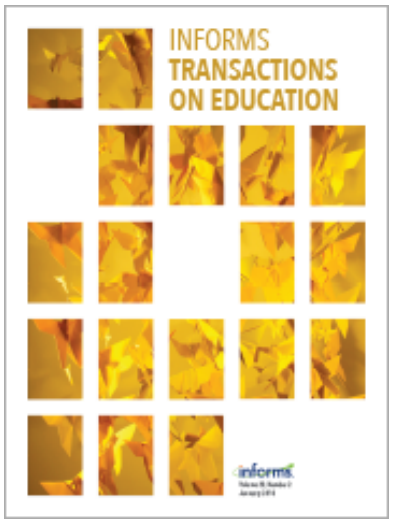

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Using Homemade, Short, Fictional Cases for Teaching the Theory of Constraints

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Abstract. For our undergraduate Operations Management course, a lack of case studies meeting our specific needs, coupled with our reluctance to reuse cases too frequently, inspired development of a collection of "homemade" cases. These cases, which focus on application of the Theory of Constraints, are fictional (of necessity) and short (by design); however, we have found that these two characteristics have not limited the effectiveness of the case assignments: They are consistently meeting our pedagogical objectives, including eliciting deliberation and varied responses from students. This paper discusses the motivation for developing homemade cases, the nature of the cases (short, fictional) and associated implications, advice for development and implementation, and feedback from students.

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1. Introduction

If you cannot find it, make it! When we discovered that there was a limited supply of published case studies that fit our specific needs, and decided that we did not want to use the same case in consecutive school terms (or even twice within a few years), we developed a collection of "homemade" case studies. These case studies are deliberately short (exactly two pages), are fictional (but based on information about real processes), and are intended to create context suitable for the application of the five focusing steps of the Theory of Constraints. We have been implementing this type of case assignment in our undergraduate introductory Operations Management (OM) course for seven years, and have found that it is effectively meeting our pedagogical objectives, including eliciting deliberation and varied responses from students.

The purpose of this paper, in general, is to describe an effective case-based assignment and to provide suggestions for other Instructors who may wish to do something similar. More specifically, the paper will briefly discuss why a case-based assignment has been used for this topic; explain the advantages of a *short* (rather than lengthy) case in this application, and discuss the use of *fictional* cases; share experience and offer advice for developing these types of cases; and describe an implementation from the Fall 2016 term, including a brief exploration of student feedback.

2. Background

2.1. MGTS 352

MGTS 352 is an introductory OM course, taught face-to-face to primarily third-year students in class sizes of forty, as a requirement of the Bachelor of Commerce program at MacEwan University in Edmonton, AB. An introductory Statistics course is the only prerequisite. Following an introduction chapter that discusses Business Strategy in an OM context, the course covers five main topics: Forecasting, Project Management, Constraint Management, Inventory Management, and Waiting Lines Management. The course is quantitative in nature and includes weekly fifty-minute Excel lab sessions in addition to regular classroom (lecture) time. The course emphasizes problem-solving and concept application as much as rote calculation using formulas, and includes a statement in the course outline to the effect of the following:

> *This course is intended to be a hands-on problem-solving course that emphasizes application of theory and problem-solving skills. Students are not only expected to know specific terminology and how to make relevant calculations, but*

are also expected to know why these concepts exist (*i.e., the fundamental business problem behind them*) *and what the quantitative models do.*

The evaluation methods used, including the case study assignment described in this paper, reflect this philosophy. The case study assignment centers on a specific topic from our Constraint Management chapter—The Theory of Constraints.

2.2. The Theory of Constraints

(Because the requirements for the content and format of the case study for our assignment are motivated by the specific topic, we begin with a description of this topic. The following is based on Orchard 2015.) The Theory of Constraints (TOC) was created by Eli Goldratt in the mid-1980s and became widely recognized through a novel called *The Goal* (Goldratt and Cox 1986). Goldratt himself describes TOC as "an overall theory for running an organization" (Rahman 1998, p. 336). Dettmer (1997, p. xxi) characterizes TOC as "a collection of . . . principles and tools or methods for improving overall system performance." The interpretations, representations, and applications of TOC are vast. For our introductory OM course, we focus on what Goldratt (1990) calls the "five steps of focusing" (1990). These steps provide an effective and somewhat concrete framework for focusing system improvement efforts, and are a useful articulation tool. A brief description of these steps is as follows:

Step One—Identify the Bottleneck: The central premise of TOC is that every system has a constraint (bottleneck), which could otherwise be described as a resource whose "capacity is less than the demand placed upon it. Bottlenecks control the rate of output for the entire plant" (Goldratt et al. 2007, 23:40). Once identified, the bottleneck becomes the focal point for the remaining steps.

Step Two—Exploit the Bottleneck: Given that the bottleneck constrains factory output, it is important that the bottleneck operates at as close to capacity as possible. Any production time lost on the bottleneck (e.g., due to set-ups, waiting for materials, maintenance, etc.) is lost factory production time. Exploiting the bottleneck is about making sure that as much of the existing capacity is realized as is possible.

Step Three—Subordinate to the Bottleneck: Although the previous step implies that it is important that the bottleneck always has work available to it, it is also important not to continually operate activities that are "upstream" of the bottleneck at full capacity; otherwise, excessive work-in-progress (WIP) inventory will accumulate. Slowing upstream production to the pace of the bottleneck is one example of subordinating to the bottleneck: All decisions and plans must be based on the bottleneck needs and pace.

Step Four—Elevate the Bottleneck: Once the bottleneck has been exploited to maximum output, it may still be a system constraint and the only way to increase output (and therefore increase system output) may be to increase the capacity of the bottleneck, such as by investing in additional production equipment.

Step Five—Repeat: After step four, it may be that the original bottleneck is no longer the system constraint, at which point the first four steps will need to be repeated for a newly-emerged bottleneck. In essence, the TOC's five steps of focusing are a continuous cycle.

In our course, we introduce these five steps of focusing by way of a fictional context that describes a simple linear process of activities (cut→drill→sand→assemble→finish) to produce wooden chairs. We then watch the movie version of "The Goal" (Goldratt et al. 2007), which illustrates the five steps first in the context of a youth group hike and then in the context of a factory. This is followed by classroom discussion. Most Instructors will follow this with additional examples of the application of one or more of the five steps. Finally, students are asked to apply the five steps to a new context, i.e., the case study assignment that is the topic of the current paper.

2.3. Overview of Case Assignment—FALL 2016

In Fall 2016, students were provided with an 1,100-word case that described, in terms of a number of substeps, the production process that the supposed "SUPER-Crunch Potato Chip Company" used to manufacture potato chips (see Appendix A for the full case). This case study is fictional (written by the current paper author) but is based on information about potato chip production gained from general web searches, including Tsung Hsing Food Machinery Co., LTD. (2016) and Alibaba.com (2016). The core issue of the case is that the company finds that their *system output* is less than they would like, while WIP inventory has a tendency to build up at various substeps within the system. The case provides some basic numerical data to allow students to compute approximate throughput capacities at the substeps, and hints at ways in which the organization could better manage the capacity at these individual substeps. Students are asked to (1) determine the capacity of each substep in the system, as well as the overall capacity of the factory, and (2) provide advice, based on applying the TOC to the specifics of the production process described in the case, on how the factory can maximize (or increase) system output. Students submit, as a group of three, a 4-to-6 page (net of title page, table of contents, and appendices) report. (We embed the case in an assignment, rather than using it in classroom discussion; more details about how we implement our assignment are provided in Section 4.1.)

Note that from one school term to the next, the core issue and the fundamental question of the case remain the same, but the case context and particulars (and thus problem solutions) vary. In other words, the *assignment* remains consistent between school terms, but the *case* changes. Although these cases tend to follow a specific "formula," we have found that they still leave ample room for interpretation and result in varied solutions, and are true in many ways to the spirit of case analysis. To date, these case assignments have been taught by more than 10 different course Instructors to an estimated 4,000 students with primarily positive results and feedback.

3. Homemade, Short, Fictional Cases

3.1. Why Cases for This Topic

It is safe to say that most undergraduate Business students are not abundantly familiar with the "real world" context that frames the business problems behind the quantitative models of an OM class. Grossman et al. (2016, p. 44) discuss these challenges in their paper, which focuses primarily on quantitative and spreadsheet applications, and point out that many business students lack "intellectual curiosity" when it comes to these types of topics. They recommend "embedding instruction in a real-world context" Grossman et al. (2016, p. 45) as a student-centered teaching principal for overcoming these types of challenges, including the use of case studies Grossman et al. (2016, p. 46). McFarlane (2015) also recommends case studies as useful for "instructors that want students to explore how what they have learned applies to real world situations." We have found this to be true for OM topics that center around a set of equations (e.g., the Economic Order Quantity) and/or a methodology (e.g., an algorithm for determining project schedules) that provide a focal point for the students, but perhaps even more so for topics in which there is *no* tangible focal point, such as our Constraint Management TOC chapter, which is more of a collection of principals than a set of equations or precise methodologies. Furthermore, the TOC is usually described within production settings, with which most undergraduate students have limited, if any, experience. For all of these reasons, we have found that case studies are an effective teaching tool for this chapter. A case assignment also provides some balance in our course, since other chapters rely more heavily on automated Learning Management System-based multiple-choice assignments.

3.2. Case Length and Extraneous Content

There appears to be no definitive consensus on how long cases should be, and how much peripheral (and sometimes irrelevant) information should be provided. Herreid et al. (2016, p. 61) surveyed case teachers and found that the least important of the 12 listed case characteristics is that they be short. However, in the same survey, only 12% of participants were okay with cases exceeding four pages. In a UK survey about the use of cases for teaching Operational Research (OR), Penn et al. (2016, p. 18) found "appropriateness to the material being taught" and "ease of use with students" to be the most important factors in selecting case studies; length was near the bottom of the list. On the one hand, the main benefit of a longer case seems to be that "one of the most important things that a student—and a manager—must learn is . . . an ability to wade through lots of material and decide what is relevant" (Andersen and Schiano 2014, p. 22). (However, these authors also point out that "this strategy can backfire badly," and they emphasize considering the fit with the content and the course. Penn et al. (2016, p. 20) do not include *managing information overload* in their list of skills that case studies are intended to assess.) On the other hand, Dunne and Brooks (2004, p. 45) list brevity in their "ten characteristics of a good case." McFarlane (2015) emphasizes proper case selection and provides a number of guidelines, with none emphasized more than *case length* and *relevance*, such as in their observation that "students prefer short case studies that are extremely relevant and whose contents and substance directly reflect concepts being reinforced in highly practical and often more explicit than implicit ways." Herreid (2005, p. 14) also discusses the *How Much Information*? dilemma without arriving at a definitive answer to the question, wisely concluding that "it depends."

It would thus seem that two factors should determine appropriate case length: pedagogical objectives, and the implementation of the case (how it will be used by the teacher). If the pedagogical objective is to have students develop their ability to read a large amount of content and determine what is relevant, then longer cases would be appropriate; otherwise there does not seem to be a compelling reason for a case being any longer than to provide "just enough information for a good analysis" (Dunne and Brooks 2004, p. 45). Considering that we are teaching undergraduate students in an introductory course, we felt that our pedagogical needs are more centered on concept application. Our intuition has been that if our TOC cases are carefully developed to be approximately, but never more than, two pages, this might influence student perceptions and enthusiasm for the case. This is not to say that our cases are devoid of any ambiguity: In fact, we see appropriate variety in the student submissions each term. Perhaps this is where sharing our approach with other teachers can add value. We have found that even without much extraneous information, students still need to grapple with prioritizing the information they have, and with the ambiguity that emerges

in the case. In short, with our case assignments, we have come to see first-hand what Herreid (2005, p. 12) points out: "in many (most) instances, the straightforward approach without contradictions poses enough challenge without confusing asides and red herrings."

Case implementation also has an impact on appropriate case length. Herreid (2015, p. 54) says that only 20% of the success of a case comes from the written case itself; the other 80% depends on presentation (by which they mean how it is treated in the classroom by the teacher). They point to an example where an enthusiastic teacher turned a one paragraph case into "an hour and a half [of] magical discussion." Our short cases are built into a broader context with other examples shown in class, and thus do not seem to require length. We discuss this further in Section 4.1, which describes the specifics of our implementation of the case assignment.

Using a short case for our assignment was also supported by our success using the approximately 500-word *Chad's Creative Concepts* case from the textbook (Krajewski et al. 2016, p. 28) for classroom discussion in our Introduction module. We appreciate that the case does not require extensive reading: This improves the chances that all of the students will have read it beforehand or can do so at the start of class, and that the case concisely emphasizes a point about strategic alignment, without any unnecessary distractions or encumbrances. Short end-of-chapter cases such as this are popular in OM textbooks. Krajewski et al. (2016) include cases at the end of their chapters that range between approximately 500 and 2,300 words, with the majority being fewer than 1,000 words and some including one or two tables and/or diagrams. The Heizer and Render (2011) textbook also includes end-of-chapter case studies, most in the 300–1,200-word range, with the majority fewer than 500 words plus a table and/or diagram or two.

3.3. Fictional Cases

As described earlier, we had a specific need in terms of what we wanted the core issue and the fundamental question of the case to be, even though we wanted the case itself to be different from term to term. (Note that there are a number of reasons that we do not like to repeat cases too often, including that it allows us to repeat the fundamental question we are asking, and to provide more thoughtful and extensive feedback to students when grading. Penn et al. 2016, p. 23 briefly discuss the trade-off between case development and re-use frequency.) The first time we administered a case study assignment for the TOC topic, in 2009, we used a published case (see Blok and Grasby 1998), which worked quite well. In searching for a suitable case for the next term, we found several good cases, but none which met our needs (perhaps due in part to the choosy nature of the current paper author!). Thus, a short, fictional homemade case was developed for Fall 2010. In subsequent years, five more cases were added (for a total of six homemade cases to date). Each case took an estimated eight hours for one person to craft, spread over a number of days and with some editing/feedback from a colleague. We later added a second publisher case study (Wood and Klassen 2011) to the collection of cases that we cycle through.

While a case that is entirely real *and* fits our particular needs would be ideal, in the absence of such a case our choice is between cases that are entirely real but do not precisely fit our needs, and cases that are not entirely real but are a better fit. Concluding his discussion of considerations and recommendations for case selection, (McFarlane 2015) provides the following advice: "it is highly recommended that, where possible, instructors should write and develop their own case studies so that they are more aligned with current modes of instruction, concepts, ideas, and theories or lessons being taught." Andersen and Schiano (2014, p. 24) discuss the use of anonymous cases (versus real field-based cases) and suggest that cases should be selected based on the "relevance and quality of the case alone," but add that "students like to learn some real context in addition to the core issue of the case." We feel that we have achieved this balance by developing our own cases, exactly as we want them, but basing them on actual processes and attempting to make the context realistic. An added benefit of homemade, rather than published, cases is the ability to make revisions between uses.

Finally, perhaps there is no better proof that a fictional business case can be an effective teaching tool than the success of *The Goal* (Goldratt and Cox 1986), which has exceeded four million copies in sales, is "used in management colleges to teach [Constraint Management]" (The Goal 2016), and has been listed by Time magazine as one of the "25 most influential business management books" (The Goal 2016). The setting of the book is entirely fictional (the book is a novel).

3.4. Developing the Cases

Given our desired case content and length, the structure must necessarily be one whereby we linearly describe the production or service process step-by-step, similar to Blok and Grasby (1998). The production and service processes chosen for our cases were simply based on experiences and everyday observations, followed by an Internet search. It was not difficult to find resources on the web for the processes about which we wanted to write: These processes include chocolate production, T-shirt manufacturing, Cruise Ship check-in/embarkment, ceramic production, retail stock replenishment, and potato chip production (as per the current paper). From there, the challenge was

to (1) create a setting that includes a person (e.g., a Manager) to inspire student interest, and (2) be mindful of the fundamentals of the five focusing steps of the TOC, such that some opportunities for students to suggest process improvement will be present in the case. Next, we discuss these two aspects of our case development in more detail; see the sample case provided in Appendix A (*SUPER-Crunch Potato Chips*).

Creating a setting for our cases was not difficult, although one might argue that our cases are generally devoid of any real color in terms of flesh-and-blood characters and business context. While we are aware that there would be some benefits to eliciting more emotional engagement in our cases, we have forgone some of these for the benefits of brevity (see Section 3.2). Herreid (2015, p. 54) points out that "the text of a case is only the scaffolding . . . it is in the classroom where flesh is put on the bones." We agree with this: Our homemade cases are embedded into a broader teaching plan for our TOC chapter, which includes the colorful movie "The Goal" (Goldratt et al. 2007), classroom activities and discussions, and the case assignment itself (described in Section 4.1). A case that simply introduces an organization and a person, but is otherwise concise, has worked for us. We are also careful to weave the organizations' business strategy (i.e., their competitive priorities) into the case, which in turn allows keen students the opportunity to ensure the alignment of their recommendations.

Opportunities in the case for process improvements should include some that are somewhat obvious, so that students gain momentum and confidence, and some that are subtle, to allow students the chance to focus and be creative. However, this does not mean that we are "planting correct answers" in our case. In fact, we have found student responses to be quite varied, and have been pleasantly surprised by some unexpected (but strong) recommendations that came from unique interpretations and approaches. Herreid (2005) describes designing cases that *support* and *challenge* students. *Supporting* students, in this context, means allowing them to work in their comfort zone. For example, our SUPER-Crunch case (Appendix A) requires some very basic numerical calculations, and also strongly hints at a few opportunities for improvement such as implementation of more sophisticated production planning, and modifying the layout of the facility. *Challenging* students, as described by Herreid, is asking them to stretch: Our SUPER-Crunch case includes some variability in the numbers (see, for example, the "Slicing" and "Seasoning" steps), which requires students to address ambiguity when performing calculations, and makes it less clear that there is a single bottleneck (e.g., slicing is not the most prominent bottleneck, but it can still be one occasionally). Challenging students is also achieved by imploring them to be specific in their recommendations. For example, a student group might recommend better production scheduling, but there is a lot of room for elaboration on this point, given that the frequency of changing the knife blade and the seasoning would both be impacted by a production plan, but possibly in contradictory ways. (Note that, although the assignment is not meant to delve into complex production planning methodologies, there is opportunity for general discussion of what a plan would need to accomplish and the inherent complexities of such a plan.) Overall, through experience in contemplating various TOC applications (using first-hand observation, video, literature, etc.), a case writer can weave in a few common conditions that can be impediments to process flow (I have given only a few examples above), and Instructors can inspire students to provide depth in their response to these impediments and to look for less obvious opportunities.

We have also found that careful articulation of the problem (see the last sentence of the introduction and the last paragraph in the SUPER-Crunch case) is helpful when working with undergraduate students in an introductory course. This is consistent with advice from the Learning and Teaching Office at Ryerson University (2017, p. 1), who point out that "good case studies focus on one issue or problem, and have a clear problem statement." As mentioned earlier, students will encounter enough challenges in the case without the central issue being fogged. Thorough editing is also necessary to achieve suitable length and establish clear focus in the case. It was also found that any attention (beyond a simple reference) to the sources of information used as the basis for the case can result in students searching external sources for details, which they hope will be helpful. Unfortunately, such external sources are usually too far outside the fictional case context and can detour the analysis to an unwanted tangent. Thus, students are advised that there is no need to consult the referenced source (i.e., all of the information is provided in the case itself).

4. The Case Assignment (Implementation)

4.1. The Assignment

The general assignment used in the Fall 2016 term was described at the end of Section 2.3. More specific practices that were used are described below. These practices seem to go hand-in-hand with the nature of our cases, and have been an important aspect of the overall success of the assignments.

Lead-up classes—Throughout our TOC chapter, we use illustrative examples to demonstrate the main concepts. We begin with a simple example with a five-step production process for making chairs, and ask questions that start the students thinking about material

(or customer) flows in a system, and how separate process activities can affect one another. The outcome of this exploration is to define the five focusing steps of TOC (as described in Section 2.2). Next, we watch "The Goal" (Goldratt et al. 2007) as a class. This is followed by a detailed discussion of how the five TOC steps are applied to (1) the hike (in the movie), and (2) the factory. Next, one or more "real world" examples are described in class, such as looking at the grain export process (from field to bulk ocean vessel) and describing the application of TOC concepts to it. An enthusiastic Instructor can make the movie and other supporting examples quite interesting, and culminate the week of classes by telling the students that they have been shown the TOC applied to a number of different processes, and now it is time for *them* to apply it to a *new/different* process: This is the basis of the case study assignment.

***Clarifications*—**Although most of the work that students will need to do for this assignment occurs outside of the classroom, it is often useful to respond to students' questions about the case by including the entire class in a discussion. For example, in the SUPER-Crunch case in the Fall 2016 term, a student asked for clarification about equipment changeovers at the seasoning activity. This provided an opportunity to discuss favorite potato chip flavors, identify two that are very different and which would require a *major* changeover if they followed each other in the production sequence, and get students thinking about how intelligent production sequencing would exploit the existing capacity of the factory. Additional clarifications and suggestions were brought up a few more times before the assignment was due, by way of brief discussions at the start/end of class and/or using the Learning Management System (LMS).

***Individual drafts*—**"Groups are better . . . at generating possible solutions to problems" (Herreid 2009, p. 63). While this is the generally accepted thinking when using cases to teach, we find that it works best when the students have contemplated the case on their own before coming together for group discussion. We therefore require each student to submit an individual draft in which they brainstorm some ideas about the fundamental case issues (it does not have to be a polished report), and submit this to their group by way of uploading a document to the LMS. There is a firm due date for the individual drafts, and the Instructor can see all drafts, although they are not graded or even viewed except where necessary. The assignment (i.e., the group report) is due one week after the due date for individual drafts. During that time students in each group engage in discussions, reconcile differences in interpretation of the case, combine ideas, and collectively arrive at one solid report for submission. Overall, TOC is discussed in approximately one week of classes; the assignment extends approximately two weeks beyond that.

4.2. Feedback from Students

Seventy-nine students who were enrolled in two course sections were provided a Survey Monkey link to a short survey about the specific case assignment implementation in the Fall 2016 term. The survey was anonymous and was administered after the assignment due date but closed before students received their assignment grades. The survey asked students about how the fictional nature and length of the case affected their interest level and perceived quality of learning.

Sixteen of the 79 students responded to the survey. There is no information on which students responded, and only those students who were in course sections taught by the current author were surveyed. Note also that the survey was not intended to be extensive or a primary focus of the current paper: Students are regularly surveyed in this course to ensure effective course delivery; this particular survey was primarily for that purpose as well. Nonetheless, it is hoped that this anecdotal information can provide some insight for th reader.

Survey results are provided in the online Appendix Two. Overall, the assignment seemed to be a positive learning experience for the students, and succeeded in meeting the learning objectives. As to the students' level of interest and perceived quality of learning, although it did matter to the students that the context and company in the case were not real, it mattered more that the case was *based on* a real process. Herreid et al. (2016), who surveyed Instructors who use cases, explicitly include a comment from one survey participant who stated that it matters more that a case *feel* real than that it *be* real (p. 61). Interestingly, we had a similar response in our survey: A student commented that

> *I had never considered whether the case was from a real company, or that it was based on one. What I think is more important is for the case to seem realistic, so students could get a sense of how the concepts could be applied in the workplace.*

The survey results about *case length* seemed conclusive: Students were very happy with the short length of the case in terms of interest level and perceived quality of learning. This is hardly surprising, but perhaps if a two-page case was badly lacking in depth we would have heard so from at least a few of the students, so there is some validation here.

Open-ended comments from students (not included in the online Appendix Two) suggest that some students felt they needed more information and/or guidance and were unsure of how to proceed with the assignment. Note that caution should be exercised in interpreting these comments: One of our pedagogical

objectives is that students apply the TOC principals to a new/different setting from what they saw in class, and stretch themselves a bit. Thus, some onus should be on the student to seek clarity in interpretation of the case, by way of questions in class and/or their own contemplation/discussion process, rather than through a more precise case or instructions. In other words, it seems doubtful that a longer or a real case would alleviate any of the concerns that students expressed. These types of comments seem to come with the territory when using case studies.

5. Conclusions

For students and the instructors, our case assignment has generally been a welcome break from the impersonal and mechanical online and hand-in assignments that focus on applying quantitative formulas and methodologies. Further, we are fond of the TOC topic on which our Constraint Management module is based, but this topic is generally without the types of equations and algorithms that are found in the other topics of the course. It thus seems that a case assignment is a good fit for this topic in this course, and that there are few if any drawbacks to developing and using homemade fictional cases to meet our needs, aside from the time required to develop and vet them. It is also apparent that a short case is most appropriate in these conditions, and that lacking large amounts of extraneous information does not seem to significantly impede the spirit of using a case assignment, particularly for application in an undergraduate, introductory course.

One area for possible improvement would be to take additional steps to make the cases feel as real as possible. Something as simple as a diagram and/or chart might enhance our homemade cases: A case that is still only two pages of text, but with an additional page of informative yet concise diagrams, would provide adequate richness without unwanted length.

Appendix A. SUPER-Crunch Potato Chips

Introduction

The SUPER-Crunch Potato Chip Company has a problem: They are having trouble meeting the aggregate demand for their potato chips, yet often have excess work-in-progress (WIP) inventory. Senior managers feel that better management of current capacity, more specifically, better management of constraints (i.e., bottlenecks) in their process, is preferred over the addition of another work shift and/or major capital expenditures for physical expansion. The company has thus enlisted your help—you are asked to *analyze their production process (as described below), and make recommendations, based on the concepts of the Theory of Constraints, that will help them increase throughout whilst reducing WIP inventory*.

The Company

The SUPER-Crunch Potato Chip Company is known for the variety of flavors that they offer, such as cola flavor, fries and gravy flavor, and fruit-smoothie flavor, to name a few. At the same time, SUPER-Crunch chips are seen as good customer value: They are near the lower end of the scale in terms of price. In the words of the Marketing Manager "a reasonable price is an order qualifier for our customers, with the wacky flavors being an order winner. However, that does not mean that we have to be the cheapest, it just means that we have to be below a certain price point." Low costs are maintained by using ingredients (potatoes, seasoning, oil) of a modest quality and price, as well as through efficient operations and reasonable but not excessive wages. However, the high product variety, as well as their unsophisticated, ad hoc production planning process, requires frequent changeovers (set-ups) of production equipment which can add to cost and eat at capacity (pun intended). Generally, daily production plans are based on a visual examination of the warehouse stock, with items that are low in inventory being called into production for that day. The company currently operates one eight-hour shift per day, five days a week. They would like to avoid overtime or additional shifts, if possible.

The Production Process[1]

Washing. The process starts by removing fresh raw potatoes from storage and feeding them into a washing machine on a conveyor. (Assume that potato procurement and raw potato storage capacity are not constraints in the process.) The washing machine is intended to do a "rough wash" to clean away dirt and dust on the potatoes before peeling. The current washing machine is capable of washing approximately 4,000 kg per 8-hour shift. Washed potatoes exit the machine and are dumped off the conveyor into a storage tank. (The physical layout of the factory has the washing and subsequent storage in a different area than the remaining steps. This is largely due to the piecemeal growth of the factory.)

Peeling. Washed potatoes are poured into a peeling machine in batches of up to 140 kg. The machine peels potatoes and deposits them onto a conveyor for inspection (described next). The peeling machine requires approximately 20 minutes to peel a batch; the time between batches is negligible. Occasionally, the peeling machine is idle waiting for a batch of washed potatoes to be brought from the storage area.

Inspection. After peeling, the potatoes are inspected to ensure that they are of suitable quality and were properly peeled. Peeled potatoes are moved by conveyor past workers who look for defects, and remove any bad potatoes. Two workers (as a team) are capable of inspecting a total of 600 kg of peeled potatoes per hour. Inspected potatoes are dumped into a "feeder" that feeds potatoes into a slicing machine.

Slicing. Potatoes are sliced by a flat knife or a wrinkle-type knife, the latter being used for ripple chips. The slicing machine is theoretically capable of slicing 450 kg of potatoes per hour, however time spent maintaining and changing the knife (e.g., when sharpening the blade, or when changing production from regular to ripple chips) can reduce this capacity by as much as 15% per shift.

Starch Removal. Sliced potatoes are washed again to remove starch that can turn the potato chips a dark color when fried. The capacity of the washing process is constrained by the time it takes to adequately drain the water on the chips to

promote frying quality. The chips drain while on a draining conveyor, and require approximately six minutes to dry 40 kg of chips (although this function is not very scientific and dry time can vary significantly).

Frying (Oil). Potato chips are fried in oil on a conveyor. This equipment is very modern (given the importance of the frying function) and has a significant capacity of approximately 6,000 kg per eight-hour shift.

Seasoning. Potato chips are seasoned with a sprayer evenly dispensing seasoning flour over the chips; a seasoning drum then rolls the chips to ensure proper coating. The capacity of the seasoning function is approximately 450 kg per hour. However, when production is changed from one flavor of chip to another, a changeover of the equipment is required to clean out the seasoning sprayer and drum and change the flour. This could take from 5 to 15 minutes, depending on the degree of difference between the flavors that follow each other. There are typically 10 to 15 changeovers in a given shift, approximately equally split between minor (5 minute) and major (15 minute) changeovers.

Packaging. The packaging equipment is very efficient, with a capacity of approximately 5,000 kg per shift, and less time lost on changeovers. Changeover of packaging equipment between flavors takes only about 5 minutes and is typically done by the same person who does the seasoning changeover, after they have performed a changeover on the seasoning equipment and before restarting the production line (since there is limited space between the seasoning and packaging equipment for inventory).

The Problem:

The company finds that in general they are producing less than they would like, despite the fact that WIP inventory can build up in various places in the plant (excessive WIP tends to lead to quality issues for this product). When asked where the bottleneck is, foreman Debbie Berg commented that "it seems to vary between a few activities and from shift-to-shift; I can't put my finger on a single, obvious bottleneck. We need some fresh eyes to take a look at the whole process and give some suggestions for how to better manage the capacity that we have before we start looking at overtime or equipment purchases."

Endnote

[1] Although this is roughly based on information from Taiwan Trade: TSUNG HSING FOOD MACHINERY CO., LTD., retrieved June 2016 from http://tsunghsing.en.taiwantrade.com/product/potato-chips-production-line-327264.html, it is not intended to be a perfectly factual depiction of a potato chip manufacturing process.

References

Alibaba.com (2016) Potato chips production line/potato chips companies/seasoning for potato chips. Accessed December 23, 2016, https://www.alibaba.com/product-detail/potato-chips-production-line-potato-chips_2009148912.html.

Andersen E, Schiano B (2014) *Teaching with Cases: A Practical Guide* (Harvard Business School Publishing, Boston).

Blok J, Grasby E (1998) *Jeffries Hardwood Flooring* (case study—Product no. 9A98D016) (Ivey Publishing, London, Canada).

Dettmer HW (1997) *Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement* (Quality Press, American Society for Quality, Milwaukee, WI).

Dunne D, Brooks K (2004) *Teaching with Cases* (Society for Teaching and Learning in Higher Education, Halifax, Canada).

Goldratt EM (1990) *What is This Thing Called Theory of Constraints and How Should It Be Implemented?* (North River Press, Great Barrington, MA).

Goldratt EM, Cox J (1986) *The Goal: A Process of Ongoing Improvement* (North River Press, New York).

Goldratt EM, Jackson D, Axotis J (2007; Originally produced in 1995) *The Goal* [*Videorecording*]*: The How-to Version* (Coastal Training Technologies Corp. [distributor], Virginia Beach, VA).

Grossman TA, Mehrotra V, Sidaoui M (2016) A student-centered approach to the business school management science course. *Informs Trans. Ed.* 16(2):42–53.

Heizer J, Render B (2011) *Operations Management*, 10th ed. (Prentice Hall, Upper Saddle River, NJ).

Herreid CF (2005) Too much, too little, or just right? How much information should we put into a case study? *J. College Sci. Teaching* 35(1):12–14.

Herreid CF (2015) The 10/80% rule: Presentation is the key. *J. College Sci. Teaching* 44(5):54–57.

Herreid CF, Prud'homme-Généreux A, Schiller NA, Herreid KF, Wright C (2016) What makes a good case, revisited: The survey monkey tells all. *J. College Sci. Teaching* 46(1):60–65.

Herried CF (2009) The wisdom of groups. *J. College Sci. Teaching* 39(2):62–64.

Krajewski LJ, Ritzman LP, Malhotra MK (2016) *Operations Management: Processes and Supply Chains*, 11th ed. (Prentice Hall, Upper Saddle River, NJ).

McFarlane DA (2015) Guidelines for using case studies in the teaching-learning process. *College Quart.* 18(1), http://collegequarterly.ca/2015-vol18-num01-winter/mcfarlane.html.

Orchard RK (2015) An MGTS 352 introduction to constraint management using the theory of constraints. Unpublished manuscript, Grant MacEwan University, Edmonton, Canada.

Penn ML, Currie CSM, Hoad KA, O'Brien FA (2016) The use of case studies in OR teaching. *Higher Ed. Pedagogies* 1(1):16–25.

Rahman S (1998) Theory of constraints: A review of the philosophy and its applications. *Internat. J. Oper. Production Management* 18(4):336–355.

Ryerson University Learning and Teaching Office (2017) Teaching methods for case studies. Accessed June 21, 2017, http://www.ryerson.ca/content/dam/lt/resources/handouts/CaseMethodBestPractices.pdf.

The Goal (novel) (2016) Wikipedia, the free encyclopedia. Accessed December 17, 2016, https://en.wikipedia.org/w/index.php?title=The_Goal_(novel)&oldid=755401867.

Tsung Hsing Food Machinery Co., LTD. (2016) Accessed June 7, 2016, http://tsunghsing.en.taiwantrade.com/product/potato-chips-production-line-327264.html.

Wood D, Klassen R (2011) *CRP Products* (case study). Ivey Publishing product 9B11D015 (Ivey Publishing, London, Canada).