Capturing action research knowledge through Strategy and Tactic (S&T) tree

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Abstract

This paper aims to demonstrate the use of S&T tree, a developed body of knowledge by Theory of Constraints (TOC) practitioners, to facilitate an action research (AR) carried out in an MTO company. Simplified-Drum-Buffer-Rope (S-DBR) pull system mechanism together with Buffer Management (BM) is pre-evaluated as the appropriate production planning and control (PPC) system as an intervention to improve the operating performance of the company. In the process of introducing the proposed PPC, the assumptions made in the original S&T is challenged with new knowledge captured and added in order to meet the contextual requirement of the company.

Keywords: Action Research, Thinking Process, Strategy and Tactic

Introduction

The heterogeneity nature of organisation challenges operations managers to adapt generic operations management (OM) body of knowledge to situational and contextual environment while striving to achieve a common set of operating performance. This has shaped the OM field to acknowledge itself as an '*applied field with a managerial character*' which deals with '*real world*' problems and challenges and is '*cross-disciplined*' (Karlsson, 2016:12). Applicability and relevancy in the impact of OM research to the practitioners has driven empirical and field-based methodology with an 'integrative' rather than 'reductionist' approach to be adopted (Flynn et al., 1990; Westbrook, 1995). Action Research (AR) has been advocated as a research methodology in-line with Research Mode 2 to capture the situational and contextual knowledge generated (Coughlan and Coghlan, 2016; David and Hatchuel, 2008; Levin and Greenwood, 2008; MacLean et al., 2002; Westbrook, 1995). Although details concerning inquiries and reflection process together with its quality and rigour within the AR has been highlighted (Coghlan and Brannick, 2014; Coughlan and Coghlan, 2016; Shani et al., 2008), there are limited discussion and demonstration on relevant tools to support these AR processes in OM. This paper aims to demonstrate how S&T tree is used as a tool to facilitate the AR cycles in the process of inquiring and reflecting actions and assumptions used in introducing intervention to a manufacturing company. The remainder of this paper is organised as follows. Firstly, a brief description about the company and the research collaboration. This is followed by an introduction to the PPC to be evaluated in this research. The AR approach together with the utilisation of S&T will be discussed in the subsequent design and methodology section. An evaluation on the use of S&T as a tool to capture knowledge generated in AR will be presented at the end of this paper.

Purpose

This research is based on a UK government funded Knowledge Transfer Partnership (KTP) project in collaboration with an SME company, Amberol Ltd (AL). AL is a company which designs, manufactures and markets its own range of plastic bins and planters with customised moulded-in graphics and wide range of colours for customers to choose from. The company adopts MTO and accepts small quantity orders from customers, with majority of the orders having quantity of less than 50 units per order. The competitive advantages offered to the customers pose a challenge to AL which utilises rotary moulding technics and is human labour dependant. There is no dedicated production line for a particular product. The production flow according to functionality is relatively simple: *Moulding – Assembly – Finishing*. Rotary moulding machines are heavily shared resources. It has a complex matrix setup of 'product' vs 'mould' vs 'machine' with different sequencing and resource utilisation time. In addition, the production touch time is significant. In order to achieve growth, the company seeks to explore and introduce best practice intervention to improve its operations performance. Although Sage software is currently used to manage its business operation, the manufacturing module pushes work orders onto the shop floor with a standard lead time without considering manufacturing related resource capacity. This causes due date performance (DDP) related undesired effects (UDEs). The lack of visibility on the utilisation of manufacturing resources resulted UDEs in making decisions on manufacturing related resources. Ultimately, UDEs consumed much of the time of senior management, which could be invested in exploring and exploiting potential market. The existing information system (IS) failed to integrate various departments within the organisation to improve operation performance. Upon analysing the situation, a time-based, pull-system PPC solution: Simplified-Drum-Buffer-Rope (S-DBR) is proposed to be introduced in AL.

S-DBR

Since the introduction of Drum-Buffer-Rope (DBR) in the early 80s by Goldratt, it has been further developed into Simplified-Drum-Buffer-Rope (S-DBR) system which is advocated to be a solution with greater applicability to a wide manufacturing environment. While inheriting the choke and release mechanism and utilising buffer management (BM) from DBR, S-DBR views 'market' as the constraint (the drum) which dictates the production. Time buffer is thus placed before the 'market' in order to ensure market demand can be satisfied (reliable due date performance). In addition, its simplified algorithm is advocated to enable the concept to be easily implemented with existing MRP software without necessary heavy investment in unique, dedicated software, which is suitable for SMEs (Small and Medium Enterprises) which are characterised by limited financial resources (Schragenheim et al., 2009; Schragenheim and Dettmer, 2000: 156). However, as highlighted by Benavides and Landeghem (2015), although the concept of S-DBR was introduced in year 2000, the attention received in literature is predominantly focused on the theoretical fundamentals with a lack of academic empirical research focusing on the practical issues in its implementation. It is thus the purpose of this research to capture the practical knowledge in the implementation of S-DBR.

Design/methodology/approach:
This KTP project has dual purposes: firstly, to solve a real-life problem in AL, and secondly, to capture the practical knowledge gained throughout the project implementation process. The employment of a KTP associate by AL working as a business system architecture designer/programmer enables a first person researcher insight/perspective into the practical issues related to the project implementation. The day to day interaction with fellow colleagues provides information and feedback regarding the project to the KTP associate as a second person researcher. The setting up of a core project team which consist of senior management from AL and knowledge expertise from both AL the university, as well as the setting up of the local management committee (LMC) enables insights to be developed by the KTP associate as a third person researcher. Practical knowledge generated through practical knowing differs from scientific knowing: scientific knowing aims to arrive at a generic and universal statement whereas practical knowing is contextual and situation specific (Coghlan, 2011). Acknowledging that there are no two identical organisation, it is the purpose of this research to capture the practical knowledge in the implementation of a generic PPC. The above discussion leads to the adoption of AR as the research approach for this project.

Action Research
In the context of management and organisation studies, Shani and Pasmore (2010) define AR as '*an emergent inquiry process in which applied behavioural science knowledge is integrated with existing organisational knowledge and applied to solve real organisational problems. It is simultaneously concerned with bringing about change in organisations, in developing self-help competencies in organisational members and in adding to scientific knowledge. Finally, it is an evolving process that is undertaken in a spirit of collaboration and co-inquiry.'* This definition highlights the importance of the process taken in AR which Shani et al. (2012) further illustrates as '*build on the past, take place in the present with a view to shaping the future*'. This is based on Lewin's (1946:146) concept of continuous cycles of planning, action and reflection on the action taken. These AR cycles are described as '*Meta-Learning'* where each cycle is comprised of a '*pre-step*' and four main steps of '*constructing*', '*planning action*', '*taking action*', and '*evaluating action*' (Coghlan and Brannick, 2014; Coughlan and Coghlan, 2016).

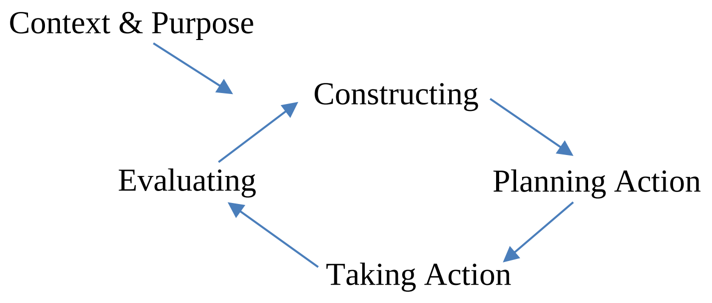

Figure 1: The AR Cycle
Source: Coghlan and Brannick (2014: 9)

In the context of OM, Coughlan and Coghlan (2016) identified some key AR characteristics such as:

- *Action researchers take action*
- *Action research always involves two goals*
- *Action research is interactive*

- *Action research aims at developing holistic understanding during a project and recognising complexity*
- *Action research is fundamentally about change*
- *Action research requires an understanding of the ethical framework, values and norms within which it is used in a particular context*
- *Action research can include all types of data gathering methods*
- *Action research requires a breadth of pre-understanding of the dynamics and structure of operating systems and the underpinning theoretical of such system*

Although much has been discussed on the merit of adoption AR in OM, there are limited discussion on the tools used to facilitate the enquiry process or in capturing the knowledge generated. The subsequent section will introduce the S&T tree which could be a potential tool to be used to facilitate AR in OM.

Strategy & Tactic (S&T) tree

S&T tree is a change management tool used by OM (Operations and Management) practitioners in Theory of Constraints (TOC) (Dettmer, 2007; Kim et al., 2008; Mabin and Balderstone, 2003; Scheinkopf, 2010). It is used to capture and proliferate the generic TOC body of knowledge developed since its inception. *Figure 2* below shows an example of a general S&T which illustrates the knowledge on the implementation of PPC solution for MTO (Make-To-Order) companies in the TOC body of knowledge. The S&T tree is made up of S&T nodes/elements, with the highest level at the top being the ultimate objective to be achieved. Referring to *Figure 2*, it is read as: '*In order to achieve Viable Vision (Strategy), it is necessary to have Profitable Growth for MTO Manufacturers*'. Moving vertically down to the next level, '*In order to achieve Profitable Growth, it is necessary to have Reliability Competitive Edge and Rapid Response Competitive Edge*'.

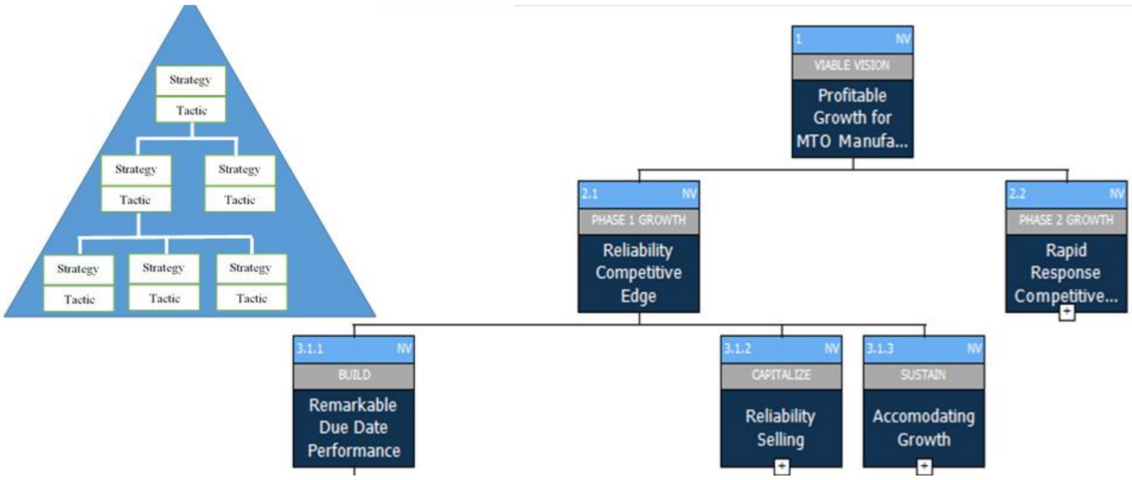

Figure 2: S&T tree for MTO Companies
Source: Harmony (2017)

For each S&T element, it is an *inquiry process* into making a change (Barnard, 2010:444):

- *Why the change is needed (necessary assumptions)?*
- *What the specific measurable objective is for the change (strategy)?*
- *Why the objective is possible and why the tactic is the 'best' way (parallel assumptions)?*

- *How to best achieve the objective of the change (tactic)?*
- *What advice or warning should be given to subordinates which might jeopardise the sufficiency of the steps in implementing the tactic (sufficiency assumption)?*

This inquiry process embraces the mapping of cause and effect (necessity and sufficiency) logic using abductive reasoning together with means of exposing and challenge assumptions in the resolution of conflicts (necessity logic). This approach makes the embedded assumptions in such interventions explicit (necessity, parallel and sufficiency) and at the same time capturing the knowledge generated throughout the change process. An example is of the S&T element '*Choke and Release*' is shown in *Figure 3* below. In this research, the existing generic S&T on TOC based PPC for MTO will be used as the body of knowledge to inform the design of a solution for AL. It will also be used to facilitate the AR inquiry process.

4:11	**Choking the Release**
Necessary assumptions	Having too many orders on the shop floor masks priorities, promotes local optima behavior and therefore prolongs the lead-time and significantly disrupts due-date-performance (DDP).
Strategy	The shop floor is populated ONLY with orders that have to be filled within a predefined horizon.
Parallel assumptions	❑ In traditionally run plants touch time is a very small fraction (<10%) of the lead time. ❑ Vast experience shows that, in traditionally run plants, restricting the release of materials, to be just half the current lead time before the corresponding due date, leads only to good results and to no negative ramifications* (lead time shrinks to less than half, DDP improves considerably, throughput goes up and excess capacity is revealed). These results are achieved irrespective of whether or not a bottleneck exists. * *Except for environments which are dominated by heavily dependent set-up matrixes. Those environments have to be dealt in a different way.*
Tactic	For each product family, a buffer time is set to be equal to 50% of the current lead-time. Orders are released to the floor only buffer time before their committed due-date (excessive WIP is frozen until its time arrives according to the above rule). Sales people are **forbidden** from using the shorter lead times to get more sales.
Warning	Trying to be more accurate than the noise is useless, distracting, and definitely delays results.

Figure 3: S&T Element 'Choke and Rlease'
Source: Harmony (2017)

AR cycle design

A macro AR cycle is designed to overarch the research phases of 'Pre-Change' (Context and Purpose, Constructing, Planning Action), 'In-Change' (Taking Action), and 'Post-Change' (Evaluating Action). Various micro AR cycles are developed in each of these phases. The three research questions (RQs) are as shown in *Table 1* below, which relates the designed project phase with RQ and the overarching macro AR cycle. The remaining of this section will demonstrate how S&T is utilised to inform as well as capture the knowledge in each project phase as depicted in *Table 1 below*.

Table 1: Project phase vs RQ vs AR Cycle

Project Phase	Pre-Change	In-Change	Post-Change
Project Research Question (RQ)	RQ1: *What are the strategic opportunities to improve the operating performance of AL?*	RQ2: *How to exploit the strategic opportunity identified?*	RQ3: *How to enable the intervention introduced to continuously grow AL?*
AR Cycle	Context & Purpose, Constructing, Planning Action	Taking Action	Evaluating Action

Findings:

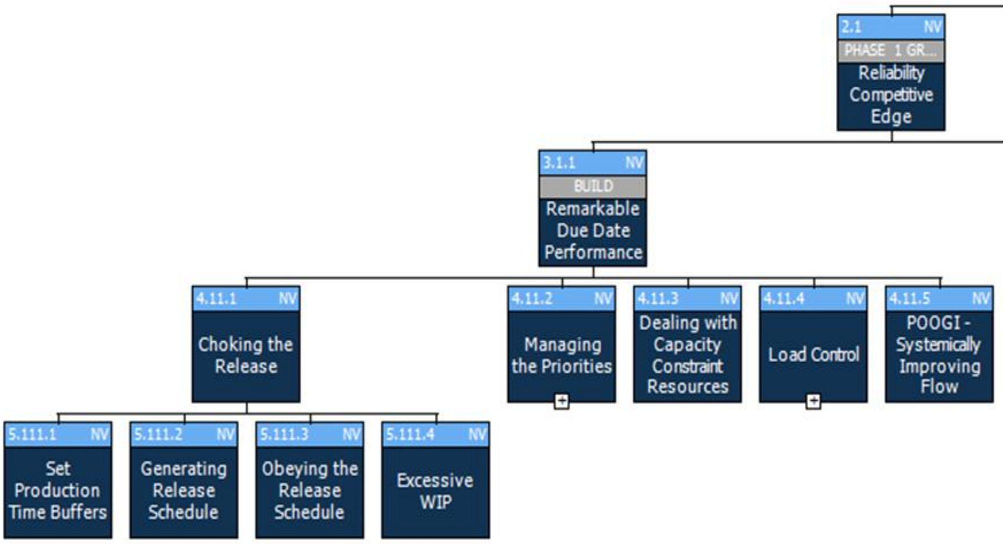

Figure 4: S&T to Build Remarkable Due Date Performance
Source: Harmony (2017)

In this section key adaption from the S&T element under 3.1.1 *Remarkable Due Date Performance* will be highlighted. Referring to *Figure 4* above, there are five necessary elements to achieve 3.1.1 *Remarkable Due Date Performance*: 4.11.1 *Choking the Release*, 4.11.2 *Managing the Priorities*, 4.11.3 *Dealing with Capacity Constraint Resources*, 4.11.4 *Load Control*', and 4.11.5 *Process of On-going Improvement (POOGI).*

4.11.1 Choke the Release

The parallel assumptions for the first element (4.11.1) is that the touch time is a very small fraction of the lead time. As S-DBR is a time based system, insignificant touch time will offer sufficient protection time from the buffer time allocated. However, in AL, the touch time for a product is significant which thus reduces the protection time available for production. The progress of the production becomes important as a slack in producing a single unit will have significant impact towards meeting the overall DDP. Thus, it is proposed that a feedback mechanism has to be designed to capture the production progress on the shop floor. The progress will be used to inform the subsequent element: 4.11.2: *Managing the Priorities*. Details on this design will be discussed in the subsequent S&T elements. The production time buffer (*5.11.1*) is recommended to be 50% of the production lead time, with the assumption that production touch time is insignificant. In AL, there is a standard industry accepted lead time of 15 days for all products irrespective of actual production touch time. As touch time is significant in AL, a proposed standard buffer of 9 days is placed before the standard industry accepted lead time of 15 days or due date promised.

4.11.2 Managing the Priorities

The priority of work order (4.11.2) is managed by the percentage of buffer penetration (BP) into the proposed 9 days Production Time Buffer. The standard buffer management (BM) in TOC with the colour representation of *black* (BP > 100%), *red* (67% < BP ≤ 100%), *yellow* (33% < BP ≤ 67%) and *green* (0% > BP ≤ 33%) is adopted. However, considering the contextual requirement, a new release rule is introduced where work orders ≤ 0% is represented by *blue* and is meant to put on hold. This is to create a natural '*pooling*' for potential work orders with similar products to be produced together in batch to reduce machine setup time. This natural '*pooling*' is also meant to reduce excessive WIP in the system which at the same time allow some flexibility to stop the work order if customer decides to withdraw the order or for further customisation. As described in 5.111.2, SDBR allows flexibility for the expertise on the shop floor to re-order the work order to be processed among work orders with similar priorities without jeopardising the DDP. This allows AL experts on the shop floor to take informed intervention according to contextual situation.

4.11.3 Dealing with Capacity Constraint Resources (CCR) and 4.11.4 Load Control

From the surface, the CCR was initially thought to be only the Rotary Moulding Machine. However, it is observed that CCR is subjective which can be the machine as a whole, a particular arm of the machine (due to the arm setup), the position on the arm (due to the size of the mould) or the mould itself. In order to effectively monitor the usage of potential CCR, heuristic algorithm is developed together with AL expert team to sufficiently determine a planned load for rotary moulding machine. User input interface is developed to allow shop floor to allocate potential CCR to a work order. Progress of each work order on each potential CCR is updated daily. Heuristic algorithm will reprioritise each work order according to the actual and planned usage of potential CCR. This allows visibility to shop floor and management to make informed decisions in managing additional capacity resources which includes additional mould, machine or working hour according to market demand. In addition, visibility on potential CCR loading allows reliable due date to be quoted by considering the system loading. Incorporating with the BM discussed above, during the phase of sales enquiry, touch time of enquired product is computed and added behind the next available time slot of the suggested CCR. The estimated due date is then compared with the BM. If the BP falls in the yellow zone or below, standard lead time is quoted. Else, if the BP falls within or beyond the red zone of BM, the system will automatically propose an additional five days in addition to the later date between standard lead time or estimated complete date as illustrated in *Figure 5* below.

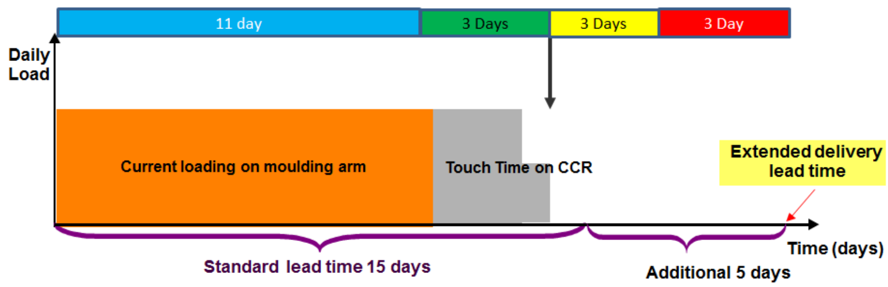

Figure 5: CCR Planned Load and Buffer Management to determine Reliable Delivery Date

The initial design merely concentrated on considering rotary machine related resources as the CCR. However, during implementation, it is observed that 'mould availability' is also a potential CCR as in some cases, mould is being shared to produce different products. Instead of developing a detailed planned load for mould, the latest availability date of mould is being tracked and incorporated into the heuristic algorithm. If the work order associated with the mould enters into *red* zone and beyond, the relevant mould status will be flagged up to alert management. The notion of planned load with the heuristic algorithm is not to dictate the sequence of the work orders. Rather, it is visually populated to explicitly unveil the workload vs potential CCR buffer status. The purpose is to allow appropriate intervention actions to be introduced contextually. This information will subsequently inform and encourage decision making in S&T element 4.11.5 *POOGI – Systematically Improving Flow*, which is to take further action for continuous improvement.

Relevance/contribution:

The overall PPC system design is shown in *Figure 6* below which aligns the end-to-end business process, starting with providing reliable due date in the pre-sales stage, managing work order priorities on the shop floor in order to provide satisfactory after-sales service by meeting market demand. Initial results obtained two months into the deployment of the trial solution is apparent. Although AL has experienced unprecedented growth of sales within this period comparing to previous years, the solution successfully assist the company to fulfil market demand without increasing the number of working shift, which was used to be a 'normal' practice to deploy additional shifts during this period of the year. The solution introduced visibility with a systemic view (by integrating with existing Sage system) and thus presented a platform to engage inputs from various levels (from shop floor to the top management) which includes conversation on ways to elevate potential CCR. The planned load together with the shop floor progress feedback introduced provides pre-alert on potential CCR consuming the standard three weeks production buffer time. Upon analysing the available options to manage the potential CCR, a collective decision was made to increase the working time on the potential CCR by an extra hour each day which has successfully navigated AL through an expected busy

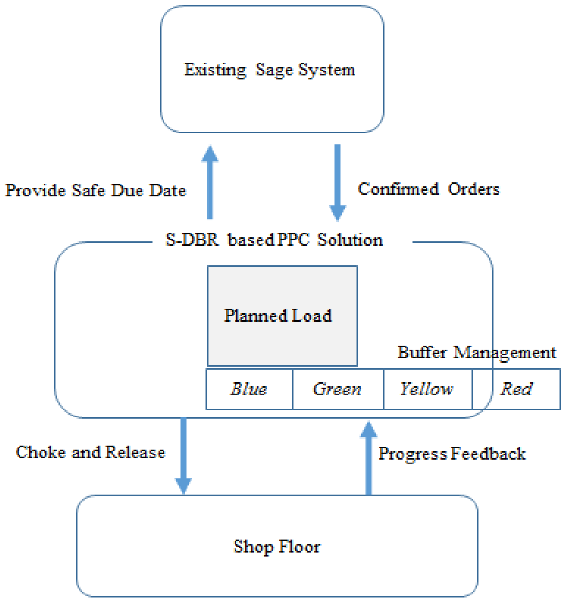

Figure 6: Overall System Design

period. Further detailed review is currently in progress which includes monitoring and collection of key operating performance parameters such as DDP, WIP and throughput for further evaluation to inform further subsequent action cycles for improvement.

This brief account firstly demonstrates the success in deploying SDBR in an environment with significant touch time. Secondly, it demonstrates the benefit of using S&T as a generic guide in implementing an established OM best practice. The explicitly stated assumptions allows OM researchers and practitioners to adapt the steps according to contextual requirement. This is in line with the call from fellow OM researchers of not to engage in the act of 'copying best OM practices' but rather to identify the underlying dependencies and assumptions to inform the appropriate best practice or intervention actions to be taken (Boer et al., 2015; Hopp and Spearman, 2004; Voss, 1995; 2005). S&T as a tool shows similar dual purposes as AR, to provide a solution to the practical problem as well as capturing new knowledge by developing contextual S&T. The five associated inquiry questions behind each S&T element is itself a 'shadow' of AR cycle as illustrated in *Figure 7* below.

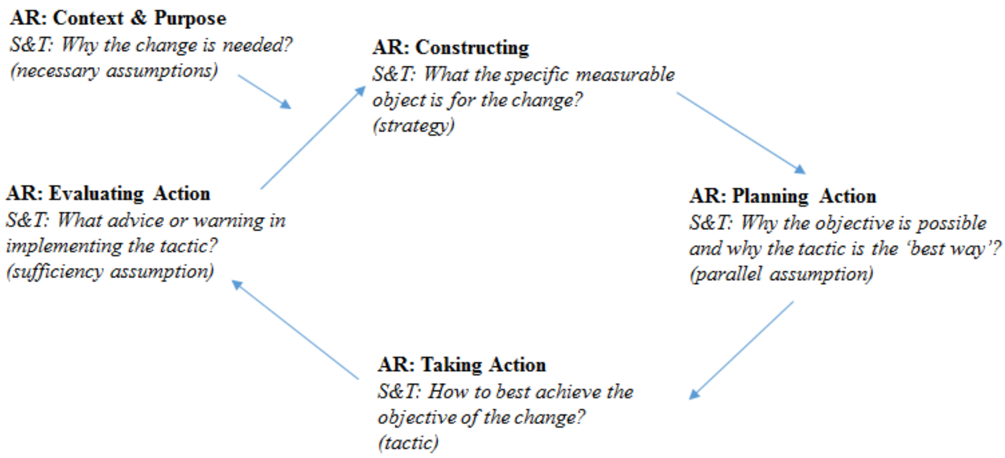

Figure 7: AR steps and the corresponding S&T inquiry process
Source: Adapted from Coghlan and Brannick (2014: 9) and Bernard (2010:444)

Although S&T is commonly used by TOC consultants, there are very few research studies that have focused on the application of these tools and none that have looked into using these tools in the support of AR. This research offers preliminary insight into using S&T as an effective AR tool and created opportunities to further evaluate the claims associated with this tool with a wider implication of adopting it as a general AR tool in OM research and practices such as for Kanban and Workload Control (WLC).

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