaching. This paper helps to devise an efficient use of a mixture of face-to-face on-campus, classroom, and online platforms to effectively cover the necessary Operations Management material for a specialized group of students. This paper also contributes to an ongoing discussion about teaching methods in healthcare management.

The Healthcare MBA Program

I teach the Operations Management course in the Healthcare MBA program at the University of St. Thomas, a nationally ranked private university. The students primarily consist of physician leaders, nurse managers, clinic/hospital administrators, medical product/pharmaceutical professionals, and other healthcare system professionals. The Healthcare MBA program is delivered via an innovative combination of on-campus and distance learning methods. Two three-day sessions on campus, held every three months, provide concentrated, face-to-face work with faculty and fellow students, building strong relationships and enhancing the learning experience. Between campus visits, all coursework and class meetings are conducted online. This includes lectures, case discussions, assignments, exams, group work, and presentations in synchronous and asynchronous modes. My challenge was to devise

an efficient mix of classroom and online platforms to effectively deliver the Operations Management contents necessary for a core course in an accredited program.

Content vs. Channel Setup

The first column in Table 1 lists the Operations Management topics covered in this course. In addition to the traditional topics, I include three additional categories—case discussion, assignment review, and office hours—that require advanced planning.

The second, third, fourth, and fifth columns indicate the different platforms/channels that are available. "Classroom" is a typical on-campus face-to-face classroom setup in a business school with the usual multimedia facilities. The constraint here is that this specific group of students comes to campus for a predetermined number of days, front-loaded in the course term. This translates to only 14 hours of face-to-face classroom instruction for each course.

"Blackboard" is the intranet platform where course material can be posted with password protected access. Discussion board is extensively used for interactive sessions on Blackboard. Yet, blackboard remains an "asynchronous" platform: The instructor and the students need not be present together in this interaction session, and a time lag between postings is expected. The Discussion Board feature of Blackboard can be effectively used to have students post comments on a given topic in a predetermined time frame (e.g., a week). This could also include case discussions. Rollag (2010) discusses effective and efficient ways to teach business cases using discussion board asynchronously.

"WebEx" is a software product for "synchronous" interactive sessions, similar to video conferencing and webinar. This is where the instructor and the students sign in during a pre-determined time period for an "online classroom." The instructor (and some of the students) uses a webcam, especially for presentations. The computer split-screen can be designed for a specific format that facilitates the instructor's style of teaching.

Some of the components can be delivered via email. Examples include assignment review and some of the office-hour requirements for distant students. Thus, in a separate column, Table 1 also shows email as an option for material coverage.

Other effective teaching methods for such a course include putting students in a role-playing situation. McHugh (2009) discusses an interesting way to use the book, and now a motion picture, *Moneyball*, to keep students engaged in business situations by role playing.

A typical student in this program is a medical professional who does not have the time and flexibility to come to campus regularly to attend classes, and who is interested in this MBA program specifically because of the online portion of the course coverage. In a typical course, we would have 14 hours of on-campus instructions first, and the remaining portion covered online. It is estimated that approximately 15 hours is assigned to online synchronous interaction (WebEx) for each course. The time limit for Blackboard use, which is asynchronous, is considered unlimited. Figure 1 illustrates a generic blended course matrix comparing face-to-face versus online meetings as well as synchronous versus asynchronous platforms.

Thus, the challenge becomes how to best use the different instruction platforms (classroom, Blackboard, WebEx, and email) so that course coverage is optimal.

The Scoring System

Addressing the above challenge is the primary objective of this paper. To measure effectiveness, I assigned a "Relevancy" score for my Operations Management course contents using my judgment on the current level

Table 1 The Effectiveness Grid

	Effectiveness scores				
Topics	Classroom	Blackboard	WebEx	E-mail	Relevancy
Introduction	10	5	6	0	5
Process management	10	2	5	0	10
Project management	10	2	4	0	8
Inventory	10	5	6	0	6
Supply chain	10	2	4	0	10
Waiting line/Queuing	10	4	5	0	7
MRP/ERP	10	6	7	0	7
Lean/Six-sigma	10	5	6	0	10
Forecasting/Aggregate planning	10	5	6	0	4
Cases in general	10	8	7	0	9
Assignment review	10	8	8	5	7
Office hours	2	2	5	5	5
Maximum total hours	14	Unlimited	15	Unlimited	

Figure 1 Blended Course Matrix

	Synchronous	Asynchronous
Face-to-Face	• Regular classroom teaching • In-class exercises • Physical games • Physical break-out sessions • Hands-on labs • Field trips	• Lab tests without actual meeting • Physical bulletin boards
Online	• Web casts • Virtual classroom (WebEx, Adobe) • Conference calls • Video broadcast • Online real-time chat • Virtual labs • Online collaboration • Instant messaging	• Web-based tutorials • Intranet (Blackboard, Web-CT) • Threaded discussion boards • Blogs • Online references • Online recording/podcast • Emails

of application of course topics to this specific student group, i.e., healthcare professionals. This is based on my experience in teaching Executive and Healthcare MBA programs for over 15 years and my consulting experiences. These scores are listed in the last column of Table 1. For example, the topics Process Management, Supply Chain Management (SCM), and Lean/Six-sigma are considered very relevant (score of 10), while Forecasting and Aggregate Planning is considered less relevant (score of 4). The relevancy scores also take into consideration Association to Advance Collegiate Schools of Business (AACSB) accreditation as well as the importance to the specific group of students, in this case, healthcare professionals.

Next, scores are assigned to capture the effectiveness of teaching each content topic on each of the four alternative channels/platforms. It is estimated that classroom teaching would be most effective for most of the topics (i.e., score of 10), but we get only 14 hours of face-to-face classroom instruction for each course. Certain topics, such as Project Management, are very difficult to cover on Blackboard, while some other topics, such as Material Requirements Planning/Enterprise Resource Planning (MRP/ERP) can be reasonably taught on Blackboard and WebEx (scores of 6–7). Similarly, different scores are assigned to all other channels. For example, cases can be better covered on Blackboard than on WebEx, but Process Management can be better covered on WebEx than on Blackboard (due to certain games and exercises). These scores are listed in the main body of Table 1. Note that the only two items that can be covered by email are assignment review and office hours.

Models and Results

In principle, the model attempts to distribute available hours to the different instruction channels to maximize teaching efficiency (a combined score of relevancy and effectiveness). The verbal formulation of the model is:

Decisions: assignment of topics to channels Objective: Maximize teaching efficiency (a combined score of relevancy and effectiveness)

Constraints: total coverage required, and time available in different channels.

I will model this problem as an MIP in four ways: (1) strictly as an assignment problem, i.e., each topic can be assigned to only one channel, (2) allow fractional split of a topic to different channels, (3) impose a few additional constraints, for example, forcing course introduction at the beginning of the term, and (4) impose sequencing requirements.

Model 1: *Assignment Problem.* Let,

$x(t, m)$ define whether topic t has been assigned to channel m, for $t = 1, \ldots, 12$ and $m = 1, \ldots, 4$;

$x(t, m) = \{0, 1\}$; 1 if assigned, 0 otherwise
$h(t) =$ time (in hours) needed to cover topic t, for $t = 1, \ldots, 12$
$\bar{h}(t) =$ total time (in hours) available for channel m, for $m = 1, \ldots, 4$
$r(t) =$ relevancy assigned to topic t, for $t = 1, \ldots, 12$
$e(t, m) =$ the effectiveness score of topic t taught in channel m, for $t = 1, \ldots, 12$ and $m = 1, \ldots, 4$.

Model 1 is:

$$\text{Maximize} \quad \sum_{t=1}^{12} r(t) \sum_{m=1}^{4} e(t,m)x(t,m) \tag{1}$$

$$\text{subject to:} \quad \sum_{m=1}^{4} x(t,m) = 1 \quad \text{for } t = 1, \ldots, 12 \tag{2}$$

$$\sum_{t=1}^{12} h(t)x(t,m) \le \bar{h}(t) \quad \text{for } m = 1,2,3,4 \tag{3}$$

Expression (1) maximizes the effectiveness score for relevancy. Constraint set (2) ensures that every topic is

Table 2 Model 1 Results

Topics	Classroom	Blackboard	WebEx	E-mail
Introduction			1	
Process management	1			
Project management	1			
Inventory			1	
Supply chain	1			
Waiting line/Queuing			1	
MRP/ERP			1	
Lean/Six-sigma	1			
Forecasting/Aggregate planning			1	
Cases in general		1		
Assignment review		1		
Office hours				1
Total hours used	12	6	15	3
Maximum total hours	14	Unlimited	15	Unlimited

Table 3 Model 2 Results

Topics	Classroom	Blackboard	WebEx	E-mail
Introduction			1	
Process management	1			
Project management	1			
Inventory			1	
Supply chain	1			
Waiting line/Queuing	**0.67**		**0.33**	
MRP/ERP			1	
Lean/Six-sigma	1			
Forecasting/Aggregate planning			1	
Cases in general		1		
Assignment review		1		
Office hours				1
Total hours used	**14**	6	**13**	3
Maximum total hours	14	Unlimited	15	Unlimited

covered, and constraint set (3) limits each channel to its maximum available hours.

In my specific case, 14 hours are available for on-campus classroom instructions, and 15 hours for WebEx. Available hours for Blackboard and email are viewed as unlimited. Also, it is assumed for this paper that three hours will be needed to cover each topic. This is a reasonable assumption for a 3-credit course and in line with our Evening MBA program in which classes are held for three hours. Topic sequencing is not included in Model 1; it will be considered in Model 4.

The optimal solution for Model 1 is given in Table 2. The optimal solution suggests that the topics that should be covered in on-campus classroom instructions are Process Management, Project Management, SCM, and Lean/Six-Sigma. Blackboard should be used for case discussions and assignment review; WebEx should be used for Introduction, Inventory Management (IM), Waiting Line, MRP/ERP, and Forecasting/Aggregate Planning; and email should be used for office-hour coverage only.

Model 2: *Distribution Problem.* In Model 1, the binary variables forced the condition that each topic be taught on exactly one channel. However, this need not be a true requirement. Therefore, I relax that condition in Model 2, in which the hours for each topic can be distributed among the four channels. I replace the binary variables with fractional variables (fraction of total coverage of a topic) by replacing the binary constraints with constraint set (4). By spreading the topic coverage across multiple channels, one might enhance the effectiveness score.

$$0 \le x(t, m) \le 1 \quad \text{for } t = 1, \ldots, 12 \tag{4}$$

Table 3 shows the optimal solution for Model 2. The change from Model 1 is that two of the three hours for Waiting Line Management are shifted from WebEx to the classroom, which makes the classroom total hours constraint binding.

While the total relevancy times effectiveness objective function means nothing by itself, note that it increased by 3.30% from Model 1 to Model 2.

Model 3: *Distribution Problem with additional constraints.* In the Model 2 solution, no part of the Introduction and no case discussion is done on campus. This is undesirable, because I would like to begin the on-campus session with certain parts of the introductory material (while other introductory material, such as Operations Strategy, can be done online); I would also like to cover at least one case on campus. To achieve this, I add two constraints:

$$x(1, 1) \ge 0.333 \quad \text{where } t = 1 \text{ indicates Introduction, and } m = 1 \text{ indicates on-campus} \tag{5}$$

$$x(10, 1) \ge 0.333 \quad \text{where } t = 10 \text{ indicates case discussion.} \tag{6}$$

Equation (5) ensures that at least a third of the introduction material will be covered on campus. Equation (6) does the same for the cases.

Table 4 shows the optimal solution for Model 3. To free up time for the introductory material and the case discussion on campus, Waiting Line Management is moved completely to WebEx coverage. Coverage on Blackboard decreased by a few hours. These additional requirements resulted in only a slight decrease (1.46%) to the objective function.

Model 4: *Sequencing Problem.* So far I have not imposed any constraint on topic sequencing. However, appropriate sequencing is desired for effective assimilation of naturally connected topics, for example, IM and SCM. In Model 4, I add constraints to ensure the following sequencing requirements:

- All materials for "introduction" must be covered before all other topics;

Table 4 Model 3 Results

Topics	Classroom	Blackboard	WebEx	E-mail
Introduction	**0.33**		**0.67**	
Process management	1			
Project management	1			
Inventory			1	
Supply chain	1			
Waiting line/Queuing			**1**	
MRP/ERP			1	
Lean/Six-sigma	1			
Forecasting/Aggregate planning			1	
Cases in general	**0.33**	**0.67**		
Assignment review		**0.67**	**0.33**	
Office hours				1
Total hours used	14	4	15	3
Maximum total hours	14	Unlimited	15	Unlimited

- SCM must be done after IM;
- Waiting Line Management must be done after Process Management AND Project Management;
- MRP/ERP must be done after IM.

The new optimal solution is given in Table 5. All introductory material is now covered in the classroom during on-campus visits. Much of IM is brought forward to the classroom, parts of SCM are moved back to WebEx, and Lean/Six-Sigma is pushed back to WebEx. The objective function decreased by 4.26% to accommodate these additional sequencing constraints. To see why, note that the effectiveness score of IM on WebEx is 6 while that of SCM is 4; so Model 3 resulted in covering SCM in the classroom and IM on WebEx. Yet the forced sequencing resulted in the bulk of IM to be done in classroom and pushed some SCM to WebEx, while also pushing Lean/Six-Sigma from the classroom to WebEx.

Table 5 Model 4 Results

Topics	Classroom	Blackboard	WebEx	E-mail
Introduction	**1**			
Process management	1			
Project management	1			
Inventory	**0.67**		**0.33**	
Supply chain	**0.67**		**0.33**	
Waiting line/Queuing			1	
MRP/ERP			1	
Lean/Six-sigma			**1**	
Forecasting/Aggregate planning			1	
Cases in general	0.33	0.67		
Assignment review		**1**		
Office hours			**0.33**	**0.67**
sum	14	5	15	2
Maximum total hours	14	Unlimited	15	Unlimited

Sensitivity Analysis

I conducted sensitivity analysis on Model 2 because it does not include integer constraints; therefore, one can generate a sensitivity report. I investigated sensitivity to two parameters: (1) the available hours in the classroom and (2) the effectiveness scores for different topics in different channels.

In particular, the following questions were addressed:

1. If another hour is made available in classroom meetings, how much will the objective function increase?

2. In the current optimal solution, SCM is not taught on WebEx with an effectiveness score of 4. How much does this score need to increase to make the optimum solution cover SCM on WebEx?

The first question is answered by looking at the shadow price for the classroom hours constraint. It shows that an additional classroom hour will increase the objective function by 1.60%. Whether this improvement can be justified by the investments necessary to make the additional hour available is not addressed in this paper.

The second question is answered by looking at the allowable increase for the relevant objective function coefficient. It shows that the current optimal solution stays optimal until the SCM effectiveness score for WebEx becomes 6.5, beyond which it will be covered on WebEx. This is useful information especially because some of these are judgment scores; knowing the cushion on the selected value indicates the robustness of the solution.

Similar sensitivity analysis can be done for other parameters.

Discussion and Limitations

Preparing a course on Operations Management for healthcare professionals in a program that is partly on campus and partly online is a constant challenge to instructors. The models presented here offer a simple yet useful tool in planning for material coverage for a course that uses different instruction channels. The Healthcare MBA program admits one cohort every year, and the Operations Management course is a core course in the program. I teach the course once a year. I found this tool to be quite effective in preparing my teaching material for our Healthcare MBA program which, in my opinion, gives me an edge over instructors teaching other courses. I expect that my success in implementing this model in the Operations course will lead to application of the model to other business courses.

While I do not have direct evidence that use of this model has improved my teaching effectiveness, my teaching evaluation score did improve, when I used this model to design my course, from the previous

year when the model was not used. More important, I felt more confident going into the program when topic scheduling was decided using the models. For example, I am comfortable splitting a certain topic (e.g., Waiting Line Management) to multiple channels (classroom and WebEx) knowing the estimated increase in its effectiveness, as indicated by Model 2. Similarly, now I do not mind forcing minor constraints to cover certain topics in certain channels since the sacrifice in effectiveness is minor, as the results for Model 3 show.

The models have some limitations:

(1) To keep the model simple for illustration, I assumed the time assigned for each topic to be exactly three hours. In reality, the time could vary from topic to topic. In my actual application of this model, I have used varying time durations assigned to each topic.

(2) Topics can overlap. For example, case discussion and Process Management can overlap if a case is used to cover a Process Management topic. To keep the model simple in this paper, I assumed all topics to be distinct and independent. In my actual teaching, I allowed overlaps where I felt appropriate. However, the total of 36 instruction hours falls within the range of 35–40 hours prescribed for a typical 3-credit course.

(3) The relevancy and effectiveness scores in Table 1 are based on subjective judgment, which will vary from instructor to instructor or from program to program. This is beneficial because local conditions and instructor competencies can be captured. However, individualization can take away some generality from the model. However, my rationale for those scores is not completely random; I base them on my general experience in the applicability of different operations topics in the healthcare industry over the past several years. In the future, I can incorporate feedback from other constituencies such as students, alumni, and the career placement office in deriving these subjective scores.

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