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Use of a discrete-event simulation in a Kaizen event: A case study in healthcare

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ABSTRACT

To improve service delivery, healthcare facilities look toward operations research techniques, discrete event simulation and continuous improvement approaches such as Lean manufacturing. Lean management often includes a Kaizen event to facilitate the acceptance of the project by the employees. Business game is also used as a tool to increase understanding of Lean management concepts. In this paper, we study how a business game can be used jointly with discrete event simulation to test scenarios defined by team members during a Kaizen event. The aim is to allow a rapid and successful implementation of the solutions developed during the Kaizen. Our approach has been used to improve patients' trajectory in an outpatient hematology–oncology clinic. Patient delays before receiving their treatment were reduced by 74 percent after 19 weeks.

1. Introduction

Considering the increasing needs for services in healthcare, hospital services must review their practices to improve them and increase their performance. Healthcare facilities look toward continuous improvement approaches such as Lean manufacturing to improve service delivery (Houchens & Kim, 2014). Lean manufacturing is a management approach aiming to improve the performance of an organization by reducing waste, delays, etc. while involving staff in decision-making. During the last few years, the DMAIC (Define, Measure, Analyze, Improve and Control) problem-solving approach combined to six sigma was used jointly with Lean to become Lean six sigma.

Operations research techniques and discrete event simulation have also been used by healthcare managers (Fone et al., 2003). Since healthcare services are mostly dynamic and stochastic processes, discrete event simulation has been more often used to model and analyze flows in healthcare processes (Fone et al., 2003; Jun, Jacobson, & Swisher, 1999; Mielczarek & Uzialko-Mydlikowska, 2012). More recently researchers included a Lean approach to discrete event simulation in a facilitated mode (Robinson, Worthington, Burgess, & Radnor, 2014). Robinson, Radnor, Burgess, and Worthington (2012) describe the role of simulation in a Lean approach (before, during and after a Kaizen event). A Kaizen event is a group activity, commonly lasting 5 days, in which a team identifies and implements a significant improvement in a process (Lean Enterprise Institute, 2014). It is a participative activity and it facilitates the acceptance of the project by the employees. Tako and Kotiadis (2015) combine discrete-event simulation, a hard OR approach, with soft systems methodology (SSM) in order to incorporate stakeholder involvement in the simulation study lifecycle.

Business games are also used as a tool to increase understanding of Lean management concepts (Ashenbaum, 2010; Billington, 2004; Martin, 2007; Swanson, 2008). van der Zee and Slomp (2009) assert that they could help workers find solutions for specific problems, or to familiarize themselves with and ease their acceptance of new work methods or systems. Originally, business games have been used to help find solutions in different business environment. A business game has been defined by Greco, Baldissin, and Nonino (2013) as "a game with a business environment that can lead to one or both of the following results: the training of players in business skills (hard and/or soft) or the evaluation of players' performance (quantitatively and/or qualitatively)". The business game allows a better understanding of complex problems. The pedagogical principle underlying the business game is involving participants in a virtual environment. Business games were originally developed to educate business managers. They reproduce a process in a virtual environment while being inspired by reality. It can also be used to let employees perform a task or a given operation for real (Ellis, Goldsby, Bailey, & Oh, 2014). However business games can be helpful to educate managers, employees and change agents in healthcare or education. The

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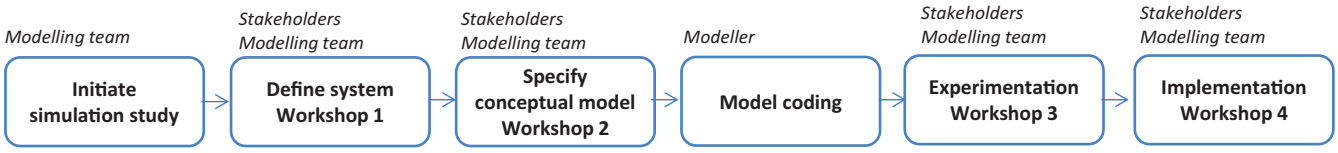

Fig. 1. PartiSim (Tako & Kotiadis, 2015).

play themes are not only related to enterprise strategy but address other topics such as quality, work organization, planning, safety at work or project management.

In this paper, we ask how it is possible to facilitate rapid implementation of solutions found in a kaizen event and reduce barriers when implementing Lean in healthcare. We believe that discrete-event simulation, business game and the involvement of the project team can play a crucial role in achieving those goals. In doing so, we present an approach to implement a Lean project according to the DMAIC problem-solving procedure (de Mast & Lokkerbol, 2012). The DMAIC approach has been used to analyze patients' trajectory in an outpatient hematology–oncology clinic in order to propose and implement improvements aiming to reduce patients' waiting time when receiving a chemotherapy treatment. Data were gathered only 3 months after the Kaizen event to evaluate the impact of the modifications implemented. A Kaizen event was organized at the Improve step during which a business game was used to help find solutions. During the Kaizen event, discrete event simulation was used to test how the solutions could modify patient waiting times. We describe the role of each stakeholder in this approach and how it is facilitative and participative. We also explain the advantages of using a business game and discrete event simulation during a Kaizen event.

The paper is organized as follows. Section 2 presents relevant literature while Section 3 presents the methodology. The implementation of our approach and results are described in Section 4. Finally the results are discussed in Section 5 and Section 6 presents the conclusion of our research.

2. Relevant literature

The heart of Lean consists in preserving value with less work by the identification and elimination of "waste" and in developing standardized, reliable processes. This is performed in a context of connectedness, respect, and growth of all employees who are trained to identify waste and errors, and suggest possibilities for improvements that will be tested using scientific methods. Lean seems to be an effective way of improving healthcare organizations and the growing number of implementations and reports found in the literature reinforce this view (Brando de Souza, 2009)

Lean implementation in healthcare requires adaptation and development to fit the specific context and allow healthcare staff to take ownership of the approach (Poksinska, 2010). Literature review shows that there have been some significant tangible outcomes in healthcare organizations that adopted Lean principles such as increased patient throughput (Dickson, Singh, Cheung, Wyatt, & Nugent, 2008; Van Lent, Goedbloed, & Van Harten, 2009), reduced waiting times (Al-Araidah, Momani, Khasawneh, & Momani, 2010; Lodge & Bamford, 2008) and improvements in work environment (Kaplan & Patterson, 2008; Nelson-Peterson & Leppa, 2007). However, many papers identified barriers when implementing Lean management in healthcare organizations such as lack of ownership of proposed processes, skepticism and resistance to change (Brandão de Souza & Pidd, 2011; Proudlove, Moxham, & Boaden, 2008; Radnor, Walley, Stephens, & Bucci, 2006).

In the last few years, discrete-event simulation has been considered as an interesting tool to help improving healthcare services (Brailsford, Harper, Patel, & Pitt, 2009; Fone et al., 2003; Mielczarek & Uzialko-Mydlikowska, 2012) as in outpatient clinics (Jun et al., 1999; Rohleder, Lewkonia, Bischak, Duffy, & Hendijani, 2011). Discrete-event simulation has been applied to solve a wide variety of healthcare problems such as patient appointment systems (Klassen and Yoogalingam, 2009; Ogulata, Cetik, & Koyuncu, 2009), patient waiting time (Paul, Reddy, & De Flitch, 2010; Santibanez, Chow, French, Putterman, & Tyldesley, 2009), patient flow, (Rohleder et al., 2011; Sepulveda, Thompson, Baesler, Alvarez, & Cahoon, 1999; White et al., 2011), operational performance (Berg et al., 2009; Griffiths, Jones, Read, & Williams, 2010) and others problems (Hagtvedt, Griffin, Keskinocak, & Roberts, 2009; Katsaliaki & Brailsford, 2007).

Too often, discrete event simulation models have been developed and used by experts to find solutions without involving stakeholders in the development process. Recently, more work has been done on facilitated modeling to involve stakeholders in the development of discrete event simulation models.

Facilitated modeling consists in developing models jointly with a client group: from defining the nature of the problem, to supporting the evaluation of priorities and development of plans for subsequent implementation (Franco & Montibeller, 2010). Franco and Montibeller (2010) discuss in detail facilitated modeling as an OR intervention tool in organizations. Jahangirian, Taylor, Eatock, Stergioulas, and Taylor (2015) examine the stakeholder engagement in the context of healthcare simulation. They find that "communication gap between simulation and stakeholder groups" is the top primary factor contributing the most to the poor stakeholder engagement in healthcare simulation projects, followed by "poor management support", "clinician's high workload" and "failure in producing tangible and quick results". Recently managers began to be included in problem definition and process modeling (Kotiadis et al., 2013; Tako, Kotiadis, & Vasilakis, 2010a; Tako, Kotiadis, & Vasilakis, 2010b). This participation is especially important for studies in healthcare characterized by the presence of many stakeholders with tacit knowledge of their part of the system and often multiple views and objectives. Tako and Kotiadis (2015) combined the steps required to develop a discrete event simulation model with the participative steps of Soft Systems Methodology. Their whole procedure, called PartiSim, allows stakeholders to be involved at every stage of the model development and experiments (except for programming which requires a specific expertise). Fig. 1 presents the PartiSim steps in which stakeholders are involved through workshops. Our approach differs from Tako and Kotiadis (2015) because it includes the Lean project steps together with the development of the discrete event simulation model.

There are few studies on the use of discrete event simulation through a Lean approach, or other continuous improvement process, in healthcare systems. Young et al. (2004) propose the use of simulation to evaluate the benefices of a continuous improvement project in healthcare before the implementation. Khurma, Bacioiu, and Pasek (2008) present a discrete event simulation model to study the impact of a Lean project in an emergency unit. Even if they do not specifically consider Lean management, Proudlove, Black, and Fletcher (2007) show how a simple simulation model can improve efficiently patient flows. Robinson et al. (2012) explore potential complementary roles of discrete event simulation and a Lean approach in healthcare systems. Their model, *SimLean*, defines three roles for discrete event simulation used with Lean: education, facilitation and evaluation (Fig. 2).

According to Robinson et al. (2012), discrete event simulation can have an educational function in teaching Lean principles (Educate