USING THE THEORY OF CONSTRAINTS AS A CROSS FUNCTIONAL TEACHING TOOL

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ABSTRACT

The Theory of Constraints (TOC) (Goldratt, 1988) is introduced as a classroom tool for cross functional exercises. TOC might be viewed as a global managerial methodology that helps managers focus on the most critical issues by emphasizing the importance of a system's constraints and their exploitation according to the goals of the organization. After discussing the performance measures used by Goldratt, we present the 5 step process used for decision making in the TOC. Next, we present a classroom exercise that uses the TOC approach for evaluating a series of decisions with different functional constraints including production, marketing and finance. We conclude with a homework exercise that is used to reinforce the classroom presentation.

INTRODUCTION

Most business textbooks suggest a generic model for decision makers that includes a 5 step process similar to the one given in Figure 1. However, while this approach offers a reasonable description of how decision makers might go about making a decision, it suffers from a number of shortcomings particularly in a cross functional setting. The first step in this process provides no guidance for how decision makers should recognize the existence of a problem. Furthermore, it seems to imply that there may be times when no problems exist. In addition, no performance measures are incorporated to guide students on how to select a course of action from the list of alternatives generated. Finally, the model seems to imply that implementation of a decision ends the process. This paper outlines an alternative model for teaching about decision making that can be applied in any of the functional teaching areas in business and is an excellent alternative for cross-functional teaching. An example used by the author in a team taught, cross-functional, curriculum is used to illustrate the approach.

THEORY OF CONSTRAINTS

Goldratt (1988) has suggested a more comprehensive and intuitively appealing approach that he refers to as the Theory of Constraints (TOC). TOC emerged as a result of Goldratt's earlier work on a software system referred to as Optimized Production Technology or OPT (see, for example, Goldratt (1984) and Goldratt and Fox (1988)). The software was intended to assist managers in making decisions about production mix, equipment scheduling, and capacity. While the software proved successful commercially, Goldratt became frustrated by what he viewed as a lack of decision making skills in many of the managers from client firms, and turned his attention to innovative approaches for teaching decision making in a cross functional setting. His first effort, a novel about manufacturing, was a radical departure from traditional management education. The novel, *The Goal* (Goldratt and Cox, 1988), has been an enormous success and is used in many accounting and production/operations classes around the world. Subsequently, Goldratt has written a number of other novels, toured with an acting company, and opened the Avraham Goldratt Institute. More recently, Goldratt has funded efforts to introduce TOC in elementary schools. His foundation has funded the non-profit TOC for Education Foundation (http://www.tocforeducation.com/).

TOC might be viewed as a global managerial methodology that helps managers focus on the most critical issues by emphasizing the importance of a system's constraints and their exploitation according to the goals of the organization. A constraint may be broadly defined as anything that limits a system from achieving higher performance relative to its goal. There are four different types of constraints - physical constraints within the business, a supply constraint, a market constraint (the market will not buy all we can sell) and policy constraints, the way things are done, are probably the most important and least understood.

The goal of any for-profit organization should be *to make money now and in the future.* However, Goldratt realized that this goal did not offer sufficient guidance to mangers and so proposed three performance measures for evaluating alternatives that differed markedly from those used in practice (Goldratt and Fox (1988)). A managerial action should result in either (1) an increase in throughput, (2) a reduction in inventory, (3) a reduction in operating expenses, or some favorable combination of these global operational measures. However, the definitions that Goldratt and Fox (1986) have developed for these measures are somewhat different than those that are typically used in manufacturing. Throughput is defined as the rate at

which the system generates sales not production. If a firm produces to stock, throughput is zero until the goods are actually sold. Inventory is defined as all the money that the system invests in purchasing things it intends to sell. Notice that this definition of inventory excludes the added value of labor and overhead and includes capital items like furniture and equipment. Operating expense is defined as all the money the system spends in order to turn inventory into throughput. Defined this way, operating expense would include all cash outlays exclusive of material expenditures like direct labor and overhead. These performance measures run counter to traditional full absorption cost accounting measures, and more closely resemble decision making using marginal rather than average cost criteria (Noreen, et al. 1995)

The core of the TOC philosophy consists of the five step process outlined in Figure 2 (Goldratt, 1990). The first step helps students to think about a business as a system of interdependent functions. It helps them look at a business as a chain - with many interdependent links. All a manager has to do is to look for the constraining function of the business - the weakest link. There will always be one. What is the most frequent response to a physical constraint? Often it is to invest in more capacity. The second step then gets students to focus on "what decision(s) must I take to exploit the constraint?" This decision will, if implemented, ensure that the output of the system is maximized. To implement the exploit decision we must now subordinate everything else to the above decision (Goldratt's third step). This is a huge paradigm shift for many managers. How often will a sales director subordinate to manufacturing, or vice versa? How often does the constraining resource determine what will be done? If the constraint is still in the same place after it has been fully exploited, it is time to elevate capacity by investing money (the fourth step). Only now after constraints have been fully utilized in generating throughput does one know they are investing in the right place.

When a business adds capacity or breaks market constraints through segmenting or price discrimination, the whole situation changes - all the things a manager knows about a business need to be re-evaluated. The last of Goldratt's five focusing steps is simply: If during any of the above steps the constraint is broken go back to step one. BUT do not let your inertia (your paradigms about your business system) become the systems constraint. This caution is extremely important. Managers must re-evaluate all their assumptions about the system or risk expensive mistakes.

COURSE EXAMPLE

Our faculty team has used a number of different exercises to illustrate TOC. The setting for this exercise is our integrated business curriculum (IBC). The IBC is an 18 credit hour curriculum that team taught by faculty members from five different functional areas and makes use of a comprehensive case. A series of course modules has been developed which is cross functional in nature and focuses on major business decision areas such as product and process planning (see Stover et al. 1997 for a more complete discussion of the IBC program). The program makes use of a year long integrative case firm that serves as the basis for the course example given in Exhibit 1.

Classroom Preparation

Students are given approximately 1 month to read *The Goal* prior to classroom discussion in our *Business Operating Decisions* course module. Our faculty team then spends 3 class hours introducing TOC and developing a case scenario for our case firm. In addition, our marketing faculty member spends approximately 2 classroom hours on price discrimination. Finally, our finance team member discusses the use of capital budgeting for making capacity expansion decisions. The combination of these lectures sets the stage for our case exercise.

Case Firm Background

Micron Technology, Inc.(MTI) was our case firm for the last academic year. The case is introduced in the fall semester and students are required to develop an industry analysis as a fall semester project. The project provides students with an in depth look at the case firm that faculty build on throughout the year. One of MTI's subsidiaries produces custom printed circuit boards for a variety of customers in a batch operation and serves as the focus for the exercise given in Exhibit 1.

TOC Classroom Lecture and Discussion

Students are first introduced to the basics of TOC including the general 5 step process and performance measures. Next, we introduce the product/process information for our case as outlined in Exhibit 2. T he information is an adaptation of a problem presented in *The Haystack Syndrome* (Goldratt, 1990). Students teams are then asked to address the following

question: "How much profit can Micron make in this market?" Even after 3 hours of lecture on TOC, students typically begin by using traditional cost accounting measures as outlined below.

Product: MME Board
Sales Price per unit: $90
Material Cost per unit: $45
Gross Margin: $45
Direct Labor: 60 minutes

Product: XKU Board
Sales Price per unit: $100
Material Cost per unit: $40
Gross Margin: $60
Direct Labor: 50 minutes

Their analysis typically ignores capacity constraints at Resource B and students are led to the conclusion that they can make a profit of $1500 after subtracting operating expenses of $6000 from the $7500 in possible revenues. Next, we ask the student teams to observe the capacity constraint, and ask them to reconsider their answer. On the second pass students use the products' gross margin and typically respond that MTI should produce as much of the XKU product as possible, and allocate remaining capacity to the MME board. This time they are led to the conclusion that Micron will lose $300 on the product mix of 50 XKUs and 60 MMEs.

At this point we start a systematic analysis using the 5 step TOC process to arrive at a conclusion that is exactly the opposite of the students' intuition. In step 1 we identify Resource B as the capacity constraint. Next, in order to "exploit" the constraint we calculate the throughput (sales revenues less material cost) per minute of time required on the constraint resource as follows.

MME Boards
Throughput per unit =Sales Price-Material Cost
(TPT) $90-45=$45
Bottleneck Time required = 15 minutes
TPT per Bottleneck minute = $45/15min=$3/min.

The correct answer is to produce as many MMEs as possible and to allocate remaining capacity to the XKU product. This produces a product mix of 100 MMEs and 30 XKUs resulting in a net profit of $300.

Next the Finance faculty member discusses how to analyze capital investments to break or elevate the system constraint using net present value and capital budgeting techniques. We motivate this section of the material by asking the following question:

XKU Boards
Throughput per unit =Sales Price-Material Cost
(TPT) $100-40=$60
Bottleneck Time required = 30 minutes
TPT per Bottleneck minute = $60/30min=$2/min.

How much would you be willing to invest in an engineering idea that increases the direct labor by 1 minute?

Generally, the students respond saying that the engineer should be fired or ignored. We then point out that if the idea produces savings in the time required at the resource constraint by offloading work to another non-constraint resource, the investment may have merit. We use gain in throughput as the basis for cash flows used in the net present value analysis and conclude that the investment should be made.

Finally, we motivate the homework assignment given in Exhibit 2 by concluding with the last step in the TOC analysis- *Do not let inertia become the constraint.* Now

that the resource constraint has been broken, an analysis of marketing alternatives should be considered. Goldratt (1994) focuses on market constraints in his follow-up novel to *The Goal*, another novel entitled, *It's Not Luck*. In this novel, Goldratt examines marketing strategies for breaking market oriented constraints. In particular, he discusses price discrimination and niche markets, service after sale, special product features, and promotes an extended product view similar to that found in most introductory marketing texts (see Berkowitz et al., 2000). We introduce the total product view given in Figure 3 to generate ideas about how to exploit and then elevate the market constraint.

Students are then asked to complete the exercise given in Exhibit 2 as a homework exercise. In this exercise, Micron's sales force has used price discrimination to expand the company's market overseas to Japan and students are asked once again to decide on the product mix that Micron should use to allocate capacity to its markets. The additional market demand for Micron's products puts pressure on production resources and again result in a capacity constraint starting the TOC cycle again.

Student and Faculty Reactions

We have been very encouraged by student participation in this exercise. Students thoroughly enjoy reading *The Goal* and become immersed in the characters and storyline. During the course of the semester we rarely hear students ask: "When we will get to Chapter X in the text? I really enjoyed reading that material." However, it is not uncommon to have our students ask about material they have read in *The Goal* prior to coverage in class. Students also find the TOC framework intuitive and easy to transport to other classes.

Our faculty team has found this exercise and the TOC methodology in general to be one of the better integrative vehicles that we use during the semester. The material that we present would be hard to include in a conventional course setting due to the difficulty in coordinating the schedules in three or more classes (i.e., marketing, finance, and operations management). In addition, it is helpful to have a champion for this exercise who has read more extensively about the TOC and is willing to structure the exercise for a given case firm.

SUMMARY

The Theory of Constraints offers an excellent methodology for making business decisions. Students generally enjoy reading about this approach in *The Goal* and perform well on subsequent exam questions that reflect the material. In addition, TOC promotes the cross-functional implications that decisions in one functional area have on other areas.

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