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In this issue, Professor John Davies and Associate Professor Vicky Mabin discuss the Theory of Constraints (TOC), an approach that has been around for some time and has gone through some significant changes. However, while a powerful ‘tool,’ it is still unknown to many and often misunderstood. In this paper, Davies and Mabin explain the TOC and show how it can be of value in solving many problems. [*Miles G. Nicholls, Feature Editor*]

Theory of Constraints

by John Davies and Vicky Mabin, Victoria University of Wellington, New Zealand

The Chambers dictionary defines **T**emerge as “To rise out of anything; To reappear after being concealed; To come into view.” The notion of coming into view is a helpful one, as often the new disciplines have been around for a little while before they come into our view. New ideas/methods emerge—as if from nothing. They are often presented with a brashness—fitting considering their youth—but often unwelcome to the established order. The newcomer can pose several threats: threats to established ways of seeing and doing, of established curricula and established levels of support for current policies, procedures, actions, and methods. The advantages of the newcomers are often overstated, and justifiably called into question by the ‘old guard.’

However, there comes a time with all these newcomers where we need to take a fresh look—allow the newcomer to ‘come into view’ and be reassessed in an objective way to see how it may be incorporated into the established bodies of knowledge. The ‘emerging’ disciplines can be seen to have something in common with the metamorphosis of a caterpillar into a butterfly—they are often perceived as unwanted upstarts initially, but in time, emerge into well-rounded, very attractive additions to the array of models already in existence.

The field now known as the Theory of Constraints (TOC) is a case in point. TOC began as a production scheduling aid, developed by Eliyahu Goldratt in the late 1970s (Gardiner et al., 1994). It was termed ‘optimised production timetable,’ and was quickly developed into a software package commonly known as OPT (optimised production technology). Ten years later it had become known as TOC and had shed its computer package like an old skin, embracing the more potent field of human behavior. For it was the failures caused by the expectations associated with a turnkey package that led Goldratt and others to realize that what was needed was to convince people to change their ways, rather than tailor the package to simply automate their old policies and procedures—changes to their thinking and actions were needed if the potential gains were to be realized.

Conceptualized as a philosophy of continuous improvement and described in the best seller novel *The Goal* (Goldratt & Cox, 1984), TOC encompassed a systematic approach to organizational problem solving in the form of “5 focusing steps,” first providing a means of identifying the constraining factors preventing a company from achieving its goal through “breaking” the constraints and repeating the process of improvement. Companies that adopted this way

of thinking were able to realize some remarkable gains, even after other improvement methods such as Just-in-Time and TQM had been applied (Mabin & Balderstone, 2000; Mabin & Balderstone, 2003). Recent controlled experiments in real plants within a manufacturing organization have demonstrated the improvements achievable with TOC's Five Focusing Steps in combination with Lean and Six Sigma, over those two methods in isolation (Pirasteh & Farah, 2006).

Several general approaches or 'standard solutions' for typical applications in addition to production have since been developed, such as distribution (supply chains), marketing and sales, performance measurement and projects. Examples of published case studies include radical reduction of hospital wait times (Umble & Umble, 2006) and the Edelman Award-winning application of Critical Chain project management to aircraft repair at Warner Robins (Srinivasan et al., 2007).

Alongside this emergence and growing acceptance of TOC for production, processes, and projects, has been its infusion into managerial practice, into academic courses and into the literature. Major car companies are now reportedly using TOC, while universities around the globe use *The Goal* as a textbook and include TOC in some form in courses.

Moreover, over time the TOC field has grown to include not just guidelines for what to do but also how to think differently. Efforts to codify the 'thinking' that led to such improvements has provided a set of logic tools collectively known as the TOC Thinking Processes (TPs) which aid the decision making process for any intervention (Scheinkopf, 1999).

In much the same way as the "5 focusing steps" address identifying and managing any constraints on improving performance, the TPs also focus on factors that are currently preventing a system from achieving its goals. The original suite of TPs comprises five logic diagrams (four trees and a "cloud"): Current Reality Tree (CRT), Evaporating Cloud (EC), Future Reality Tree (FRT), Prerequisite Tree (PRT), Transition Tree (TT), and a set of logic rules, the Categories of Legitimate Reservation (CLR).

The TPs first identify problematic symptoms which provide evidence that the system is not performing as well as desired. The TP tools then provide specific structures and guidelines for diagnosing and analyzing the underlying causes of problematic symptoms in order to determine what needs to be changed (via the CRT and EC), devising a strategy to address these causes (the EC and FRT), culminating in detailed plans to lead the implementation (PRT and TT). Doubts and 'resistance' to change are examined along the way, the solution and plans being modified to incorporate those reality checks provided by people's doubts, harnessing the intuitive and creative powers of those intimately involved with and affected by the problem and the proposals (Mabin et al., 2001).

How can, and do, users benefit? Our recent review of the TP literature (Kim et al., 2008) suggests that reported usage of TOC methods and processes reflects the field's emergence and growing acceptance in the operations management—and general management—academic and practitioner community.

Indeed, the TPs can be used together for major organisational change, and on their own or in various combinations for everyday problems. The EC process designed for conflicts, dilemmas, and trade-offs, is ideal for re-examining traditional and seemingly inevitable tradeoffs that we have come to think of as being inevitable tradeoffs, such as the EOQ (Jackson et al., 1994; Mabin et al., forthcoming). The Negative Branch process—a spinoff of the FRT—is ideal for examining and preventing potential harmful side effects of proposals, while the PRT is ideal for achieving ambitious targets, especially in a team environment.

The review found that over three quarters of peer-reviewed papers (92/114) sought to explain or demonstrate TP tools used individually or in combination with others. Interestingly, well over one third of papers (38/92) involved only one TP tool. A related finding was that the tool most frequently used is the EC process, most often by itself, to address conflict in many different forms and guises. Few papers sought to demonstrate the full TP analysis; indeed, barely one eighth of

applications papers (12/92) used the full set of tools. The variety of combinations-in-use implies that the application of TP tools can be regarded as situational and selective, and that different combinations of tools and logic diagrams may find acceptance amongst users.

It is not surprising that full TP analyses are not often published—the full set of TPs take a fair time to work through, especially constructing the trees—depicting current and future reality, and detailing prerequisites and transitions required. Each thinking tool demands conceptual rigour and understanding of the problem situation, but they do provide a good overall picture; indeed we have elsewhere shown that the tools and methods of TOC can be viewed as a methodological set of complementary hard and soft tools and methods that contribute to all phases of problem solving and decision making (Mingers & Brocklesby, 1997), and they share the ontological and epistemological characteristics and assumptions of extant OR/MS methodologies with which we are more familiar (Davies et al., 2005).

The suite of TP tools and methods now comprise more than the basic set described above—as a web search can quickly reveal—each aiming to provide improvements in terms of building better or faster logic tree representations. There are also debates on the relative efficacy of the tools, which seems a healthy development as TOC gains greater acceptance generally and reaches a more mature stage where such debate can take place. However, there is much in common between the various TOC methods, and between them and OR/MS. The TOC methods can add clarity, comprehensiveness and a well-articulated rationale for the management of change, extending and formalizing good practice, and as such they enhance the more standard OR/MS methods. Additionally, many TOC methods are invaluable on their own for everyday managerial and personal decisions.

What are the challenges and opportunities for integrating a new discipline into the mainstream of education and management? There are many ways one can incorporate TOC into the regular

decision-making curricula, as well as into finance, production/operations, marketing, accounting, quantitative methods, strategy—in fact it would be difficult to find a field within DSI where TOC could not have relevance. One doesn't have to attempt to cover the whole field of TOC, nor even to teach the whole set of TPs—the EC process is easily taught on its own, and the Five Focusing Steps have just as much relevance to service and personal contexts as to manufacturing. In many cases, it could be that just including some readings and suggesting students may try to apply these concepts is sufficient to get started—for example, asking students to try applying the Five Focusing Steps to a standard Linear

Programming assignment is a low-risk approach I have used which was surprisingly successful in terms of learning for both students and instructor (Mabin & Gibson, 1998).

The field has reached a sufficient level of maturity, and provides benefits in terms of results and thinking processes, such that it warrants an additional look. While the lessons I learned from *The Goal* will forever stay with me and have proven to be of benefit to me, my clients, and my students on countless occasions, I have come to value enormously the set of TOC 'thinking processes.' They help us discover 'how to think' differently, and I would encourage you to integrate them into your various disciplines.

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Analysis	What to Change?	What core conflict is responsible for the undesirable effects observed? Is the core conflict really the core conflict?	Evaporating Cloud (EC) process Current Reality Tree (CRT)	Problem Identification
Strategy	What to Change To?	What assumption(s) are we going to challenge? What key change ('injection') will we introduce to eliminate the core conflict? How can we ensure that this starting injection will lead to all the desired effects without creating negative side effects? (negative branches)	EC process Future Reality Tree (FRT)	Constructing the Solution
Tactics	How to Cause the Change to Happen?	In what order do we need to achieve the planned changes, what blocks their implementation, and what must be done in what order, to overcome the obstacles? What actions must we take to implement the Prerequisite Tree?	Prerequisite Tree (PRT) Transition Trees (TrT)	Designing the Implementation

Table 1: The TOC Road Map.

competitive environment, knowledge sharing is very critical for individuals and organizations to utilize as a means to gain competitive advantage.

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