Analysis of the Theory of Constraints for Education and its impact on educational systems

Análise da Teoria das Restrições para a Educação e seu impacto nos sistemas educacionais

Stela Marques
Mestre e Doutora em Educação pela Newcastle University, Reino Unido
Professora Adjunta da Pontifícia Universidade Católica de Minas Gerais
sm.pucminas@gmail.com

Ronaldo Moreira de Castro
Especialista em Controladoria pelo Instituto de Educação Continuada da PUC/Minas
Professor da Pontifícia Universidade Católica de Minas Gerais
castro.ronaldom@gmail.com

Abstract

There has been a continuous adjustment of educational proposals for the past decades, as well as an increase in the number of scientific studies that aim to understand the inner workings of the teaching and learning process and that seek to establish more successful educational strategies and practices. Yet, a large number of schools around the world are still experiencing educational problems, namely in terms of ineffective teaching methodologies that are incompatible with the cyberculture lifestyle, demands and expectations of the 21st century student. This article discusses a teaching methodology that is deep-rooted in a well-established business management method that employs the Socratic method of questioning. By evaluating cause and effect, individuals are urged to question and to investigate for themselves to find the best suited answers to those questions. Thus, students that are typically given the answers to all questions are encouraged to seek their own answers. As a result, they will develop a greater sense of participation and responsibility and become more committed to their learning. This article will examine an approach known as *Theory of Constraints for Education* and its educational implications for Brazilian schools and for educational systems in countries where it has already been implemented in schools.

Keywords: Theory of Constraints. Pedagogical innovation. Teaching methodology.

Resumo

A sucessiva mudança de paradigmas educacionais tem sido evidente nas últimas décadas, assim como a proliferação de estudos científicos que visam aprofundar o conhecimento sobre os contornos do processo ensino-aprendizagem e delinear estratégias e práticas educacionais que sejam cada vez mais eficazes. Todavia, escolas em todo o mundo continuam registrando problemas educacionais derivados de metodologias de ensino inadequadas e pouco efetivas para o alunado do século XXI, que está cada vez mais conectado ao mundo virtual. Este artigo apresenta a discussão de uma metodologia de ensino baseada em um consagrado método de gestão empresarial, cuja operacionalização se dá através da utilização do Método Socrático e sua forma específica de questionamento. Através da avaliação de causa-efeito, o indivíduo é instigado a questionar e a averiguar por si próprio as possíveis respostas para seus questionamentos. Destarte, o aluno habituado a receber respostas prontas é incentivado a buscar as suas próprias respostas, o que incute nele um maior sentido de participação, responsabilidade e compromisso com o seu aprendizado. A seguir, vamos discutir um método conhecido como *Teoria das Restrições para a Educação* e examinar suas implicações educacionais para a escola brasileira e refletir sobre o que já está ocorrendo nos países onde já está implantado na escola.

Palavra-chave: Teoria das Restrições. Inovação pedagógica. Método de ensino.

Introduction

Education in Brazil had a marked evolution since the Vargas era, which began in 1930 with the election of Getúlio Vargas to the presidency. This government, considered dictatorial and interventionist defined social, labor and teaching policies (with an unprecedented chapter on education figuring largely in its Constitution). Since then, the government guaranteed primary schooling to the public, and, along with other measures, took greater control of private institutions. As a direct result of the implementation of a public education system, the population as a whole benefitted from this mandate, which introduced new and improved teaching conditions which had become necessary for students' development, even if this had not, for a long time, been shown to be the case in practice. The focus of this education was literacy, which consists of teaching students how to read and to write, and how to carry out the four basic mathematical operations. One may also argue that teaching methods have been keeping up with this development, as much as possible, in the face of countless constraints, both in the number and qualification of teachers, as well as the structural and financial resources necessary to achieve a quality education (D'ARAUJO, 1999; FAUSTO, 1995; SZMRECSÁNYI; GRANZIERA, 1986).

Considering 2015 as a reference, we can state that this institutionalized education, historically, is a relatively recent phenomenon with a mere 85 years of existence. This explains a large portion of the current educational problems in our society (BRAGA, 2002). Speaking strictly to the question of which teaching method most merits use, much has been done and continues to be done. We are searching for a method that encourages students to learn about issues that will serve their personal, professional and social growth, even though they may not necessarily possess the discernment to understand the importance of education. Many curricula have been created to be used by the public education system during these 85 years, seeking inspiration in American and European schools, each of which addressing the need for learning, based upon a given time in our history (CORSI, 2000).

Some students, parents and teachers may feel that curricula do not change as fast as the pace at which society evolves. Such curricula often become outdated by several years, which may account in part for the students' indifference towards the class content they are studying. This ostensive delay in updating school curricula has skewed students´

perceptions of their educational environment. They are no longer able to perceive any practical use in the course content, for perceived discrepancies between curricular and contemporary life. Innumerable teaching methods have been developed, which seek to motivate students to learn and allow students to actually see the practical use of the content learned in the classroom. Seeking a solution to this problem, a new teaching method was later developed in the United States, based on an Israeli model for business management, known as TOC – Theory of Constraints. This technique of entrepreneurial origin/nature has a lot to do with the "way" by which content is transmitted and the simplicity with which its content may be understood and the technique's effectiveness in bringing about the desired results. Since its creation in 1994 to date, over 8 million children around the world have benefitted from this teaching method in 6 continents and in over 20 countries, including Brazil. Furthermore, more than 250 thousand education professionals have been trained to use this technique and that number is rising year after year.

In this article, we intend to explain the concepts and application of this method that has achieved so much success worldwide, yet its recognition in Brazil is restricted to a small-scale experiment in some municipal educational institutions in Joinville, a city in the southern state of Santa Catarina. We are currently investigating this particular experiment as part of a Master´s research project and we plan to publish our empirical data in 2018.

This article is divided into three parts. The first concerns the presentation of the creator of the Theory of Constraints (TOC) and a brief explanation of his basic founding principles. The second part is about the rise of TOC for Education and its application, addressing its basic premises and the use of its tools as well as an explanation of the latter's functions. Lastly, we present some final considerations about this teaching methodology.

The creator of the Theory of Constraints

The Theory of Constraints (TOC) was created by the Israeli physicist Eliyahu M. Goldratt (1947-2011). Dr. Goldratt, as he was known, was an educator, author, scientist, philosopher and business leader. Yet, before all else, he was a thinker who moved others to think. He was often characterized as unconventional, stimulating and "an exterminator of sacred cows" (NOREEN *et al.*, 1996, p. V), Goldratt exhorted his audience to examine and reassess the business practices used through a new vision.

Goldratt was a world-renowned leader in the development of new business philosophies and management systems. He was an educator consulted by many of the world's largest corporations, including General Motors, Procter & Gamble, AT&T, Philips

NV, ABB and Boeing. He obtained his Bachelor of Science degree from Tel Aviv University and his Master of Science and Doctorate of Philosophy degrees from Bar-Ilan University. In addition to his pioneering work in business management, he also founded TOC for Education, a non-profit organization dedicated to bringing the TOC ideas to teachers and collaborators around the world.

TOC concepts were first presented in a 1984 best-seller called *The Goal*, a non-traditional approach to transmitting knowledge – it is a business book written as a romance, disguised as a love story. During his career, he released other books, all of them about the application of TOC in specific areas, as well as learning games and numerous other teaching and training methods. The video recordings of his presentations, programs and series are available at the TOC.tv site (TOC-GOLDRATT.COM, 2015).

The Theory of Constraints

According to Corbett (2005), the Theory of Constraints sparked significant changes in the 1970's. At the time, the TOC creator got involved in solving logistical problems of production and despite lacking any administrative experience, he began studying a way to solve them. He applied concepts from physics and developed a very successful method and, since then, other businesses became interested by his work. To understand TOC, we first need to understand the main premise that defines the theme that gave rise to the methodology. According to Goldratt, business success depends on knowing what a business' profit is intended for. Certain aspects need to be analyzed in greater depth, such as (GOLDRATT; FOX, 1992):

- What is it exactly that we are trying to achieve in our business?
- Will investors and employees invest their money and effort in a business with the altruistic intention of offering a better service to their customers?
- Or could it be that they simply did this for the prestige of having the largest market share?
- Do they wish to boast about having lower costs than their competitors?
- Is the goal of investors and employees really the pride inherent to having the highest-quality products?
- Are they investing their money and effort into a company as simply a means to survive? (p.18)

Goldratt states that all these issues are useful for achieving business goals, but that the objectives themselves are not the goal. Goldratt (GOLDRATT; FOX, 1992) assures us that the goal of business is: "To make money in the present as well as in the future" (p.19).

We add to that statement that rules of ethics must be observed in business such as guaranteeing investors and employees alike, market reliability and operational transparency. When we divert our attention from the main goal and create operational controls that point us in other directions, especially non-financial controls, we are compromising the business profitability by ignoring basic fundamentals.

The holistic vision of TOC and its inherent simplicity

The TOC sees the business as a system whose parts are interdependent and interact with the larger system around it. According to Goldratt (2013), to manage any system proficiently, we must first understand the meaning of "complexity". In Figure 1, we see systems A and B.
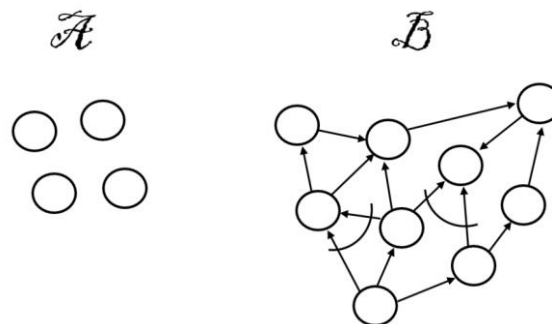

Figure 1 – Systems' demonstration
Source: GOLDRATT (2013, p 58), adapted by the authors

For Goldratt (2013) "the prevailing definition of complexity is: the more data you need to fully describe the system, the more complex it is" (p. 60). In other words, if we need lots of pages to describe a system, it means that the system has a high degree of complexity. However, according to the author (GOLDRATT, 2013),

> [...] if you are a scientist or a manager, you are not so interested in *describing the system,* but rather in the *difficulty of controlling and predicting the system's behavior*, especially when changes are introduced. In that case, the definition of complexity changes its focus and is measured accordingly: *the more degrees of freedom a system has, the more complex it will be* (p.60).

To understand what *degree of freedom* is, we return to Figure 1. In system B, if we touch just on one of the points, the entire system will be affected, which means that that system has just *one degree of freedom*.

Whereas in system A, to affect the entire system, we will have to touch on four different points, which translates to *four degrees of freedom*, making the implementation of actions difficult (GOLDRATT, 2013, emphasis added).

The statement made by Goldratt (2013) that a system with four degrees of freedom is by many orders of magnitude more complex, more difficult to control and predict than a system possessing only one degree of freedom, makes us realize the extent to which we are influenced by our own paradigms and why we have so much difficulty managing systems.

The author also states that, to reduce the degree of complexity of a system, we have to create a cause-effect relationship, and when we discover a root-cause, we will see that it is extremely simple. The systemic vision allows us to see that systems as well as people, may be highly complex and at the same time, extremely simple; that complexity and simplicity may coexist (GOLDRATT, 2013).

The leverage point

TOC's greatest premise is the necessary condition that in a system, whatever it is, there is at least one constraint, based on the idea that without any constraints, the tendency of a system trends towards infinity.

According to Corbett (2005), "TOC uses the analogy of a chain to illustrate some of its principles. If we follow the links of a chain, where will it break? In the weakest link (in a single link)" (p. 46).

This analogy applies to systems in general, whose parts, by definition, are interdependent. If we want to get a better result in these systems, we just need to act upon the weakest link, i.e., the system constraint.

By acting upon any other link, we will not strengthen the chain. It will be a waste of time and effort. A constraint, while simultaneously preventing us from obtaining a better result, provides us with a leverage point to increase the result and achieve higher gains.

Given this finding, Goldratt created a methodology for continuous improvement which became a fundamental part of the TOC, which he called "The Five Focusing Steps" (GOLDRATT; COX, 2002, p.349).

The five focusing steps

The methodology for continuous improvement is a process comprising five steps, analyzed sequentially, and directs us towards the solution to all sorts of problems and with focus on various areas of knowledge (GOLDRATT; COX, 2002).

The steps for the continuous improvement process are described in Table 1:

STEP	WHAT IS IT?
1st step: **IDENTIFY** the system constraint(s).	Identify the weakest link, as it is this link which determines the strength of the chain.
2nd step: decide how to **EXPLOIT** the system constraint(s).	Discover which way to strengthen the weakest link. Strengthening any other link, but the weakest, we will not strengthen the strength of the chain and the effort will have been wasted.
3rd step: **SUBORDINATE** everything else to the previous decision.	Once the weakest link has been strengthened, to align the rest of the chain with this link so that all the rest work to support it.
4th step: **ELEVATE** the system constraint(s).	Once the weakest link has been strengthened and the tension having reached its limit, causing the link to break, search for another link which may have superior strength to replace it.
5th step: Caution required - If during any previous step a constraint was broken: go back to step 1, but do not allow *inertia* to become the system constraint.	Upon strengthening the weakest link, it may become stronger than another. Therefore, the constraint will become the new link and we later go back to identifying it as such. After reaching the ideal strength of the chain, the tendency is to leave it be. Hence the importance of not allowing inertia to become the new system constraint.

Table 1 – Demonstration of the five focusing steps
Source: CORBETT (2005), adapted by the authors

We cannot stress enough the importance of the warning stated in the 5th step. What generally happens is that, within our systems, we derive many rules from the presence of the current constraints. This is done sometimes formally, many times just intuitively. When a constraint is broken, it seems like we do not worry about revising these rules. As a result, our systems are, in most cases, limited by policy restrictions, which are linked to the way in which we manage systems, those are our paradigms. This alert serves to remind us that actions should be taken as soon as the constraint has been broken and that the system must work stably and constantly. In other words, this means that we must not get too comfortable with a system that appears to be working perfectly now, but which later may prove too late to fix (CORBETT, 2005).

These five steps serve as the base for the implementation of the Theory of Constraints methodology. Many companies that have used this methodology achieved significant short-term gains using the concepts in production lines, but soon afterwards, fell back into their routines once the constraint was no longer inside the company but in the market. Nooren states that "at this point, new enhancements were, in general, thwarted by managers outside of production who saw no relevance of the TOC" (NOREEN *et al.*, 1996).

The Theory of Constraints for Education (TOCfE)

To fully understand the application of a business theory in an educational atmosphere, we need to first understand where it came from. According to a report by Kathy Suerken (2013), BA in History from the University of Wittenberg, it all started after reading Goldratt's romance *The Goal* in the 1990s.

Suerken (2013), using the knowledge she learned in the book, introduced them in her classes and tells us:

> I began to perceive the potential of TOC as a teaching methodology when I saw the results of these efficient thinking tools with my own integrated students [understood as those students with special needs in regular classes during specific periods] from elementary school, including those whom we believed suffered from learning disabilities and other special needs (p. 806).

Many people consider Goldratt´s book *The Goal* as a business novel about production. However, as a teacher, she applied the book´s tactics to education teaching how to "learn to learn, learn to think, learn to lead". This is due to the fact that the methodology used in the book has an educational connotation which enables people to think for themselves, to solve their own problems and use the knowledge they have acquired with the implementation of simple and effective solutions in their day-to-day lives. After applying the methodology, she was surprised by the development and interest shown by her students as well as the quality of schoolwork they produced.

According to Suerken (2013) who, out of appreciation, wrote a letter to Goldratt informing him of the work she was doing and the results she achieved. As a result, she was rewarded with an academic scholarship to the Avraham Goldratt Institute (AGI) in Milford, Connecticut, USA, for business management training and as a facilitator of the implementation of TOC concepts. Shortly later, after observing how effectively the TOC thinking process could be transformed into practical and highly beneficial results in the

classrooms and, in accordance with his own lifelong goals, Goldratt founded the TOC For Education Inc. (TOCfE) in 1995, a non-profit organization and invited her to become the organization's first president, a position she holds to this day.

Suerken is also a certified expert in TOC Thinking Processes by TOCICO – The Theory of Constraints International Organization Certification, an international organization which unites professionals with TOC experts. Suerken (2013) states that this is not a particularly innovative methodology, but what caught her attention was how Goldratt was able to demonstrate the way in which the scientific method and Socratic questioning techniques could be used to motivate people to be more productive and gain greater control of the results they achieve in their daily lives.

It is a methodology both tested and approved by all those professionals who have used it and is applicable to all individuals throughout the world, regardless of age, race, creed, religion, gender, etc.

The Theory of Constraints methodology for Education

In the book *The Goal*, along with the rest of the books written by Goldratt, the author used an educational tool to both disseminate and define the central idea of his work, the Socratic Method, cited by the author himself in some of the passages in his books. For Goldratt, this method encourages individuals to use one of the noblest faculties of our brain, namely our reasoning. According to Cabral (2015),

> Socrates created a method which many people today mistake as a mere figure of speech. The Socratic **irony** was, first of all, the method of questioning about a topic under discussion, of defining a concept and, contradicting it, refuting it. Even the verb from which the word irony (*eirein*) is derived means to ask questions. Therefore, the objective was not to embarrass anyone, but rather to purify their thinking and deconstruct their illusions. The idea was not to ridicule people's beliefs, but to break through the *aporia* (i.e., the obstruction which impedes individuals from true knowledge about a concept or idea) of understanding. However, to escape from this aporetic state, the interlocutor must abandon his or her preconceptions and the relativity of others' opinions which govern the way individuals perceive and act and begin to think for himself/herself. This exercise was what became known as **maieutics**, which means the art of eliciting knowledge (p. 34).

Since the methodology involves a teaching and learning process which uses logical reasoning, many educators (driven by conflicting ideologies; or resistant to anything that challenges the status quo; or perhaps merely ignorant of the method) attempt to discredit this approach, without even seeking to understand it.

Like a powerful ingredient now allied with the Socratic Method, Goldratt also observed that in society many individuals arrive at solutions to problems without knowing the latter's root causes.

Thus, these solutions, instead of correcting the problem itself, only address the undesirable outcomes of the problem. We thereby become hostages to our own palliative, momentary solutions, allowing the effect caused by the root problem to later resurface. Goldratt categorically states that: "Although every improvement is a change, not every change is an improvement" (SUERKEN 2013).

The process of change

The process of change is complicated in every sense and for any company or professional, including those involved in education. For Falconi (2009), the process of change is time-consuming, requiring lots of training, monitoring, reporting as well as intervention and commitment by upper management, without which such change would not be possible:

> [...] the learning process is slow, there are islands of excellence and there are islands of resistance within companies, and those who will never accept it. However, the majority of employees accepts the new method and become happier at work. The leadership at the top of the organization, of the CEO, is fundamental to the process (p.19).

This statement, even written in a few short words, gives us an idea of how difficult the process of change is, be it within an organization or on an individual level. According to Falconi (2009), the absorption of a change by the organization takes at least 5 to 7 years. This period includes incessant training of the teams involved and the full support of upper management, with regular and thorough monitoring of the entire process. The individuals will only change if there is an obligation imposed from the top down, otherwise inertia will prevail.

Using this line of reasoning, we can cite Project Proalfa (The State of Minas Gerais Literacy Assessment Program), which proposes to evaluate and intervene in the literacy programs in state schools. It is a top-down intervention and, according to the report (CARVALHO; MACEDO, 2015),

> [...] it was interesting to note that, for teachers, the change was positive and only occurred due to the obligatory nature by which they were subjected to it [...] Perhaps this fact may be explained by the persuasive power of being evaluated. This is not to say that the prospect of failure never haunted them before, but perhaps it had never

been as explicit as in this case; the students' result had never been exposed by the media, nor was there ever any organized external scrutiny around them (p. 563).

The goal of the government is to achieve an improvement in the quality of education offered in state institutions. With Proalfa, the change in the evaluation process of the students combined with the consequent change in teaching methods is the strategy adopted to achieve this goal. With this imposition, the State has been able to make improvements and provide greater support to teachers, even though some do not approve of the method, perceiving it as authoritative.

Furthermore, Falconi (2009) argues that, without a high level of pressure, changes do not happen.

The three basic measures that cause changes

Taking into account that constraints or conflicts of interest exist in the system, these must be resolved in order to achieve our goal. To this end, according to Ean´s pursuits of the Socratic Method, we must verify three questions as shown in Table 2 below:

What to change? Identifying the solution.	What to change it into? Identifying the solution.	How to cause the change? Construction of the tool, finding the solution and communicating it to all those involved.
This is the definition of the problem.	This is the solution to the problem.	This is the implementation of the solution.

Table 2 – Resolving a conflict
Source: EAN (2003), translated and adapted by the authors

According to the logic of the TOC's five focusing steps, we can see that the first question "What to change" brings us right back to the first step which is: IDENTIFYING the constraint(s) of the system. This is due to the fact that, in many cases, before knowing exactly what the root cause of the problem is, we already have a solution. Suerken (2013) states that, "in these cases we often, at times end up creating palliative, temporary or partial solutions where problems may later resurface. For this reason, there is a fundamental difference between the solutions which cause change and solutions which cause improvements" (, p.808).

Suerken also testifies that, to respond to these questions, Goldratt developed three tools, each of which has its own specific purpose. He labeled the first tool *Cloud*, the second *Negative Branch Reservation* and the third *Future Reality Tree*.

What to change?

When people are involved in so many academic as well as administrative activities, it is not always possible to clearly identify the root-cause of the problems which are preventing us from making improvements to the system (SUERKEN, 2013).

The same way that the goal of businesses is to make money, we can say that the goal of an academic institution is "good quality teaching". All students need to be prepared for life – to become productive and responsible citizens (SUERKEN, 2013). To achieve this objective or goal, teachers can act in two opposing ways:

- the first - meeting the learning and behavioral needs of all students, and

- the second - prioritizing in accordance with the limited existing resources or establishing criteria to meet these needs.

What to change it into?

According to Suerken (2013), the ability to reason and communicate clearly is the pillar that generates a quality workforce and determines the future of a civilized society. Suerken also states that a methodology or tool that can be used by both teachers and students and can motivate students to reason and communicate clearly would be a great positive source for change. This tool would have to be simple as well as being easily understood plus it should work universally in one's academic and personal life.

These tools must meet the diverse learning needs of both students and teachers and enable the students to apply these solutions wherever they are. Suerken (2013) adds that these tools can help teachers deliver the prescribed course curriculum in a way that students should:

- Simultaneously develop their analytical and communication skills;
- Apply the methods to problem solving and decision making;
- Make logical associations, interpret and question information;
- Achieve the desired standards and academic benchmarks according to which they are evaluated;
- Realize that learning is important, valuable and transferrable between what they study and their real-life experience, and

- Have the necessary motivation and skills to feasibly achieve individual and collaborative goals (p. 810).

As we can see, Suerken is not proposing anything beyond what the large majority of teachers, students and society want and that, in relation to the teaching methods currently used in most schools, they either do not work or only partially work. The achievement of these goals is what leads us to a larger objective or goal which is "good quality teaching".

How to cause the change?

Goldratt (2013) knew how to deal with the problems arising from change, and stated that:

> people's behavior depends on their comfort zone: when they operate within their comfort zone, they are open-minded and active and, when pushed outside their comfort zone, we can expect hesitation and resistance (p.197).

According to him, the comfort zone is characterized by an area in which the person feels in control, or at least has a certain influence. In addition, this person also supposes that they have enough cause-effect knowledge about the result of a given action. Therefore, when we make a suggestion and the person, based on their knowledge of the cause-effect relationship from their own life experience and convinced that the suggested action cannot bring about the desired effect, or has little chance of doing so, it is obvious that we should expect resistance.

This occurs at the measure in which the person's view diverges from our view of the proposed cause and effect. In this situation, references to similar situations can be a viable alternative of persuasion, but this may also incur the risk of the person rejecting the suggestion on the premise "this case is different".

Approaching a standstill, a plausible way to cause change is to propose a "test", in which by applying the proposal in a sample case, the level of acceptance/rejection of the proposal can be measured, as well as a numeric estimate of the magnitude of the results, as, for example, the increase in the extent of learning. Goldratt (2013) concludes:

> People's behavior is not arbitrary. Open-minded people are not necessarily going to agree with me – not when my arguments make little or no sense to them. But open-minded people who listen, and, if I explain (and when it is important), will be predisposed to invest to reassess their cause and effect connections (p. 206).

We see that, even with all the challenges that provoke changes, we can solve them through the construction of a solution. This construction can be demonstrated in a cause-effect diagram taking into consideration the history of the situation and the people involved, based on an application test with the construction of a prototype that will show us the success/failure rates.

Then, we can expand the change to the whole situation.

The Reasoning Tools (thinking processes) of TOCfE

Created to assist in resolving three basic questions (What to change? What to change it into? How to cause the change?), the tools of reasoning consist of formal and structured instruments that are designed to help people answer these three questions. The roles played by these tools are summarized in Table 3.

One specific problem may require the use of all the tools, but they may be also used selectively (NOREEN *et al.*, 1996).
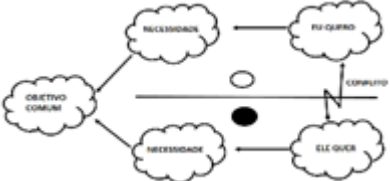
TOC Tool	What is it?	Concepts and Definitions
Evaporating Cloud	It is a graphical organizational tool used to answer the 5 questions in a conflict situation. With it, you can identify a problem or conflict situation.	Conflict situation between I want/you want to meet the needs in search of a common goal. It enables the possible injection of a win-win solution.
Negative Branch Reservation/Ramification	It is a tool for assessing the consequences. Its objective is to modify a negative conduct or behavior or idea by the person in question taking responsibility for the change.	It aims to discover the cause and effect, demonstrating both the positives and negatives of the solution, its consequences, biases, assumptions and facilitates the elimination of negative situations and prevents the convergence of ideas.
Ambitious Targets	This is a tool that facilitates the construction of a strategic planning, taking into consideration both the current and desired situation. It is also possible, using this tool, to predict obstacles which get in the way of achieving the goal.	Aids in the development of strategic planning, identification of obstacles, definition of intermediary or medium-term objectives as well as cause-effect connections and prerequisites.

Table 3 – Reasoning Tools used by TOCfE
Source: EAN (2003), translated and adapted by the authors

Like a scientist, Goldratt sought to structure conflict situations in a causality diagram, seeking win-win solutions. According to Ean (2003), it is a powerful tool of graphical representation, a logical diagram that allows us to discover a problem or conflict situation, based on 5 questions.

These questions, shown in the Cloud diagram, define the conflict fairly and without provocation, in accordance with the Socratic Method. We identify the origin of the problem, emphasizing our wills and desires which are found to be in conflict, the needs to be met for both sides of the conflict and the common objective that we hope to achieve.

Hence, when we examine the assumptions between wills and desires, it will be possible to find an alternative, known by the methodology as *injection*, which will lead us to a win-win solution, allowing us to "evaporate" the conflict and remove *the Cloud* (EAN, 2003).

Its structure is shown in Figure 2.
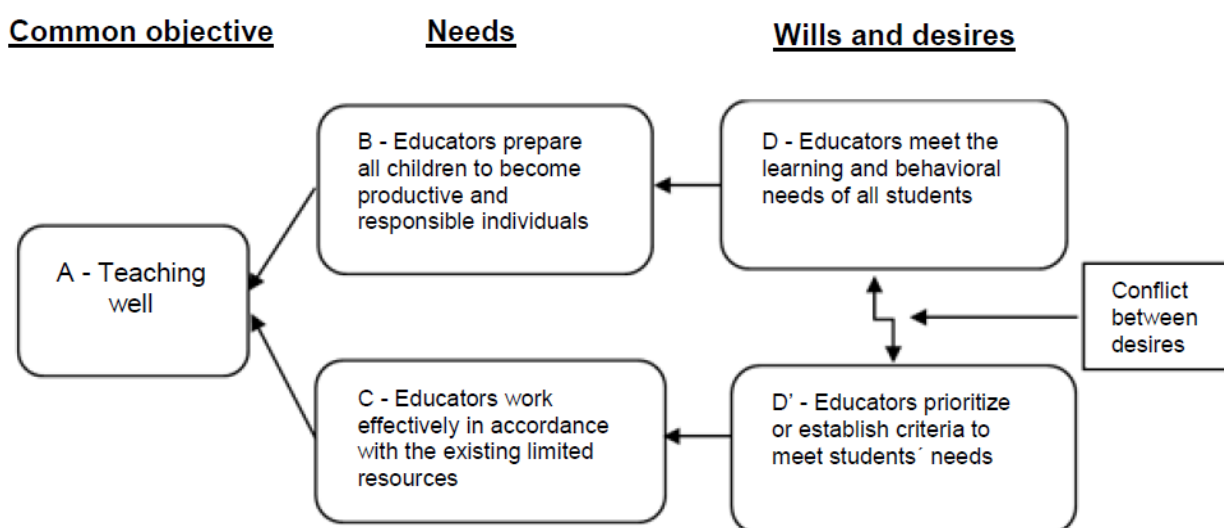
Figure 2 – Cloud Dispersion Diagram
Source: SUERKEN (2013), adapted by the authors

In Figure 2, we see a conflict between wills and desires of educators reported in balloon D and balloon D'. As we can see in B and C, the needs are not the same, however both seek the same objective expressed in A which is "to teach well".

From this statement, we seek to understand the assumptions which lie behind these wills and desires and find a win-win solution that satisfies both parties and try to satisfy the needs of B and C, which at times, is done greater than expected, and other times, makes both parties concede a little for the sake of the greater good.

Ean (2003), through the TOC tactical manual, gives us a good example for us to better understand how to analyze the cloud in search of a solution to the conflict, as shown in Table 4 below:

QUESTION	ANSWERS
Why is there a conflict between D-D'?	Because one side wants the opposite of what the other side wants, or both want the same and you cannot have both at the same time.
What is really important?	Satisfying the NEEDS is the most important, not your WILL or DESIRE.
Why not give in to wills and desires?	Because each side says that their WILL and DESIRE is the only way to satisfy their NEED.
What could resolve the conflict?	A WIN-WIN solution focused on the needs of B and C.
Can you think of a way to satisfy the needs of B while satisfying the needs of C at the same time?	A WIN-WIN solution. An injection is a distinct alternative to meeting the NEEDS.
What is a partial solution (compromise)?	To reach a solution in which each one of the parts concedes a little of its expectations of fully satisfying its´ NEEDS.

Table 4 – Seeking a solution to the conflict
Source: EAN (2003), translated and adapted by the authors

We can anticipate that the main goal of *the Cloud* is to demonstrate the conflict, showing that to achieve the very same goal, we may pursue at least two distinct conflicting paths. This account helps us to be more flexible and to try to understand more. Together our goal is to find a conflict-free win-win solution without concession or coercion.

Logical ramification

One of the greatest challenges teachers face is trying to teach their students facts and ideas that are linked to the reality of the world they live in, and even more challenging is teaching students how interconnected these are to the other disciplines of the curriculum, as Suerken (2013) explains:

> By nature, students try to make sense of the world around them and struggle when they try to learn facts and ideas which are, or appear to be, disconnected from their world (p.816).

The logical ramification proposes giving students, as well as the teachers for that sake, ways to systematize these connections to make sense of these connections and organizing this information in a sequential way. By developing the logical sequence, students are able to deduce and identify information and ideas contained in the texts more easily, once they make sense of the interconnectivity that exists among the different areas of knowledge, providing a more effective learning experience, without requiring the memorization of isolated facts, which is the case in most schools.

We can see an example of a logical ramification as well as its interpretation in Figure 3.
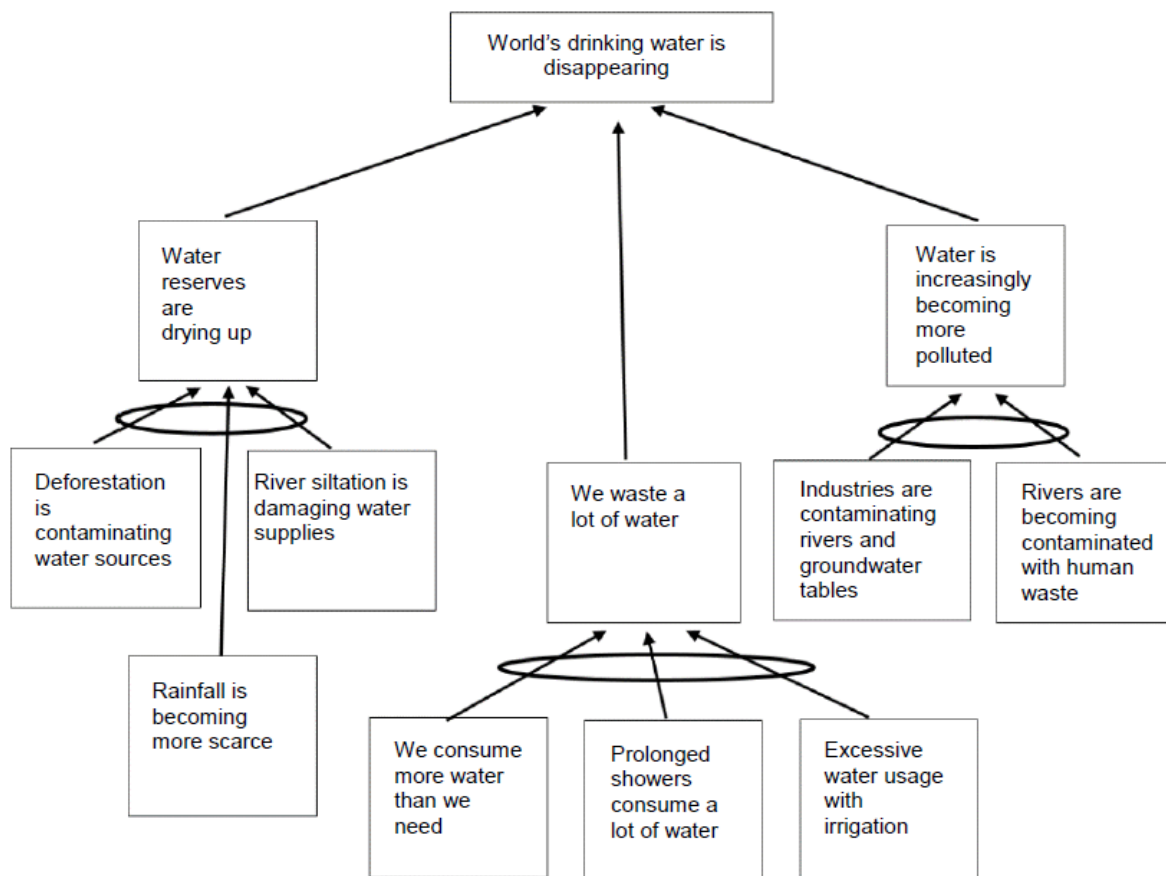
Figure 3 – A graphic analysis of global availability of drinkable water
Source: Authors´ elaboration

In Figure 3, we see the existing cause-effect logic which corresponds to the explanation that we give to the relationship between events and their elements. With this, we form a systematic idea of the effects which arise from a supposition of for what reason we decided that a Logical Ramification step leads us to the other.

The reading we have done is based on "if" and "then".

In this example, we see that: if industries are polluting the rivers and both the groundwater table and the rivers are becoming polluted with waste, then the water is

becoming more polluted than ever. This reasoning is followed by all the other ramifications which indicate the cause-effect. Suerken (2013) reports that in schools which use this method, "the assessment teams were not able to note any difference between the work of their students with learning disabilities and the work of students considered talented" (p. 816).

This statement is extremely relevant bearing in mind that there is a "discrimination" mentality towards those students who have greater difficulty learning.

The author also describes a number of cases of students who became more dedicated and changed their behavior by adopting the technique promoted by TOC.

The Ambitious Target Tree

Like any business environment where we have many problems achieving the goal of making money; in education, the creation of an ambitious target tree begins with defining the goal to be achieved. This goal has to make sense to the students and it can be a situation that is both real and makes sense to them. According to Ean (2003, p.54), "to achieve an Ambitious Target we use a tool which allows us to focus on a goal which is highly desirable, relevant to all team members, even if at first glance it may seem impossible". It is a form of strategic planning which contains all the necessary steps to achieve a proposed goal with a real possibility of success. Prepared by the students, this planning stimulates their thinking and motivates the group to develop this plan with common agreement among its participants.

It is clear that by using these tools, the learning process becomes more solid and effective, allowing students to begin solving problems rather than simply giving them pre-formulated answers. This tool will guide students towards a solution. In Table 5, we see the stages of development of this Target Tree.

ORDER OF STEPS	WHAT TO DO?
1 – Establish an Ambitious Target	Students decide what they want to do and if it will be done individually or as a group
2 – Construct a list with all possible obstacles	Each person makes a list of obstacles. The obstacles bring a *condition of impediment* for the Objective to be achieved
3 – Link the Intermediate Objectives (IO)	Each student suggests a way to overcome the obstacles they presented in the previous step
4 – Prioritize the Intermediate Objectives	Students analyze the IO and define the order that will be used to analyze the first and the following ones
5 – Design of some connection of "Prerequisite" for your Intermediate Objectives	Individually analyze each IO and establish the Prerequisite connections for all of them.
6 – Cluster the Intermediate Objectives in a logical way	Students establish the order in which they will carry out the task: which comes first and which comes after.
7 – Convert the Intermediate Objectives into a "Prerequisite" Tree	The IO list (now converted into a Prerequisite Tree) becomes a Strategic Plan that will be used by the group or by the individual.

Table 5 – Steps to construct the Ambitious Target Tree
Source: EAN (2003), translated and adapted by the authors

Suerken (2013) cites a statement made by Belinda Small, a primary school teacher working within a project from Saginaw Valley State University in Michigan, which uses the TOCfE tools, more specifically the Ambitious Target Tree. She used them in the English course for the 7th Grade, obtaining surprising results with the development of strategy and tactics carried out by students to solve classroom problems.

According to Small, developing the Tree took around an hour and fifteen minutes. Her report is mentioned in Suerken (2013), as follows:

> The TOC thinking and communication tools offer a framework and the necessary questions to enable students to analyze and appreciate the importance of what they are learning, and to apply it to their own lives, both now and in the future. When children assimilate not only the answers, but also the questions which allow them to make sense of the world around them, they become much more capable and motivated to take responsibility for what they have learned and how they behave. This reality widely meets the expectations of those interested in a good education to prepare children to become productive in the work atmosphere and responsible citizens, in a way which actually broadens and reinforces the resources for those who offer instruction – especially the time resource that they particularly apportion to it (p.822).

The enthusiasm in the professor's words was obvious when reporting the gains achieved by using the TOC tools. On the TOCfE website – tocforeducation.com – there is a tab with case studies and reports by professors from around the world with experiences similar to those of Ms. Small, which leads us to believe that it is a methodology which is already accepted and growing steadily.

A process of continuous improvement

As in any successful change at the beginning, when a satisfying or even surprising result is obtained, all the participants feel happy and motivated. Once those initial moments have passed, old habits set in and routine begins to reappear and complacency knocks on the door.

The application of TOCfE concepts is no different. The students, teachers, coordinators and managers are enthused about the new methodology and the positive initial results, but after a while, what was once a novelty becomes routine.

In this sense, the TOC, in its fifth step "If during some previous step a constraint has been broken, return to step 1, but do not allow inertia to become the system constraint" (CORBETT 2005, p.38), it leads us to treat inertia as a new constraint.

This constraint will deserve new attention returning to all the procedures described herein, in a circle of continuous improvement as we see in Figure 4:

Figure 4 – Five focusing steps: Process of continuous improvement
Source: GOLDRATT; COX (2002), adapted by the authors

Final considerations

During our examination of the TOC, it became clear that this theory has been gaining strength throughout the world in various educational institutions and with the support of the

State Departments in many countries. It also shows us the simplicity of its tools and its power to create individuals capable of deciding things for themselves, without having to memorize previously pre-solved problems. Its results are uplifting and provide a new way of teaching, studying and learning.

When in contact with this methodology, students become more confident, responsible and more participative, stimulating those teachers who share and expect these attitudes from their students. Reports about the success of its application are abundant, aside from scientific production as master and doctoral theses.

However, we return to the question of change. All the teachers and directors want quality education, nevertheless, they continue using practices which are incompatible with the current reality, which sets us back in the evolution of our society. This teaching model does not necessarily modify the content of the subjects, but brings a new approach to teaching.

References

BRAGA, Lucelma Silva. *A dupla face progressista e conservadora do liberalismo aplicado à educação nas décadas de 30, 70 e 90.* Campinas: 2002. Dissertação (Mestrado em Educação) – UNICAMP, 2002.

CABRAL, João Francisco Pereira. *Ironia e Maiêutica de Sócrates; Brasil Escola.* Available at: http://www.brasilescola.com/filosofia/ironia-maieutica-socrates.htm. Accessed on September 19th, 2015.

CARVALHO, Gisele F.S; MACEDO, Maria do Socorro A.N. *Avaliação oficial*: o que dizem os professores sobre o impacto na prática docente. Available at: http://www.scielo.br/scielo.php?pid=S1517-97022011000300007&script=sci_arttext, accessed on October 25th, 2015.

COGAN, Samuel. *Contabilidade gerencial*: uma abordagem da Teoria das Restrições – São Paulo: Saraiva, 2007.

CORBETT, Thomas. *Bússola Financeira:* O processo decisório da Teoria das Restrições. São Paulo: Nobel, 2005.

CORSI, Francisco Luiz. *Estado Novo:* política externa e projeto nacional. São Paulo: UNESP; FAPESP, 2000.

D'ARAÚJO, Maria Celina (Org.). *As instituições brasileiras da era Vargas.* Rio de Janeiro: EdUERJ; FGV, 1999.

EAN, Khaw Choon. *Manual táctico para principiantes (La Teoría de Restricciones En la Educación).* TOC para la Educación (TOCFE, Inc.) Detroit, 2001 Revised in Caracas, August of 2002 by R. Conde y J. Arévalo. Modified in March 2003 by R. Conde. Available

at: http://www.oocities.org/tocfe/documentos/manuales/, accessed on September 19th, 2015.

FALCONI, Vicente. *O verdadeiro poder.* – Nova lima: INDG Tecnologia e Serviços Ltda., 2009.

FAUSTO, Bóris (Org.). *O Brasil Republicano*: economia e cultura (1930-1964). 3.ed. Rio de Janeiro: Bertrand Brasil, 1995. (História Geral da Civilização Brasileira: t. 3, v. 4).

 GOLDRATT, Eliyahu M. *A escolha*; translation by Thomas Corbett. – 1. ed. – São Paulo: Nobel, 2013.

_____.; COX, Jeff. *A meta:* um processo de melhoria contínua. Translation by Thomas Corbett Neto. – São Paulo: Nobel, 2002.

_____.; FOX, Robert E. *A Corrida pela vantagem competitive.* translated by Claudiney Fullmann. São Paulo: Educator, 1992.

NOREEN, Eric W.; SMITH, Debra; MACKEY, James T. *A teoria das restrições e suas implicações na contabilidade gerencial: um relatório independente.* Translation by Claudiney Fullmann. São Paulo: Educator, 1996.

SUERKEN, Kathy. *Handbook da Teoria das Restrições* / Organizers, James F. Cox III, Hohn G. Schleier, Jr.; [Translation: Beth Honorato; technical revision: Daniel Pacheco Lacerda ... et al.]. – Porto Alegre: bookman, 2013, p. 806-832.

SZMRECSÁNYI, Tamás, GRANZIERA, Rui G. *Getúlio Vargas e a economia contemporânea.* Campinas: Unicamp, 1986. p. 131-146.

TOC-GOLDRATT.COM. *Biografia de Eliyahu M. Goldratt:* Available at: https://www.toc-goldratt.com/en/biography-of-eli-goldratt, accessed on September 19th, 2015.

TOC.Tv. Site distribution of educational of educational videos on TOC. Available at: https://www.toc.tv/TV/index.php?pn=#.VhgT-3pViko, accessed on October 09th, 2015.