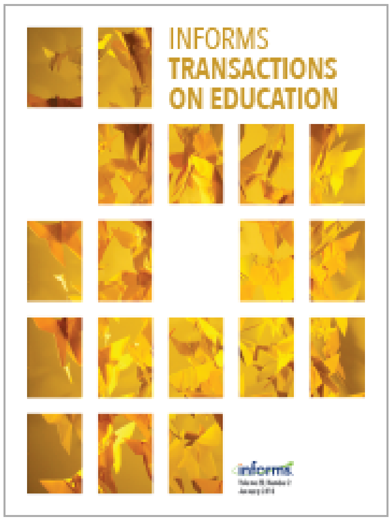

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Case Article

Stickley Adhesives

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Abstract. A two-part case study is presented that integrates several operations management topics while addressing service applications. The case describes a globally dispersed service system provided to new and existing customers of an adhesives manufacturer. The firm wishes to centralize the service that is offered to customers in six regions. Part A of the case study asks students to determine capacity requirements using a simulation that mimics the centralized system, in particular with consideration of the variation in both demand and service activity times. Part B of the case study, positioned one year later, describes problems associated with the new system and asks students to apply Lean methods to improve the service. The case study was inspired by an actual service system at an adhesives company, but details have been fictionalized to create a better educational experience for students.

Supplemental Material: Supplemental materials can be found at https://doi.org/10.1287/ited.2019.0231ca. The Teaching Note is available at https://www.informs.org/Publications/Subscribe/Access-Restricted-Materials.

Keywords: service operations management • process improvement • lean principles • simulation • capacity • analysis

1. Introduction

Metropolitan College (MET), the School of Professional Studies at Boston University (BU), is one of the largest of BU's 17 degree-granting Schools (www.bu.edu/met). Our mission is to provide practical and timely professional education, primarily to graduate students seeking Master's degrees and graduate certificates. MET students fall into two main categories: (a) somewhat older part-time working professionals (both online and on-campus) and (b) somewhat younger fulltime students (both domestic and international). As such, MET students can vary significantly in experience levels and technical savvy. The academic backgrounds of both online and on-campus students also vary significantly, with undergraduate majors ranging from mathematics/engineering to business/economics.

The two-part case study described in this article is used in both on-campus and online versions of the operations management (OM) graduate course, which is offered in the department of administrative sciences. The course seeks to cover manufacturing and service operations in equal measure, with an aim to prepare graduating students with the ability to analyze and improve the business processes for which they are or will be responsible. This scope would encompass business processes with external customers (e.g., assembling products or troubleshooting consumer issues) and internal customers (e.g., orienting new employees or analyzing performance data). To be clear, the course does not teach students how to, for example, orient a new employee; it teaches them how to analyze the business process that is designed for this purpose.

We have had success incorporating the *real world* into the course by leveraging our own experiences, derived through previous employment, consulting, or discussions with practitioners. The cases are informed by these interactions because they represent actual processes and systems. They are tailored to meet the needs of the course and its students. They are analogous to films that are inspired by real events. This positions the case somewhere between armchair cases (based on author knowledge and experience) and field cases (that use facts obtained from existing organizations). In this way, we eliminate the need to obtain approval from firms who may not be interested in publishing details about their business process or problems they typically encounter. It also enhances the ability to customize the case study. This approach does not reduce the effectiveness of the case because students know that the issues presented are real.

2. Literature Review

The case study integrates the topics of capacity planning and Lean methods in a service environment, and it incorporates a Monte Carlo simulation. It is designed to overcome some of the challenges inherent when teaching the broad range of OM topics by integrating Lean with other topics into a pair of related experiential assignments. The case study also illustrates a service application of Lean, which is typically taught in a manufacturing context. Marley et al. (2013) studied the contents of 14 standard academic OM textbooks. They found that, although Lean material is included in the textbooks, it is typically addressed as a stand-alone collection of techniques without substantial integration among the other OM topics. In addition, textbooks are deficient in the coverage of the softer side of Lean, such as the importance of employee engagement, which is essential for Lean implementation (Lander and Liker 2007).

Most textbook coverage of Lean is devoted to Lean production as originally practiced at Toyota (Ohno 1988). Hence, many instructors are unaware of the nuances associated with the application of Lean methods for services. For example, kanban (the Lean method for inventory control) is not applicable in a service process because inventory does not exist. Designing a manufacturing cell with single-piece flow with a specified takt time will be ineffective in most services because they have variation in task times (Maleyeff 2009). Other Lean methods that do not apply to services include Single-Minute Exchange of Die (SMED) for setup time reduction and Heijunka for leveling production loads (Shingo 1989).

Various experiential approaches have been used to support the teaching of Lean methods. Among others, Harris (2016) used a simulated manufacturing system. In this case, students produced a simple truck made with PVC pipe. Delago et al. (2016) reported on a board game that also applied Lean to a manufacturing system. Computer simulations have been used to support Lean teaching. For example, Shannon et al. (2010) simulated a manufacturing system to enhance student learning. Moevani and Chou (2016) used the Lean methods called the Five Whys to teach problem solving, which had the dual benefit of illustrating an important Lean method while teaching problem solving. Marley (2014) made use of student-produced videos that illustrate the application of Lean principles. Conger and Miller (2014) used problem-based learning to teach inexperienced students about the nuances of Lean applications outside of manufacturing environments. Standridge (2000) made use of case studies when teaching manufacturing engineering students about the role of discrete-event simulation.

The use of experiential learning methods for supporting capacity-planning instruction is difficult to pinpoint because many OM case studies and other mechanisms include some form of aggregate planning. However, some authors have used hands-on methods specifically targeted to capacity planning. Lapre (2010) used experiential approaches to teach capacity planning in hospitals and recommended their use for novice instructors. Kang and Doerr (2015) used a hands-on simulation to teach the analysis of tradeoffs when planning capacity for a public sector service. Garcia and Hernandez (2010) described the use of problem-based learning to give students a deeper understanding of theoretical queuing models for various problem types. Finally, Naidu and Sanford (2012) presented hands-on approaches to teaching the impact of learning curves on resource capacity.

We conclude this section by noting that there are several games provided in the literature to be used in OM classes. In fact, the Production and Operations Management Society (POMS) maintains a list of those games at http://www.poms.org/education. Among those games, one of the most widely used is Responsive.net's Littlefield Technologies simulation (Roeder and Miyaoka 2015). Within this comprehensive simulation, capacity planning is a game that most resembles the Stickley simulation. However, there are several differences. First, it requires that the students be familiar with several forecasting techniques and queuing theory. Second, the instructor is expected to train the students, whereas we provide a video training the students for the Stickley Adhesives simulation. Third, it needs to be purchased, whereas our simulation is free of charge.

3. Stickley Adhesives Case Studies

Although Stickley was a name created by the authors, the two-part case study is based in large part on a service offered by an adhesives manufacturer that sells its products in North America, Europe, and Asia. The case concerns a service it offers to its business to business (B2B) customers that evaluates applications (e.g., how to bond two dissimilar materials together in extreme conditions, such as under the hood of an automobile or within an implantable medical device). The service is offered in every region, with work done at local research and development facilities. Before reading further, it is recommended that readers read the "Stickley Adhesives" case study that accompanies this article.

3.1. Stickley Adhesives: Part A

Part A of the case study concerns management's desire to centralize the service by taking advantage of information technology to perform activities where the mix of skill level and labor rates is most favorable. The system includes business processes located in the United States, Puerto Rico, Bangladesh, and the Philippines. Each job starts at prioritizing (Puerto Rico), then moves to scoping (United States), where 12.5% of jobs require a scientist and the remaining jobs require a technician. Next, the jobs go to experimenting (Bangladesh), followed by analyzing, where 50% of jobs require equipment rental. Finally, the jobs move to reporting (Philippines). The assignment asks

Figure 1. Screenshot of Stickley Adhesives Simulation

Inputs only in yellow cells (Workers) - hit F9 (or Fn F9) to generate new sets of random numbers

Stickley Adhesives: Applications Services Simulation

		Prioritizing			Scoping: Scientist			Scoping: Technician			Experimenting			Analyzing w/o Rental			Analyzing w/Rental			Reporting		
		No. Workers:		2	No. Workers:		1	No. Workers:		3	No. Workers:		4	No. Workers:		2	No. Workers:		6	No. Workers:		3
Day	Demand	InBox	Potential	Move	InBox	Potential	Move	InBox	Potential	Move	InBox	Potential	Move	InBox	Potential	Move	InBox	Potential	Move	InBox	Potential	Done
1	20	20	22	20	3	6	3	21	24	21	24	28	24	12	13	12	12	12	12	24	14	14
2	16	16	19	16	2	0	0	18	20	18	24	26	24	10	8	8	14	19	14	34	34	34
3	20	20	25	20	5	0	0	13	26	13	18	15	15	14	12	12	12	10	10	22	19	19
4	22	22	20	20	7	1	1	18	23	18	16	24	16	10	17	10	9	15	9	25	17	17
5	31	33	26	26	10	5	5	16	23	16	19	30	19	5	8	5	11	19	11	27	31	27
6	32	39	26	26	6	4	4	25	24	24	21	34	21	13	11	11	6	13	6	16	34	16
7	23	36	16	16	5	3	3	24	23	23	28	29	28	11	17	11	12	13	12	17	30	17
8	17	37	31	31	4	1	1	15	13	13	26	25	25	9	9	9	19	11	11	23	16	16
9	26	32	28	28	3	5	3	33	12	12	15	27	15	9	10	9	24	11	11	27	23	23
10	19	23	15	15	0	1	0	49	24	24	15	27	15	7	10	7	21	19	19	24	21	21
11	15	23	32	23	2	6	2	38	29	29	24	28	24	8	11	8	9	8	8	29	27	27
12	18	18	29	18	2	1	1	30	21	21	31	17	17	12	15	12	13	12	12	18	32	18
13	25	25	20	20	3	5	3	25	28	25	36	21	21	12	12	12	6	15	6	24	27	24
14	28	33	26	26	4	4	4	16	29	16	43	19	19	15	16	15	6	17	6	18	23	18
15	30	37	22	22	3	0	0	23	19	19	44	28	28	9	14	9	10	19	10	21	18	18
16	21	36	33	33	6	6	6	23	29	23	35	21	21	14	19	14	14	13	13	22	19	19
17	14	17	29	17	2	4	2	31	30	30	43	28	28	13	18	13	9	9	9	30	21	21
18	28	28	19	19	1	2	1	17	14	14	47	33	33	16	16	16	12	12	12	31	21	21
19	18	27	31	27	0	0	0	22	17	17	29	23	23	18	6	6	15	16	15	38	22	22
20	30	30	19	19	5	3	3	27	24	24	23	15	15	25	7	7	10	12	10	37	30	30
21	34	45	16	16	4	0	0	20	25	20	35	24	24	22	8	8	11	5	5	24	15	15
22	20	49	29	29	7	3	3	13	18	13	31	22	22	27	15	15	17	13	13	22	33	22
23	16	36	30	30	9	1	1	24	14	14	25	29	25	20	12	12	18	18	18	28	34	28
24	29	35	21	21	13	5	5	35	20	20	15	21	15	19	10	10	14	7	7	30	22	22
25	18	32	20	20	11	0	0	33	16	16	25	34	25	17	16	16	14	9	9	25	34	25
26	29	41	17	17	16	6	6	32	24	24	16	17	16	15	7	7	16	14	14	25	15	15
27	19	43	18	18	14	6	6	21	21	21	30	24	24	15	13	13	11	5	5	31	23	23
28	34	59	23	23	9	1	1	17	26	17	33	26	26	15	17	15	17	12	12	26	34	26
29	32	68	19	19	10	4	4	21	15	15	25	25	25	14	18	14	17	14	14	27	14	14
30	31	80	23	23	9	1	1	22	14	14	19	19	19	14	11	11	14	12	12	41	18	18
Total	715	1040	704	658	175	84	69	722	645	574	815	739	652	420	376	327	393	384	325	786	721	630
Avg	23.8	34.7	23.5	21.9	5.8	2.8	2.3	24.1	21.5	19.1	27.2	24.6	21.7	14.0	12.5	10.9	13.1	12.8	10.8	26.2	24.0	21.0

students to determine capacity requirements at each location and anticipate problems resulting from transitioning from a local service to a global service.

A simulation is used to incorporate random demand and variable processing times at each process. The simulation, shown in Figure 1, represents one month (i.e., 30 days) of operation. Within each month, jobs are carried over from day to day. However, each month starts with the same InBox (queue) of jobs waiting to be processed. It would be impractical and not necessarily realistic to carry jobs forward from one month to the next. In the real system, extraordinary actions would be taken once an ineffective system configuration was allowed to continue. For example, if queues become excessive, jobs would be delayed and eventually demand would decrease because many customers would stop making requests. Therefore, the simulation can be looked upon as mimicking one month's operation in a stable environment. A 10-minute video introduces the students to the simulation, including its logic and its use.

The case questions start by requiring the students to determine the number of workers to assign to each location so that average capacity is equal to average demand. The values shown in Figure 1 are the values that should be input (no. workers for each of the seven processes). Then, they are required to run the simulation for 40 months of operation and use statistical methods to characterize the variation in the monthly throughput of the service system.

Then, students are asked to determine the best level of manpower (i.e., no. workers) for each process to most effectively balance throughput concerns with labor cost considerations. Each student team will usually take a unique approach to this problem, ranging from pure trial-and-error to a more sophisticated approach that considers bottleneck processes and labor costs.

Finally, each student team is asked to forecast problems that may occur after implementation of the centralized system. Several potential problems are discussed during class, and they set the stage for Part B of the case study sequence.

3.2. Stickley Adhesives: Part B

Part B of the case, positioned as taking place one year after implementation, describes issues and challenges encountered in the centralized service system. It asks students to analyze the service processes and recommend improvements. It uses interviews from managers and workers in the applications system to highlight several problems.

At the front end of the system, confusion exists among new and existing customers, the Stickley sales force, technicians, and the call center. This confusion results in proposals for work that are not submitted properly or accurately, as well as time wasted correcting these and other mistakes. Several other problems are noted in the case study. They include the types of issues that students would not be inclined to consider. For example, the *technical joy* of some scientists, who enjoy working with new products, causes them to make recommendations that are not cost effective because they can be accomplished with simpler approaches. Finally, back-end reporting problems are also discussed. The centralized reporting process needs to wade through jargon and idioms that are used by American technicians but not understood by report-generating personnel located in the Philippines.

The first question asks students to create a process map representing the front end of the system, where customers submit proposals to the prioritizing department. A flowchart or other relevant format can be used at the discretion of the students. The process maps that students turn in will likely vary in appearance, perhaps a great deal. Unless process mapping is covered in extensive detail in class, any format should be acceptable as long as it is accurate and includes the important elements discussed in the case study. Based on the process map, students are asked to list those activities that add value and those activities that are wasteful from a Lean perspective.

The next requirement is that students offer suggestions for improvement, using the methods of Lean that are described in class lectures. This requirement is open-ended because students may consider solving any of the numerous problems presented in the case study.

4. Course Topics Covered

The Stickley Adhesives case study is designed to integrate several topics covered during the first third of the semester-long course. It is also meant to expose students to service operations and challenges associated with business process management. The case integrates topics that include capacity planning, process analysis, and Lean methods. It is situated in the course as shown in Table 1. For example, in Part A, students are required to run the simulation to choose the number of workers required at seven processes so that the throughput is acceptable. This task is made difficult because of the high level of variation, both in customer demand and processing times, which is typical of many service processes. In Part B, they are required to create a process map representing an important set of activities, evaluate the map by identifying activities that add value and those that are wasteful, and recommend improvements using Lean methods such as poka-yoke, the 5 Ss, standard work, and visual workplace controls.

In addition, the cases expose students to the nuance that real life offers by integrating global issues, such as international cultures, language differences, and time zone challenges. Finally, it gives students an opportunity to apply statistical methods that, we believe, should be incorporated in most of their courses. In order to enhance understanding of the case (especially for students with limited or no business experience), a week 1 online discussion assignment requires them to describe a job they have had, including part time or an internship. They are asked to describe their work as a business process, list the key activities, and list typical problems they encountered. This assignment serves as the focus of a classroom discussion on the day the case study is assigned. Additionally, they are asked to analyze their business process in more detail as a week 3 online discussion assignment.

5. Student and Faculty Perceptions

Students have reacted well to the case studies. In a survey that we conducted to understand the effectiveness of this case study in comparison with other

Table 1. Course Sequence with Case Assignments

Week no.	Course topics	Assignment	Case study challenges
1	Introduction to business processes	Preliminary discussion assignment	
	Manufacturing process characteristics		Dealing with activity time variation
	Service process characteristics		Predicting service operations problems
	Processing systems		Explaining the impact of variation
2	Matching supply with demand	Stickley Adhesives Part A (due week 3)	
	Cost effective vs. responsive systems		Calculating capacity needs
	Role of inventory and capacity buffers		Quantifying throughput variation
	Effect of variation on business processes		Applying capacity buffers
3	Process and capacity analysis	Follow-up discussion assignment	
	Process flow mapping		Creating process maps
	Identifying value-added and wasteful activities		Dealing with activity time variation
	Calculating resource utilizations		Identifying wasteful activities
4	Lean operating methods	Stickley Adhesives Part B (due week 5)	
	Comparison of mass production and lean		Identifying a problem's root causes
	Standard work, 5 Ss, and poka-yoke		Creating Lean improvement methods
	Jidoka, SMED, and visual controls		Justifying Improvement Ideas

cases that the students have seen, we asked them the following questions. (i) Do you think that Stickley Adhesives case studies help you understand the course material well? (ii) Compared with case studies in your other classes, do you think Stickley Adhesives case study connects with class content better? The anonymous survey was completed by 38 students both on-campus (22 mostly international students) and online (16 mostly working professionals). For the first question, 15 of the 16 online students replied yes and 21 of the 22 on-campus students answered yes. For question 2, 13 of the 16 online students replied yes and 21 of the 22 on-campus students answered yes.

Instructors have learned a great deal when developing (and using) this case and other similarly developed case studies. Collaborating with practitioners brings value and adds depth to our knowledge of topics, which provides more interesting and enlightening classroom examples. Instructors have also discovered that some topics are not well understood by many students, which motivated us to change our lecture materials. For example, consider the Lean method called poka-yoke (also known as mistake proofing). We identified the need to reinforce that poka-yoke should not simply reduce the likelihood of a mistake—it should eliminate the possibility of a mistake. We also noticed that, when students present a problem solution, sufficient detail needs to be presented. Otherwise, the class (and the instructor) cannot fully comprehend (or evaluate) their recommendation. Many solutions generate new problems, which can only be surmised with a detailed presentation. Noticing this phenomenon motivated us to revisit how we present some of our classroom examples.

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