



# Linking learning and knowledge creation to project success in Six Sigma projects: An empirical investigation

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## ABSTRACT

This study investigates the impact of two organizational antecedents, (1) Six Sigma resources (technical) and (2) team psychological safety (social), on learning behaviour and knowledge creation and, in turn, on the success of Six Sigma process improvement projects. The paper proposes an integrated model to explain process improvement implementation success through two learning activities undertaken by Six Sigma project teams: *Knowing-what* and *Knowing-how*. The conceptualization of these knowledge types in this research is different from usual conceptualization as it represents the knowledge brought into projects through various phases of Six Sigma projects. The three hypotheses proposed in the model were tested using the data collected from 52 Six Sigma project teams from a single organization. Regression analysis showed psychological safety affects project performance through knowing-how. Regression and bootstrapping analyses showed resources influence project performance through the combined mediation of knowing-what and knowing-how.

The paper provides an interdisciplinary treatment of knowledge management in process improvement teams, and offers a research model demonstrating how Six Sigma project teams promote deliberate organizational learning. By doing so, this study empirically establishes the notion that technical and social supports jointly impact the success of operations management initiatives such as Six Sigma through learning. The limitations of the study along with the future research directions are highlighted.

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## 1. Introduction

Teams are the fundamental learning units in organizations (Senge, 1990). Team learning is a process in which a team takes action, obtains and reflects on feedback, and makes changes to adapt or improve (Edmondson, 1999; Argote et al., 2000). The literature investigates the effects of various organizational antecedents on project performance through team learning in project teams such as new product development teams (Sarin and McDermott, 2003; Tatikonda and Montoya-Weiss, 2001), information technology development and implementation project teams (Lee and Choi, 2003; Sabherwal et al., 2006), and best practice or new technology implementing project teams in hospitals (Edmondson et al., 2003; Tucker et al., 2007). However, there is a paucity of such research on process improvement teams.

Operations management scholars have found that process improvement contributes to the competitive positions of organizations (Anand et al., 2009; Shah and Ward, 2003; Zu et al., 2008)

and recognize the importance of knowledge management in process improvement (Choo et al., 2007; Linderman et al., 2004, 2010; Molina et al., 2007; Lloréns-Montes and Molina, 2006). In spite of the importance of knowledge management within the firm (Sutton and Hargadon, 1996), few studies investigate the relationship between knowledge management and quality management, in general, and process management in particular (Choo et al., 2007; Zhang et al., 2008). This study empirically investigates learning and knowledge creation in Six Sigma process improvement projects. The results and findings are equally applicable to any process improvement environment.

Invented by Motorola, Inc. in 1986 as a metric for measuring defects and improving quality, Six Sigma evolved to a robust business improvement strategy that focuses an organization on customer requirements (Antony, 2004; Harry and Schroeder, 2000; Kumar et al., 2008; Schroeder et al., 2008). In Six Sigma, process improvement projects are identified, selected and prioritized based on strategic importance to the organization, and

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management commits resources for successful completion of the projects. Each project team is led by a project leader well trained in Six Sigma methodology, and the team carries out projects following a structured approach called DMAIC, which stands for Define, Measure, Analyze, Improve and Control (Linderman et al., 2006; Pande et al., 2000; Schroeder et al., 2008).

Our review of the quality management literature suggests that recent studies on process improvement teams focused only on the mechanisms of learning and knowledge creation (Anand et al., 2010; Mukherjee et al., 1998). Very few studies have focused on influencing variables and their effects on learning and knowledge creation (Gutiérrez et al., 2011; Linderman et al., 2010) and, in turn, project performance (Choo et al., 2007; Lloréns-Montes and Molina, 2006). This is surprising since scholars have noted technical and social components of quality/process management lead to learning and knowledge creation (Hackman and Wageman, 1995; Wruck and Jensen, 1994), and organizational factors, such as managerial actions, and contextual factors, such as team composition, task conditions, learning goals, leader behaviour and socialization, influence learning in teams (Cohen and Levinthal, 1990; Van den Bosch et al., 1999; Edmondson, 1999).

This study minimizes the gaps found in the literature by reporting an empirical investigation and understanding of the impact of two organizational antecedents, (1) Six Sigma resources (technical) and (2) team psychological safety (social condition or social process practised within the team), on project performance in Six Sigma project teams through team learning behaviour, as the implementation of Six Sigma requires both technical and process perspectives (McAdam and Lafferty 2004; Choo et al., 2007). By doing so, this study empirically supports the earlier research of Linderman et al. (2010) and Lloréns-Montes and Molina (2006), and extends the research by Choo et al. (2007).

The paper proposes an integrated model to explain process improvement implementation success through specific learning activities undertaken by Six Sigma project teams. Drawing on two streams of research, team learning and operations management, the model explains implementation success through two types of organizational learning: (1) *Knowing-what*, facilitating the project team to understand the current process and its input factors (process characterization) and (2) *Knowing-how*, helping the team identify how these factors affect the process outcome and generate optimal solutions by changing or modifying input factors for improved process outcome (process optimization).

The rest of the paper is organized as follows. Section 2 introduces Six Sigma resources, team psychological safety and the two learning mechanisms and develops three theoretical models and hypotheses. Section 3 presents research methods including data collection and measures development. Section 4 presents analysis and results. Section 5 includes a discussion about theoretical and managerial implications, opportunities for future research and limitations of the research followed by conclusion in Section 6.

## 2. Theory development and hypotheses

Research shows that team-learning activities mediate the relationship between team inputs, such as composition, structure and context, and team outputs, such as innovation, efficiency and quality (Edmondson et al., 2007). Scholars focus on learning activities in terms of learning behaviours or mechanisms adopted by the team members, and investigate how various organizational antecedents affect them. Table 1 displays recent studies with key findings, which reveal that team structures, such as team contexts and leader behaviour, and shared beliefs, such as team

psychological safety, shape team outcomes through learning behaviours of the team.

Two things need to be elaborated regarding these studies. First, the relationship between learning behaviours and performance is not always positive, as it depends on the nature of learning behaviour (Wong, 2004), and the current level of performance (Levinthal and March, 1993; March, 1991). It may be possible for a team to compromise performance by overemphasizing learning, particularly when they have been performing well (Bunderson and Sutcliffe, 2003). Furthermore, not all learning may translate into organizational knowledge, as members may fail to communicate with others for use (Ancona and Caldwell, 1992). Thus, “organizational knowing” does not always translate into “organizational doing” (Pfeffer and Sutton, 2000; Maier et al., 2001). For the purpose of this paper, however, we take the position of many recent studies that learning results in improved performance (Edmondson, 1999, 2002; Edmondson et al., 2003; Sarin and McDermott, 2003; Tucker et al., 2007; Choo et al., 2007). Learning is a process of improving organizational actions through better knowledge and understanding (Fiol and Lyles, 1985). Huber (1991) asserts that organization learns if any of its units acquires knowledge that it recognizes as potentially useful to the organization (Huber 1991, p. 89). Learning implies some kind of positive change in understanding, knowledge, ability/skill, process/routines, or systematic coordination that impacts performance (Edmondson et al., 2007). More specifically, problem solving heuristics used in quality improvement projects help teams use the knowledge collectively to identify and analyze opportunities to improve quality (Hackman and Wageman, 1995).

Secondly, the conceptualization and operationalization of measures of learning are not the same across all these studies (Table 1) and do not converge; therefore, theory building is problematic (Edmondson et al., 2007). On the one hand, similar measures are used to represent conceptually different things, such as learning (Zellmer-Bruhn and Gibson, 2006), innovation (Wong, 2004) and experimentation (Gibson and Vermeulen, 2003), and on the other hand, different conceptualizations such as group interaction processes (Van der Vogt and Bunderson, 2005), the extent to which a team creates new processes and practices (Zellmer-Bruhn and Gibson, 2006), respondent’s perceptions of their future learning behaviour in the team (Sarin and McDermott, 2003), team activities such as reflection on group processes and discussions with outsiders (Edmondson, 1999), and identifying best practices and discovering the underlying root causes to implement new processes (Tucker et al., 2007) are used to mean learning.

Six Sigma requires different treatment in comparison to other teams, such as new product development, hospital improvement and information technology implementation teams. Six Sigma project teams are temporary, formed to improve a specific process, and have short project duration (generally 3 to 6 months) (Antony et al., 2007a; Pande et al., 2000; Pyzdek, 2003). Except for the project leader, members contribute only a fraction of their work time. Therefore, social ties are not as close as in other project teams (Anand et al., 2010). Learning and knowledge transfer, therefore, is through specific practices used by the Six Sigma project team during the project such as DMAIC method, and project leaders’ knowledge-gathering behaviour in gathering individual knowledge and synthesizing into team-level knowledge to solve problems (Arumugam, 2011; Anand et al., 2010; Sarin and McDermott, 2003). Consequently, learning mechanisms, and the nature of social interaction such as psychological safety and its effects on learning mechanisms, show greater variance than that of other teams.

A psychologically safe atmosphere in a team makes a member feel safe for interpersonal risk taking without fear of negative

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