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Relationship between Employee Education and Success of Six Sigma Implementation within the Automobile Industry in Europe

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Abstract

Due to increased competition and the constant need to improve operations, most companies have implemented continuous improvement programs, most notably Six Sigma. However, not all the SS initiatives have always been successful. It is widely accepted that employee education is required prior to and during successful SS implementation. According to Chakravorty, 2010, however, nearly 60% of all corporate Six Sigma initiatives fail due to diverse misconceptions and inaccurate deployments of educating employees. This paper intends to delineate and set out what practices corporations should implement in the education of employees prior and through deployment of Six Sigma initiatives. The study is conducted within the Automobile industry in Europe. The results identify which taxonomies of education are most significant for successful SS initiatives. The outcomes strongly suggest that vital key ingredients of employee education are how to use the essential DMAIC tools and comprehensive education of metrics (PPM and Sigma level) throughout the implementation of Six Sigma.

Keywords: Employee Education, Factor Analysis, Six Sigma, Success Factors, Survey

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1. Introduction

Any product might be vulnerable to rapid and constant attacks from competitors. This threat is a primary driver for the use of systematic corporate improvement, which is most often in the form of a Six Sigma initiative. However, all Six Sigma initiatives have not always been successful in meeting goals, and "…many of those companies have come away less than happy. Recent studies, for example, suggest that nearly 60% of all corporate Six Sigma initiatives fail" (Chakravorty, 2010).

The goal of this research focuses on finding links between education of employees and successful implementation within the automobile industry in Europe. This industry is a major employer and a major driver of the European economy. More specifically, it investigates what actions lead to success rather than directly proclaiming sources of failures.

Six Sigma is a statistical process methodology used to improve operations processes and to avoid negative process outcomes. It is universally accepted practice to prepare and conduct the right education of employees in order to achieve reliable and specific Six Sigma consequences. In the survey research, 69% of the participants indicated that they had obtained their Six Sigma education internally contrary to 31% who had received it externally.

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Finding and selecting the most appropriate Six Sigma education and certification for your Six Sigma agents can be a challenge. The right education is essential to enhance the improvement effort. Furthermore, employee education in the context of the Six Sigma objectives embraces both diverse forms of tools, behavior, and attitudes to change in such a way as to conduct new ways of working. "The key success factors of Six Sigma include both management and execution factors. Management factors comprise strategic planning and education training" (Liu, 2009).

The chronology of the study is as follows. First, the pertinent Six Sigma literature in context of employee`s education is reviewed. The research methods are discussed next and followed by the design of the sampling approach and data analysis. Finally, we present the findings that result from the data analysis. We utilize a longitudinal explorative mixed method (qualitative and quantitative) survey research design along with diverse statistical and explorative factor analysis.

2. Review of Literature

This literature review outlines the relevant research that has been conducted relating to Six Sigma implementations, measures of success, and educational practices. However, in the context of Six Sigma implementation, very few articles and academic findings exist regarding Six Sigma in the manufacturing domain "…the main field of application of the SS methodology is as expected the Chemical sector" (Cagnazzo & Taticchi, 2009).

Generally, "…the importance of Six Sigma and the cost of quality have not been understood as a very important analytical tool to drive continuous improvement in a prioritized manner." (Khanna, *et al.,* 2006). Furthermore, while some corporate managers claim that the, "…organisation of adopting Six Sigma does not justify its cost; they lack knowledge of Six Sigma or the internal capability to assess its potential value to their organization" (Raghunath & Jayathirtha, 2013).

2.1 Literature Review of the Employee's Education and SS Implementation

Prior to the Six Sigma improvement initiative, and throughout the stages of its deployment, education and orientation of team agents should be conducted. In addition, a straightforward role of change agents, champion training and an enhanced communication path among the workforce allows for clear expectation of desired outcomes. Accordingly, "…a communication plan is important in order to involve the personnel with the Six Sigma initiative by showing them how it works, how it is related to their jobs" (Banuelas Coronado & Antony, 2002).

Furthermore, Pande (2000 cited in Pepper & Spedding, 2010) asserts "…roles required for implementation must be specifically defined and made clear within the organization before embarking on the Six Sigma journey, so that everyone involved knows their responsibilities, exactly what needs to be done, and in what order. According to (Gijo, 2011; Godfrey, 2005) providing diminished training and extraneous content and diverse standard and certification impedes outcome expectation of initiatives and enhances the risk and inadequate execution of SS. Nonetheless "…the varied standard of training and certification offered by consultants (Gijo, 2011) is highlighted; however; conversely, it is argued that internal resource delivering training removes focus from delivering improvements and risks the quality of material delivered (Breyfogle, 2005)" (McLean, Antony & Dahlgaard, 2017).

Moreover, based on literature review, there exist some authentic technological, economic and organizational limitations of companies, which catalyzes the failure to deploy for Six Sigma outcomes. Some of these individual failure factors in the context of employee`s educations are invoked as follows:

1. Lack of employee knowledge about Six Sigma
2. Lack of appropriate education and training
3. Insufficient learning organization
4. Inappropriate or void in data collection
5. Fear of utilizing statistical tools

Accordingly, Liu (2009) asserts that, "…the key success factors of Six Sigma include both management and execution factors. Management factors comprise strategic planning and education training. On the other hand, the execution factor is comprised of project management." Breyfogle, 2005; Hariharan, 2006; Snee, 2010 postulate that "… a lack of training and education is identified as a major issue. It would be wrong to focus on training everyone rather than on achieving delivery of improvement" (McLean, Antony & Dahlgaard, 2017). However, Venkatesan, et al. (1996) claims that it "…would be wrong to provide generic training whilst making no attempt to change the mind set or beliefs of the participants" (McLean, Antony, & Dahlgaard, 2017).

To circumvent these issues and dilute the resistance to changes according to Liu, (2009), "…the company can establish the contents of training programmes according to its own requirements such as statistical methods and project management'; and 'The company holds training programmes about quality application". Furthermore, "…some companies that have succeeded in managing change have identified that the best way to tackle resistance to change is through increased and sustained communication, motivation and education" (Banuelas Coronado & Antony, 2002).

It is apparent that the high failure rates of Six Sigma implementation are due to inadequate and insufficient education and learning mainly through single-loop and double-loop learning, where most work outcomes were detection and correction of errors with limited ability to modify the existing norms and procedures. Hence, "… it would be wrong to provide generic training whilst making no attempt to change the mind set or beliefs of the participants" (McLean, Antony, & Dahlgaard, 2017). To encapsulate the relationship among the education and training of Six Sigma approaches and other theoretical viewpoints Narasimhan and Nair, 2015 (p.2), assert that education has direct relation with "Socio learning theory, Socio information processing, ethnomethodology, Decision process and administration theories, and institutional theory".

The research question pursues the following major objective:

- What are the relations and implications of education of employees and success of Six Sigma implementations?

3 Research Methods

The objectives and goals of the research consist of conceptualizing and determining which factors of education and training of SS team agents contributes most to the accomplishment of its deployments within the European Automobile Industry.

To minimize any error, to ensure reliability and to prevent research bias throughout the study, diverse forms of data collection were selected in the form of a survey, and structured and unstructured interviews. Between them, they support the analysis and assessment of the collected data.

3.1 Research Design and Methodology

Research design "…is plan that logically links the research questions with the evidence to be collected and analyzed in a case study, ultimately circumscribing the types of findings that can emerge" (Yin, 2014). There exist three main research approach typologies and features when it comes to conducting a study: exploratory, descriptive and explanatory. In line with existing theoretical research and emerging phenomena within the context of the source of the SS implementation failure, explorative research approaches use a mixed-method research design, perceived to be the most appropriate research setting and methodology for the current research.

- Exploratory: the purpose of this approach is to collect substantial knowledge and create a framework in order to shed light on a topic and make deductions concerning an emerging phenomenon, with the intention of generating a novel theoretical insight and hypotheses. This pathway is significant in situations in which the existing theory is incomplete, or in which the researcher is unable to pin down an adequate interpretation of the phenomenon under consideration.

The research is designed to test two levels of results. First, it tests the relationship between the factor of education and successful implementations. Once it is proven that education is a key factor, specific educational practices are evaluated to test which ones provide the most value for that success.

3.2 Sampling and Unit of Analysis

To enhance the reliability and effectiveness of data collection and its conclusions, and to prevent bias in the research design, a research survey involving 18 questions was formulated and designed. These 18 questions concerned various practices used as part of employee Six Sigma educations and training. The sampling strategy adopted in the research design was the Simple Random Sampling (SRS) method. In terms of a simple random sample: "…each unit has an equal chance of being in the sample. The selection of each unit is independent of the selection of every other unit. Selection of one unit does not affect the chances of any other unit" (Web.csulb.edu, 2019)

A well-developed pretest and pilot study questionnaire were designed to ensure the reliability and content formulation of both the quantitative and qualitative data gathered. In this research, the value of the Confidence Interval (CI) or margin of error was based on the 95% confidence level, and a population of 573 participants. The target unit of analysis for the present study is senior managers and engineers in Europe, who have been implementing or have implemented the SS methodology. Meanwhile, to enhance the accuracy, validation and analytic generalization of the interpretation of the findings, 260 automobile managers and engineers throughout Europe acted as the sample.

4. Findings and Data Analysis

The purpose of this research was to investigate and provide insight and highlight the source of success factors within the education and certification of SS employees construct. SPSS statistical analysis software was utilized for all statistical calculations, and the alpha was set at 0.05 levels.

The following research hypothesis is used to attempt to refute or confirm the research question:

- **Hypothesis 1 - H0:** There exists a significant effective relationship between the education of employees and Six Sigma implementation success.
- **Hypothesis 2 - H0:** There exists a significant effective relationship between specific aspects of education and the education of employees construct.

4.1 Demographic of Participants

The demographic data of the participants indicated that 4.2% were female and 95.8% were male, the majority of whom were from Germany, the UK and Sweden. 85.8% of the companies employed at least 250 employees. Additionally, 98.5% possessed some form of accreditation.

Furthermore, the additional information concerning the majority of the participants' current work titles indicated that they were quality managers, senior managers, and project leaders. The most prevalent Six Sigma belt levels in the participants' organizations were:

- Champion, Master BB, BB, and Green Belt;
- Master BB, BB, and Green Belt; and
- BB, Green Belt and Yellow Belt.

Generally, "…although the belt system offers a wide knowledge in six sigma initiative, it would not reinforce all the new knowledge and skills needed to sustain six sigma" (Banuelas Coronado & Antony, 2002).

- Sixty percent of the organizations involved implemented the Six Sigma program for nine years or more
- The most and the least profitable parts of the organizations involved were:

- Manufacturing 81%
- Purchasing 91%

- The average duration of the Six Sigma implementation was six months (23%)

- The average saving linked with the Six Sigma implementation (24%) ranged from €1,5 Million to €2 million

However, from the onset of this study, there were no demographic prerequisites concerning the gender, age, ethnicity, income, or work title of the participants.

4.2 Research Statistical Procedures

The quantitative and statistical procedures utilized in this research have been conducted through the design of surveys and coding for the purpose of conducting descriptive statistical analyses. These included frequency distribution, Cronbach's Alpha, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test, Correlation Matrix, and Explorative Factor Analysis,

The ensuing section intends to determine the primary causes and sources of the Six Sigma failure because of deficient or inappropriate education on the part of employees regarding the Six Sigma program.

An appropriate and sufficient education is essential to unfold the transformation adaption in the right direction. Furthermore, employee education in the context of the Six Sigma objectives embraces both diverse forms of tools and behavior, and attitudes to change in such a way as to conduct new ways of working. Six Sigma is in part a statistical process methodology, so it is significant to prepare and conduct the education of employees in order to achieve reliable and specific Six Sigma outcomes. In the survey research, 69% of the participants indicated that they had obtained their Six Sigma education internally as opposed to 31% who had received it externally.

The objective of the Cronbach's alpha test is to measure the internal consistency of the items in the questionnaire. The reliability test determines the peculiarities of measurement scales and the items that compose such scales. Furthermore, the model is grown on the average inter-item correlation. The alpha coefficient varies between 1 and 0. The higher the Cronbach's Alpha the greater the inter-correlations among test items.

Hence, multiple answers in the form of a Likert scale survey and questionnaire were performed. It is imperative to initially ascertain if the scale is reliable and that internal consistency exists among the items. Prior to hypothesis testing, it is essential to test for data consistency and data validation. The perceived value should be equal or higher than 0.7.

Kaiser-Meyer-Olkin (KMO) and Bartlett's test were employed to assess the appropriateness with regard to conducting factor analysis. The goal of the Kaiser-Meyer-Olkin (KMO) and Bartlett's test discloses the suitability of data for structure detection, or the measurement of sampling adequacy. High values near to 1.0 generally indicate that factor analysis may be effective as a means of defining and detecting the structure of the data. In circumstances in which the variable´s distribution occurs along the common factor, then the partial correlations should be small and the KMO ought to be nearly 1. If the value is less than 0.50, the utilization of factor analysis might not be appropriate.

4.3 Factor Analysis – Data Analysis

Factor analysis is a statistical approach applied to determine the variability among the observed and correlated values, with the purpose of reducing the number of unobserved values. "Therefore, factor analysis is applied as a data reduction or structure detection method" (Community.tibco.com, 2018).

The data reduction and analysis approaches strive to ascertain the correlations among multiple outcomes as the result of one or more uncorrelated variables, or factors.

Prior to the factor analysis, the KMO - Bartlett's test, which is a measure of sampling adequacy, was conducted to test the accuracy of the data. The KMO value revealed the value of $0.838 > 0.5$, which refers to the multivariate normality among variables. Consequently, the significance of the observed values of the KMO - Bartlett's test was less than 0.005. Factor analysis was accordingly performed.

Table 1 presents the chief findings of the statistical data analysis of research question and hypothesis 1. The table shows that education is correlated well with success and is a major factor in that success.

The second, and most important, research question and hypothesis looks into "what" approaches were employed and "why" these methods were conducted in successful implementations. The factor analysis looked into 17 components of Six Sigma education as detailed below.

The structure and components of factor analysis incorporated iterated principal axis factor with three factors and the method of extraction principal component analysis was utilized. Furthermore, as the rotation method, the Varimax with Kaiser Normalization with rotation performed in five iterations was performed.

The principal component analysis was used for data reduction and creates a composite score for subsequent analysis. Furthermore, this extraction approach the proportion of each variable's variance could be defined by the retained factor. Accordingly, variables with higher values are ably signified in the common factor, while variables with lower values are not well represented in (Table 2).

The screen plot in (Table 3) reveals the optimal number of components that account for the largest amount of variation compared to the other components. The eigenvalue of each element and component of the initial solution is plotted. The first two components exhibit to be on the steepest slope and contribute the most variation, and the others on the shallow slope contribute slightly to the solution. After those two factors, it could be deduced that the line is nearly flat,

Table 1. Summarize of statistical data analysis of research hypothesis 1

	Results
***Hypothesis 1*: There exists a significant effective relationship between the education of employees and Six Sigma implementation.**	
1. Cronbach's Alpha (Reliability Test)	0,862
2. Kaiser-Meyer-Olkin (KMO) and Bartlett's Test	0,838
3. Correlation Matrix	Correlation Coefficient
	$0 < r < 1$
3.1 Correlation Matrix of Are you suitably educated in the Six Sigma DMAIC Process:	
I know and have learned well, how to utilize the essential DMAIC Tools in my Six Sigma Implementation Goals	0.667
3.2 All Change Agents (managers and engineers) are well educated in the utility of DMAIC for Analysis and Problem Solving:	
All new Employees are educated in the utility of DMAIC for Analysis and Problem Solving	0.541
3.3 I have learned well how to utilize DMAIC Tools the Six Sigma Implementation:	
Are you suitably educated in the Six Sigma DMAIC process	0.667
My DMAIC Education meets my Needs for my Current Job	0.673
3.4 Six Sigma Employees Assess the Cost-of-Quality and Return- On- Investment:	
Six Sigma Employees are Learned Quality Management Standards	0.559
3.5 Six Sigma Employees are educated for Forming Communication Skills:	
Six Sigma Employees are Learned Implementing and Controlling of Projects	0.692
3.7 Six Sigma Employees are educated for utilizing Metrics (PPM and Sigma level) for Quality Improvement:	
Six Sigma Employees understand the Objectives and Function of Six Sigma	0.523
4. Factor Analysis:	
	EDUQ7: I know and have learned well, how to utilize the essential DMAIC Tools in my Six Sigma Implementation Goals
	EDUQ15: Six Sigma Employees are educated for utilizing Metrics (PPM and Sigma level) for Quality Improvement

Table 2. Total variance explained of variables influencing the education of Six Sigma employee

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5,655	33,262	33,262	5,655	33,262	33,262	3,296	19,388	19,388
2	1,808	10,634	43,896	1,808	10,634	43,896	3,195	18,795	38,183
3	1,421	8,362	52,258	1,421	8,362	52,258	2,393	14,075	52,258
4	1,204	7,084	59,342						
5	,963	5,662	65,004						
6	,850	5,002	70,006						
7	,762	4,485	74,491						
8	,647	3,805	78,297						
9	,607	3,573	81,870						
10	,522	3,071	84,941						
11	,510	2,998	87,939						
12	,459	2,702	90,641						
13	,410	2,412	93,053						
14	,369	2,169	95,221						
15	,334	1,964	97,185						
16	,257	1,510	98,695						
17	,222	1,305	100,000						

Extraction Method: Principal Component Analysis.

Table 3. Scree plot of variables influencing the education of Six Sigma employee

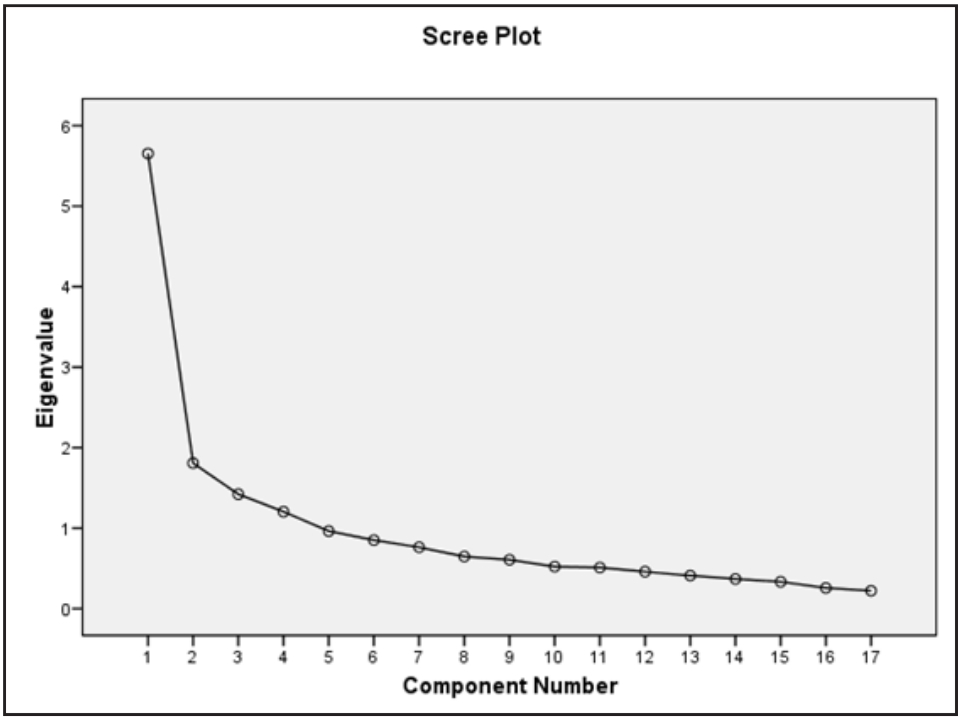

Table 4. Rotated component matrix of variables influencing the education Six Sigma employee

Rotated Component Matrix [a]

	Component		
	1	2	3
Where did you get your Six Sigma Education?			-,508
Mentoring and Education was provided to Employees of Six Sigma Belt System	,524		
Are you suitably educated in the Six Sigma DMAIC process?	,799		
Six Sigma Employees understand the Method and Philosophy of Six Sigma:	,534	,378	
All Change Agents (managers and engineers) are well educated in the utility of DMAIC for Analysis and Problem Solving	,306		,675
All new Employees are educated in the utility of DMAIC for Analysis and Problem Solving			,754
I know and have learned well, how to utilize the essential DMAIC Tools in my Six Sigma Implementation Goals	,859		
My DMAIC Education meets my Needs for my Current Job	,774		
Six Sigma Employees are educated for latest DMAIC Tools and Technology	,504	,494	
Six Sigma Employees understand the Content of Six Sigma well	,389	,573	
Six Sigma Employees Analysis the Cost-of-Quality and Return-On-Investment		,497	,372
Six Sigma Employees are Learned Quality Management Standards		,449	,532
Six Sigma Employees are educated for Developing Communication Skills		,394	,554
Six Sigma Employees are Learned Implementing and Controlling of Projects		,535	,446
Six Sigma Employees are educated for utilizing Metrics (PPM and Sigma level) for Quality Improvement		,762	
Six Sigma Employees are learned in Gauging and Auditing		,637	
Six Sigma Employees understand the Objectives and Function of Six Sigma		,706	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

suggesting the successive components accounting for slighter and slighter amounts of the total variance.

The last big descent enfolds between the second and third components, so utilizing the first two components would be the manageable and convenient opportunity as supplementary option. The rotated component metrix (table 4) highlight the two components from, the 17 tested.

Ultimately to summarize the data analysis of the research question and hypotheses:

- **Hypothesis 1:** There exists a significant effective relationship between the education of employees and Six Sigma implementation.

It could be concluded that a significant effective relationship exists between the education of employees and Six Sigma implementation.

- **Hypothesis 2:** There exists a significant effective relationship between specific aspects of education and the education of employees construct.

The following key elements greatly influence the educational performance and outcome expectations.

- **EDUQ7:** I know and have learned well how to use the essential DMAIC tools in my Six Sigma implementation goals;
- **EDUQ15:** Six Sigma employees are educated to use metrics (PPM and Sigma level) for quality improvement.

5. Conclusions

Our first conclusion is that education has a strong effect on the successful implementation of Six Sigma. However, as shown in our literature review, others have looked at this question and found similar results. The value of showing it again here is to prove it using a data set that can be used to operationalize the results and make valuable recommendations to those trying to accomplish this education goal.

To accomplish that goal of education, 17 items were included in our study. Two in particular were found to be most important. These were to make sure that all employees learned well how to use the essential DMAIC tools to accomplish Six Sigma implementation goals and to educate Six Sigma employees to use metrics (PPM and Sigma level) for quality improvement.

This has significance for the design of education programs used in conjunction with Six Sigma implementations. Emphasizing these two areas in those programs will maximize the chance of implementation success. Success in implementation improvement programs will increase the chance that these companies will continue to be profitable and contribute to the growth of the European economy.

6. References

Banuelas Coronado, R. and Antony, J. (2002). Critical success factors for the successful implementation of six sigma projects in organizations, The TQM Magazine. 14(2):92-99. https://doi.org/10.1108/09544780210416702.

Chakravorty, S. (2010). Where process-improvement projects go wrong, WSJ. Accessed 5 Jun. 2019. Available at: http://www.wsj.com/articles/SB10001424052748703298004574457471313938130.

Community.tibco.com. (2018). TIBCO Statistica® Factor Analysis TIBCO Community. Accessed 6 Jun. 2019. Available at: https://community.tibco.com/wiki/tibco-statistica-factor-analysis.

Khanna, V. K., Vrat, Prem., Shankar, Ravi and Sahay, B. S. (2006). Usage of quality tools in the Indian automobile sector, Journal of Management Research. 6(3):156-69.

Liu, C. (2009). Effect of ISO/TS 16949 on Six Sigma: The empirical case of Taiwanese automobile and related industries, Total Quality Management and Business Excellence. 20(11):1229-45. https://doi.org/10.1080/14783360903247502.

McLean, R., Antony, J. and Dahlgaard, J. (2017). Failure of continuous improvement initiatives in manufacturing environments: A systematic review of the evidence, Total Quality Management and Business Excellence. 28(3-4):219-37. https://doi.org/10.1080/14783363.2015.1063414.

Narasimhan, Ram and Nair, Annand (2015). Towards a theory-driven research agenda in six sigma quality innovation: Linking research opportunities with organization theory typology, International Journal of Quality Innovation. 1(5):1-25. https://doi.org/10.1186/s40887-015-0005-7.

Pepper, M. and Spedding, T. (2010). The evolution of lean Six Sigma, International Journal of Quality and Reliability Management. 27(2):138-55. https://doi.org/10.1108/02656711011014276.

Raghunath, A. and Jayathirtha, R. (2013). Assessment of the status of adoption of Six Sigma by auto components sector - Literature review, Journal of Business and Management. 8(4):12-15. https://doi.org/10.9790/487X-0841215.

Taticchi, P. and Cagnazzo, L. (2009). Six Sigma: A literature review analysis, Recent Advances in E-Activities, Information Security and Privacy. (1):29-34.

Web.csulb.edu. (2019). Sampling. Accessed 6 Jun. 2019. Available at: https://web.csulb.edu/~msaintg/ppa696/696sampl.htm#Simplerandomsample.

Yin, Robert K. (2014). Case study research (five). US: Sage.