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Six Sigma Projects Work Teams: A Literature Review of the Factors Influencing Their Effectiveness

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Abstract: Six Sigma (SS) has evolved from a tool to eliminate defects in production, to being a strategic improvement methodology. The literature repeatedly indicates that a significant number of companies have not achieved their objectives and obtained the expected benefits from their SS projects; although the theory explains part of the problem of SS project management and the effectiveness of Work Teams (WT), it does not provide definitive answers for companies to achieve success, nor does it explain reasonable and objectively the factors that influence the effectiveness of the WT of SS projects. In this sense, it is important to identify the main factors influencing the implementation of SS in the manufacturing industry, as well as develop the theory explaining the achievement of manufacturing objectives by SS in industrial plants located in Ciudad Juárez, Chihuahua, Mexico.

Keywords: Six Sigma, Work Teams, Effectiveness Factors. Critical Success Factors

1. Introduction

Six sigma project management improves the quality of processes and products in the industry; however, literature reports repeatedly indicate that of the strategies that are implemented, a significant number of companies have not achieved their objectives and gain benefits from their SS projects (Kumar et al., 2008; Sony et al., 2019) since their theoretical contents explain part of the problem of SS project management and the effectiveness of work teams and what their actions imply, but it does not provide definitive answers, so that companies could execute more effective strategies in their projects and achieve success.

The aim of this article is to analyze literature through uses meta-analysis (MA) methodology to identify the main factors influencing the implementation of SS in the manufacturing industry. To achieve the proposed objective, this paper is organized as follows. Section 2 comprises the theoretical fundamentals, in Section 3 outlining the methodology approach, followed by the results and findings in Section 4. The final part of this research comprises a discussion and conclusion.

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2. Theoretical Fundamentals

2.1 Six Sigma

In the mid-1880s, the then CEO of the Motorola company, Bob Galvin, began the development of SS strategies that led to quality and increased profitability, with which he won the Malcolm Baldrige National Quality Award in 1988, which later made the company an icon in business, so it was later implemented in various companies in the world (Pyzdek, et al., 2010). Due to its flexibility, the application of the SS methodology in addition to manufacturing, has the possibility of expanding to other areas in the supply chain, including the provision of services.

Tjahjono et al., (2010), comment that SS is presented in different approaches; Goh and Xie, (2004) mention that the first approach corresponds to the adoption of statistical tools within quality management for process improvement. On the other hand, Chakrabarty and Tan, (2007) the second approach is the operational philosophy of management, which integrates shared benefits between customers, shareholders, employees, and suppliers, while the third approach is the organizational culture, which falls on the commitment of senior management to involve employees in the organization. Finally, for Bañuelas et al., (2005) the fourth approach deals with a well-structured continuous improvement methodology that reduces process variability and eliminates waste in the business process.

From the methodological perspective of Green, (2006), SS integrates five components of Total Quality Management, the focus on the consumer, employee involvement, continuous improvement, leadership, and decision making based on facts and data. Siddiqui et al., (2016), mention that the two main tools applied in the SS methodology are DMAIC (define, measure, analyze, improve and control) and DFSS (Design for Six Sigma); according to Erdoğan y Canatan, (2015) and Srinivasan et al., (2014) the first is used for the continuous improvement of process quality, and the second as mentioned by Kwak and Anbari, (2006), is applied for the development of new products.

The level of SS performance measures improves by applying a group of tools to statistically analyze data that reflects customer requirements. These tools measure with the main quality indicator that are the Parts Per Million (PPM) of opportunities as indicated by Mitra, (2004). Another indicator is the standard deviation, which shows the deviation from the statistical average (defect rate). According to Pande et al., (2004), SS has a specific goal of improvement, the term "Sigma" is used as a scale to measure quality levels, whose objective is to reduce defects to "almost zero" thus achieving an SS level; on the other hand, Pande et al., (2004) and Schroeder et al., (2008) mention that the statistical measure of variation "6σ" produces 3.4 defects per million opportunities according to the training program Motorola University Design for Manufacturing in 1988.

2.2. Critical Success Factors (CSF)

Several authors including O'Sullivan, (2008) contextualize the Critical Success Factors (CSF) as variables that lead to the success of the organization, while Suárez and Díaz, (2013) mention that they are a concept concerning the resource capabilities and competitive advantages that characterize an organization, which represent areas of interest for the managers of this, as a guide for decision making.

In the approach to project management, Milosevic and Patanakul, (2005) identify CSFs as characteristics, conditions, or variables that, if properly managed, significantly impact the success of the project. Among the benefits reported in the literature is support for management to determine those factors on which senior management should focus; ensures that these factors are carefully and continuously investigated; makes the manager obliged to develop good measures for these factors, as well as seek information on each of the measures, allows a clear definition of the relevant information of the organization, avoiding the costs of obtaining unnecessary information, among others.

Taner, (2013) states that the skills described through CSFs play an important role for the success of projects in the manufacturing industry, as well as in the application of related tools and techniques. For their part, Siddiqui et al., (2016) point out that there are numerous CSFs to ensure the achievement of SS execution, with a specific objective to achieve success; lack of CSF application can lead to wasted time, money, and effort.

2.3. Work Team

Work teams are one of the pillars of the Six Sigma methodology, acording to Lloréns-Montes and Molina, (2006). One of the fundamental elements within SS is teamwork. For Bañuelas and Antony, (2002) and Zu et al., (2009) the members of the collaborative work team have high knowledge and understanding of the methodology, techniques and tools of SS, in addition to possessing the appropriate leadership, effective and participatory communication in the team; With proper leadership, effective communication and team participation, the value of teamwork made up of cross-functional teams will create a sense of ownership, better communication, teamwork value and an overview of the organization.

Some relevant aspects of CSF to effectively apply the SS methodology are to involve all employees of the company (Pamfilie et al., 2012) as well as to consider their skills and training (Antony and Karaminas, 2016). The implementation of SS is achieved through specific roles within the organizational structure; that is, a level organization of professionals trained to use tools and apply techniques to solve problems and create opportunities for business (Gaikwad et al., 2016). Staff and organization are actively involved in the implementation of SS strategies; critical success factors manifest the challenges they face, so their study is necessary for theIR understanding.

It is worth mentioning that management of ss projects and the work teams for their deployment varies in the organizations, although the theory of CSF provides a starting point for leaders to determine which factors could have the greatest impact on teamwork and on the results of their organization.

3. Method

Research begins with a literature review of the factors influencing the project performance of SS to obtain a more generalized list of factors, followed by a Meta-Analysis. The methodology consists of six stages: 1) Defining the Research Question, 2) Location of Research Studies, 3) Criteria for item selection, 4) Identifying Studies, 5) Quality Assessment of Studies, 6) Summarization, mentioned by García et al., (2017) The CSF SS/LM literature is a review of publications from 2015 to this date, from EBSCO, Elsevier, Emerald, Springer, and Taylor & Francis. The relevant publishing was refined using the keywords like “Six Sigma”, “CSF”, “Effectiveness”, “Work Team”.

4. Results

This section presents the results of the investigation, the factors identified in the literature review. Which were classified into four categories: organizational factors (Table 1), administrative factors (Table 2), technical factors (Table 3) and factors related to the work team (Table 4).

Table 1. Organizational Factors

Factor	Authors
Management involvement	Ribeiro de Jesus et al. (2016), Lande et al. (2016), Antony et al. (2018), Pathiratne et al. (2018), Sreedharan et al. (2018)
Top management commitment	Lande et al. (2016), Mustafa and Jamaluddin (2017), Sreedharan et al. (2018), Shamsuzzaman et al. (2018), Antony et al. (2018) and Pathiratne et al. (2018)
Organizational infrastructure	Antony et al. (2018)
Cooperation, effective communication, and internal transmission.	Lande et al. (2016), Tortorella and Fetteramann (2017), Lande et al. (2016), Sreedharan et al. (2018), Shamsuzzaman et al. (2018), Pathiratne et al. (2018)
Infrastructure in information technologies.	Aboelmaged (2010), Sullivan (2011)
Monitoring of results.	Brady and Allen (2006), DeRuntz and Meier (2010), Bratic (2011), Talankar et al. (2014)
Safe environment.	Hilton et al., (2008), Ismyrlis and Moschidis (2013)
Innovative spirit in the company.	Taner, (2013), Ismyrlis and Moschidis (2013), Tabassum et al. (2016)
Management of cultural change.	Sharma et al. (2012), Lande et al. (2016), Taner (2013), Bañuelas Coronado y Antony (2002), Sreedharan et al. (2018), Pathiratne et al. (2018)

Table 2. Administrative Factors

Factor	Authors
Clear expectations of the SS project.	Anbari (2006), Alidrisi (2014)
Strategic planning.	Anbari (2006), Liu (2009), Azis and Osada (2010), Lande et al. (2016)
Prioritization and selection of the project.	Tlapa et al., (2016); (Zu, Robbins y Fredendall, 2010); (Ho, Chang y Wang, 2008); (Dileep y Rau, 2009); (Banuelas y Antony, 2002)
Selection, monitoring and reviews of SS projects.	Tlapa et al. (2014), Anand (2015), Lande et al. (2016)
Alignment of the SS project with organizational objectives.	Aboelmaged (2010), Talankar et al. (2014), Tlapa et al. (2014), Tabassum et al. (2016).
Linking SS to business strategy.	Talankar et al. (2014), Tlapa et al. (2014), Ribeiro de Jesus et al. (2016), Alidrisi (2014), Anand (2015), Tabassum et al. (2016), Tyagi et al., (2017), Zagloel et al. (2018)
Integrating SS with financial benefits.	Zu et al., (2010); Omar and Mustafa (2014), Talankar et al. (2014), Abderisak and Lindahl, (2015) Tyagi et al. (2017)
Financing of SS programs.	Heckl et al., (2010), Shah et al. (2018)
Linking SS to customers.	Sharma et al. (2012), Desai et al. (2012), Antony et al. (2009b), Antony et al. (2005), Lande et al. (2016), Kumar et al. (2009a), Taner (2013), Coronado and Antony (2002), Antony and Banuelas (2002), Yang et al. (2008), Laosirihongthong et al. (2006), Kumar (2007), Antony (2006), Antony and Fergusson (2004b), Manville et al. (2012), Yang (2010), Szeto y Tsang (2005)
Linking SS with suppliers.	Sharma et al. (2012), Desai et al. (2012), Antony et al. (2009b), Antony et al. (2005), Lande et al. (2016), Kumar et al. (2009a), Taner (2013), Coronado and Antony (2002), Antony and Banuelas (2002), Yang et al. (2008), Szeto and Tsang (2005) and Adebanjo et al. (2016)
Responsiveness to external influences.	DeRuntz and Meier (2010)
Linking SS to Human Resource Management.	Coronado and Antony (2002), Antony and Banuelas (2002), Yang et al. (2008), Henderson and Evans (2000), Yusof and Aspinwall (1999) and Khanna et al. (2011)
Performance Recognition Program.	Lande et al. (2016), Kumar et al. (2009), Yun and Chua (2002), Yang et al. (2008), Sanders and Hild (2000), McAdam et al. (2004) and Spanyi and Wurtzel (2003)
Approach based on short- and long-term objectives.	Antony and Banuelas, (2002). ratic (2011), Ismyrlis and Moschidis (2013),
Results approach.	Brady and Allen (2006), Talankar et al. (2014),
Investment of adequate resources.	Antony and Desai, (2009), Tang et al. (2006), Kwak and Anbari, (2006)
Process management.	Antony (2006), Zu et al. (2010), Alidrisi (2014), Mustafa and Jamaluddin (2017),
Periodic audits.	Antony (2004), Taner (2013), Tyagi et al. (2017)
Determine project performance through results reports.	Sahu and Padhy (2011), Alidrisi (2014), Omar and Mustafa (2014), Mustafa and Jamaluddin (2017)
Management of supports for the updating of project needs.	Alidrisi (2014), Talankar et al. (2014)
Documentation of success stories.	DeRuntz and Meier (2010), Ismyrlis and Moschidis (2013), Talankar et al. (2014), Tyagi et al. (2017)
Continuous staff assessment.	Tabassum et al. (2016)

Table 3. Technical Factors

Factor	Authors
Tools and techniques of the SS methodology.	Coronado and Antony (2002), Brady and Allen (2006), Anbari (2006), Aboelmaged (2010), Azis and Osada (2010), Sahu and Padhy (2011), Ismyrlis and Moschidis (2013), Tlapa et al. (2014), Alidrisi (2014) Tabassum et al. (2016), Mustafa and Jamaluddin (2017), Tyagi et al. (2017) Marzagao et al. (2016) and Antony et al. (2018)
System adaptable to the implementation of SS.	Brady and Allen (2006, DeRuntz and Meier (2010), Ismyrlis and Moschidis (2013), Talankar et al. (2014),
Structured procedure of SS.	Brady and Allen (2006), Zu et al. (2010), Talankar et al. (2014)
SS focused on metrics.	Zu et al. (2010), Omar and Mustafa (2014), Talankar et al. (2014)
Data analysis system and statistical methods	Brady and Allen (2006), Baba et al. (2011), Bratic (2011), Taner (2013), Ismyrlis and Moschidis (2013), Ismyrlis and Moschidis (2013), Talankar et al. (2014), Mustafa and Jamaluddin (2017)
Information management systems for decision making.	Zu et al. (2010), Ismyrlis and Moschidis (2013), Talankar et al. (2014), Tabassum et al. (2016),
Coordination with knowledge management and exchange systems.	Baba et al. (2011), Bratic (2011), Pinedo-Cuenca et al. (2012), Ismyrlis and Moschidis (2013), Talankar et al. (2014), Tabassum et al. (2016), Tyagi et al. (2017)
Uniform language and terminology	DeRuntz and Meier (2010), Ismyrlis and Moschidis (2013),
Industrial infrastructure.	Zagloel et al. (2018)
Product design.	Zu et al. (2010), Sharma et al. (2012), Ismyrlis and Moschidis (2013), Lande et al. (2016), Cheng (2007a) and Khanna et al. (2011)
Benchmarking.	Henderson and Evans (2000)

Table 4. Work Team Factors

Factor	**Authors**
SS Project Team Workforce Management.	Zu et al. (2010), Tabassum et al. (2016)
Training and continuous education of specialized cross-functional teams.	Antony (2004), Anbari (2006), Liu (2009), Pulakanam and Voges (2010), Brun (2011), Leong and Teh (2012), Chakraborty and Chuan (2013), Taner (2013), Omar and Mustafa (2014), Tlapa et al. (2014), Alidrisi (2014), Tabassum et al. (2016), Tyagi et al. (2017), Zagloel et al. (2018),
Selection of project leaders.	Anbari (2006), Azis and Osada (2010), Alidrisi (2014), Tlapa et al. (2014), Anand (2015), Tabassum et al. (2016), Tyagi et al. (2017), Zagloel et al. (2018)
Role structure of the SS methodology.	Zu et al. (2010)
Collaborative team.	Tlapa et al. (2016)
Teamwork.	Aboelmaged (2010), Pinedo-Cuenca et al. (2012), Leong and Teh (2012), Taner (2013), Sreedharan et al. (2018)
Participation and empowerment of the members of the SS work team.	Liu (2009), Taner (2013), Talankar et al. (2014), Tlapa et al. (2014), Tabassum et al. (2016), Tyagi et al. (2017), Zagloel et al. (2018)
Synergy between senior management and the SS team.	Azis and Osada (2010)
Executive leadership skills.	Azis and Osada (2010), Pinedo-Cuenca et al. (2012), Taner (2013), Raghunath and Jayathirtha (2013), Talankar et al. (2014), Tlapa et al. (2016), Gijo et al. (2014), Alidrisi (2014), Anand (2015), Tabassum et al. (2016), Tyagi et al. (2017), Zagloel et al. (2018)
Employee engagement.	Talankar et al. (2014), Tlapa et al. (2016), Tyagi et al. (2017), Zagloel et al. (2018).
Motivation of the workforce.	Tlapa et al. (2016) Alidrisi (2014), Tabassum et al. (2016), Villa, et al. (2016)

Factor	Authors
Project management skills.	Zu et al. (2010), Taner (2013), Raghunath and Jayathirtha (2013), Talankar et al. (2014), Alidrisi (2014), Tabassum et al. (2016), Mustafa and Jamaluddin (2017), Tyagi et al. (2017) Kumar et al. (2009a), Taner (2013), Banuelas et al. (2005), Coronado and Antony (2002), Antony and Banuelas (2002), Yang et al. (2008), Oakland and Tanner (2007), Marzagão and Carvalho, (2016), Szeto y Tsang, (2005)

4. Conclusions

In the literature review, 54 factors were identified, which it is not possible to precisely explain the influence of each one on the effectiveness of the project and the team that manages it.

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