Implementation of Lean Six Sigma in Textile Industry: A Systematic Literature Review

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Abstract

The textile industry keeps on growing over time. This development has led to increasingly fierce and fast competition in the industry. Challenges keep on increasing and the products quality must continue to improve so as not to lose to the competitors. One of the methods and strategies recommended to be used in the textile industry for increasing profits and improving efficiency is Lean Six Sigma. The research methodology used for this study was a systematic literature review. To conduct the research, the researcher has used 46 literatures that have been filtered and adapted to the research topic. From the research that has been done, the researchers found that Lean Six Sigma can be successfully applied by companies in the textile industry, especially those that have problems with a high defect rate. In order to increase the likelihood of a Lean Six Sigma implementation's success, it is imperative to pay attention to the critical success factors. Several of the most significant factors for the success are the top management commitment, sufficient training about Lean Six Sigma, enough funds, and the acceptance or adaptation of Lean Six Sigma in the company's culture. If successfully implemented, the company may get effects, such as increasing its product quality, reducing average damage or products defect, increasing the efficiency of the process, reducing, or saving costs in the processes of the company, and so on.

Keywords
Lean Six Sigma, Textile Industry, Systematic Literature Review, Critical Success Factors and Effects of Lean Six Sigma.

1. Introduction
Textiles are something important that crucial in human beings' everyday life, as we need it to fulfil our basic necessity for clothing and other things like fashion. (Narula & Desore, 2018; Madhav, Ahamad, Singh, & Mishra, 2018). As a result of the increasing population and the increasing use of textiles, the textile industry became one of the largest industries worldwide. (Ibrahim, 2019; Sivaram, Gopal, & Barik, 2019) . The industry even plays a vital role in the development of any nation, like in India where the textile industry is significant in the country`s economic growth. (Noreen, Shahid, Iqbal, & Nisar, 2017; Pattnaik, Dangayach, & Bhardwaj, 2018).
As time goes by, the challenges that the industry has to face keep increasing. Challenges such as providing sustainable growth with maintained quality of the textile, innovative design, reducing waste, competing in global market, and many more. (Ibrahim, 2019; Ku, Chien, & Ma, 2020; Filho, et al., 2019). So, in order to be able to compete with other competitor and face some of the challenges, the industry needed to implement a good strategy or methods. One of the methods that will be discussed in this paper is Lean Six Sigma (LSS) in textile industry.

1.1 Research Questions
1. How to implement Lean Six Sigma in textile industry?
2. What is needed for the successful implementation of Lean Six Sigma in the textile industry?
3. What is the effect of the implementation Lean Six Sigma in textile industry?

1.2 Objectives
Based on the above research problems, it can be concluded that the main aim of the research is to learn how to implement Lean Six Sigma in textile industry, increase the likelihood of successful implementation, and to study the effects of implementation.

2. Literature Review
Many journal articles in various databases discuss the use of Lean Six Sigma in multiple industries, including the healthcare industry, manufacture industry, financial industry, education industry, textile industry, and so on. (Singh & Rathi, 2019). This paper will focus on the implementation of Lean Six Sigma in textile industry. With the compiled analysis and conclusion of various literatures that related to the topic, the researcher hope that this research will help the textile industry on reducing waste and increasing its profit by using lean six sigma.

There are already many cases of when Lean Six Sigma is implemented by many industries and the industries or companies that implemented it, will get competitive advantage. (Madhani, 2022; Desai & Prajapati, 2017). As Lean Six Sigma has many effects on company in different industries, such as reducing waste, reducing defects, increasing profit, giving continuous quality improvement, improving services to the customers, improving employee satisfaction and many more. (Guerrero, Leavengood, Gutiérrez-Pulido, Fuentes-Talavera, & Silva-Guzmán, 2017; M, Ganesh, & Marathe, 2018; Ahmed, Manaf, & Islam, 2018). Also, this methodology can be used for small, medium, and large companies. (Alexander, Antony, & Rodgers, 2019; Stankalla, Koval, & Chromjakova, 2018).

Lean Six Sigma itself is a combination of Lean and Six Sigma, whereas Lean is widely used to improve the industry process through the reduction of waste and Six Sigma is used for process improvement. (Chugani, Kumar, Garza-Reyes, Rocha-Lona, & Upadhyay, 2017; Gupta, Meena, Dangayach, & Jain, 2017; Ajmera, Umarani, & Valase, 2017). The combination of the two methodologies will make Lean Six Sigma more complete when improving business processes and eliminating waste.

The wastes that Lean eliminated can be categorized into 7 types of waste. The Ohno's seven categories of wastes are overproduction (producing more than needed), queues (ineffective time used for the activity that add no value), transportation, excessive inventory, unnecessary motion, overprocessing, and defective product. (Heizer, Render, & Munson, 2015). The eliminate those wastes with Lean. Some of the Lean strategies that can be used are 5Ss, JIT, Kanban, Kaizen, TQM, SMED, TPM, VSM, Cellular Manufacturing, Lean Training, Zero Defect Concept, Lean Thinking. (Chahal & Narwal, 2017).

Six Sigma that is used to improving efficiency, profitability, and capability in the process has DMAIC (Define, Measure, Analyze, Improve, and Control) that is the formal Six Sigma Improvement Model. (Heizer, Render, & Munson, 2015; Ball, et al., 2010). There are many tools and techniques that can be used in Six Sigma. The basic DMAIC tools that can be used include flowcharts, check sheets, various diagrams, statistical process control (SPC), and so on. (Ferrin, Miller, & Muthler, 2005). There already many cases where Lean Six Sigma got used successfully in the field of textiles. For example, by using DMAIC methodology with appropriate tools, the textile company successfully reduces the changeover time by 37% on the first product line. (Adikorley, Rothenberg, & Guillory, 2017). Considering the facts of this case, researcher conclude that textile companies can apply Lean Six Sigma to their business processes in order to gain benefits for their company.

3. Methods

In conducting the research in this paper, the researcher used A Systematic Literature Review (SLR) method. Systematic Literature Reviews have contributed significantly to the development of the knowledge of many fields, like science, medicine, technology, business, and many other fields. (Durach, Kembro, & Wieland, 2017; Shafril, Samsuddin, & Samah, 2020).

Systematic Literature Review (SLR) is more than just a review of the prior literatures, but rather a distinct research endeavour in itself. (Thomé, Scavarda, & Scavarda, 2016). Usually, this method is used to enhance knowledge, bring an up-to-date information, summarize relevant papers, answer research or well-focused questions, test hypotheses, and also theories. (Tranfield, Denyer, & Smart, 2003; Cronin, Ryan, & Coughlan, 2008; Petticrew, & Roberts, 2006; Thomas, et al., 2019; Nightingale, 2009). This method has also the aim to identify the primary papers, extract, analyze, and also synthesize the required or related data to create the information needed for the paper. (Dinter, Tekinerdogan, & Catal, 2021).

Preparation of this paper involves the following steps: (Figure 1)
1. Decide, identify, and formulate the problem,
   The first step that needed to be done when making this paper are deciding, identifying, and formulating the problem. By doing that, researcher can decide the topic for the paper, research questions, and objectives. Knowing the problem will let the researcher know the next steps that need to be taken.
2. Search the literatures needed,
   The next step is to search for the necessary literature. The researcher will search the literatures that the year of publication range from 2016 to 2022 with Google Scholar. To make it easier to search the related literatures, the researchers will use some keywords, such as Lean Six Sigma, Textile Industry, Systematic Literature Review, Critical Success Factors, and Effects of Lean Six Sigma.
3. Gather the literatures needed,
   Gathering the literatures with related keywords at Google Scholar, as this database makes it easier for the researcher to search and access the relevant literatures. After that the researcher will skim the abstract and conclusion of the literatures to select the related and needed literatures.

4. Analyze and comprehend the literatures,
    After that, the researcher will analyze and comprehend the literatures to write a paper correctly and in accordance with the relevant literatures.
5. Compile, compose, and summarize the paper with the literatures,
    The next step is that the researcher will compile, compose, and summarize the paper with the literatures involved. By doing so, this paper will give the exact main points from the literatures that related to the topic.
6. Conclude the paper that solved the research questions.
    Lastly, the researcher will conclude the content of the paper that will answers the research questions.
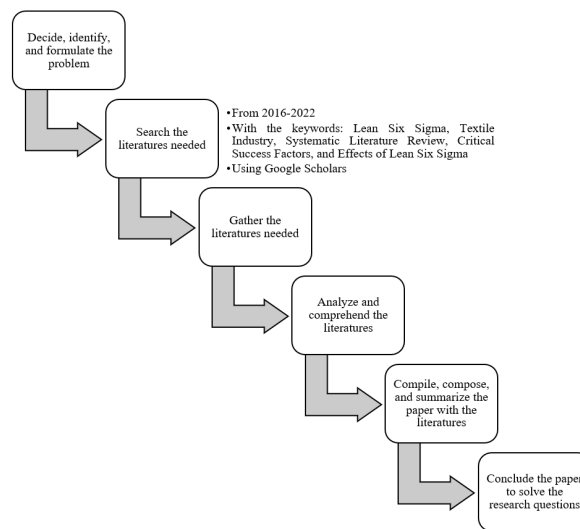

Figure 1. Six Steps That Will Be Used for Preparing the Paper
Source: Author (2022)

4. Data Collection

When doing the research in the "Implementation of Lean Six Sigma in The Supply Chain Management of The Textile Industry", the researcher used Google Scholar to access and search the literatures needed. The reason why the researcher used this database are because the researcher can easily find and access the literatures needed. Using these databases, the researcher can access not only journals but also books and many others to make the research more insightful.

For this research, the researcher already compiled 46 related literatures in total. These related literatures are used after many processes. First, the researcher read and comprehend the abstract then the literatures' conclusion to know that the literatures are related and needed for this research. After the selection, the researcher will analyze and comprehend the literatures to minimize the faults in comprehending the literatures and maximizing the use of other literatures purposes or goals in the paper.

The researcher compiled the related literatures and group them by the year of publication and literatures publishers. The bar chart for literatures according to the year of publication, as follows: (Figure 2)
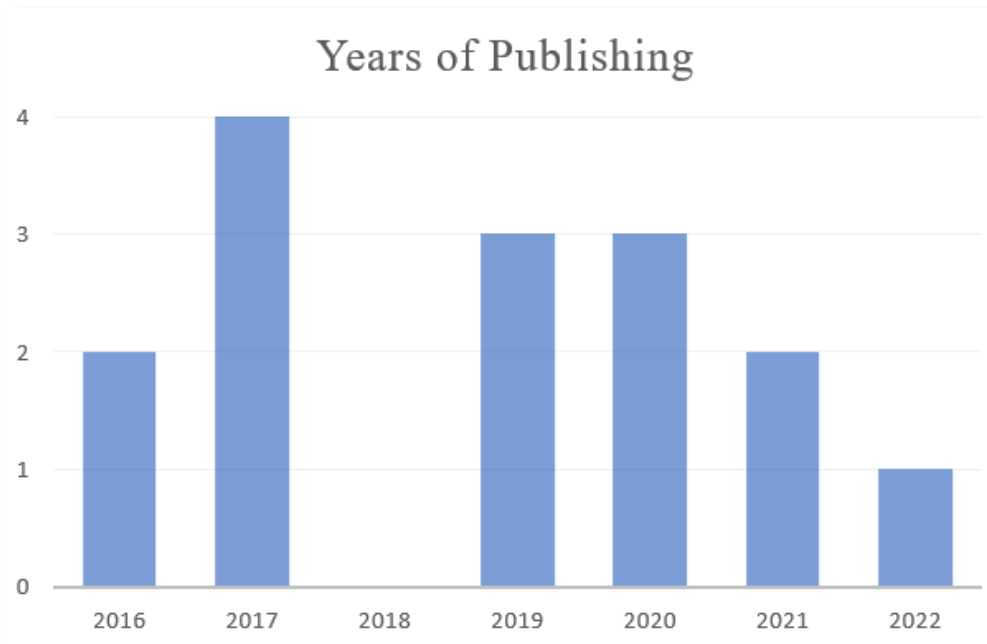
Figure 2. Classification of Related Literatures by The Years of Publishing

The bar chart for literatures according to the literatures databases origin, as follows: (Figure 3)
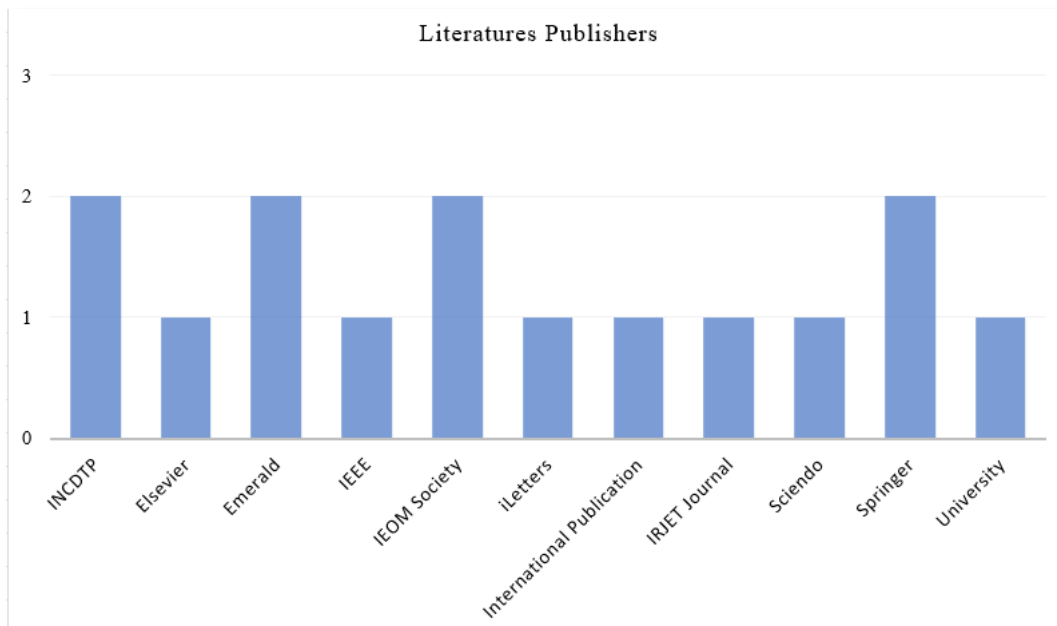

Figure 3. The Related Literatures Publishers

5. Results and Discussion

5.1 Implementation of Lean Six Sigma in The Textile Industry

The implementation of Lean Six Sigma is already implemented in various industry. In textile industry, the Lean Six Sigma is used in various process in the industry. (Table 1) From the literatures compiled the implementation of LSS in the textile industry have many types as each company have different products and processes when producing the products.

Table 1. The Findings of the Implementation Lean Six Sigma in Textile Industry

No	The articles' titles	Author name and year	Findings/Outcomes
1	"Minimization of defects in sewing section at Garment and Textile Factories through DMAIC methodology of Six Sigma, (Case: MAA Garment and Textile Factory)"	(Beyene, 2016)	The researcher uses DMAIC methods to minimize the defect percentage in the sewing process, as sewing process is one of the major processes in the textile and garment. The MAA-garment and textile factory also used Kaizen which is one of the Lean tools in its operations.
2	"Lean Six Sigma Application in The Textile Industry: A Case Study",	(Adikorley, Rothenberg, & Guillory, 2017)	The company implement the Lean Six Sigma projects in the process of changeover time of polypropylene/polyethylene terephthalate extruded fiber, control the contamination of bi-component fiber products, and the changeover of product and batch.
3	"Lean Six Sigma Implementation in Textile Industry"	(Ajmera, Umarani, & Valase, 2017)	The textile factory that created products like, T-shirt, Baba Suit, Kurta, and many others use the LSS with DMAIC method to reduce the defect in the final products.
4	"Application of Lean Six Sigma in SMEs That Produce Ethiopian Cultural Clothing"	(Nessibu, 2017)	The article shows that the implementation of Lean Six Sigma' DMAIC can be used by small and medium size Enterprises (SMEs). Using DMAIC, the author created the solution of the SME products (Ethiopian cultural clothing) that are not standardized, inability to deliver the products in time, and the customers dissatisfaction.
5	"Sustainable Practices in Textile Industry: Standards and Certificates"	(Amutha, 2017)	According to Kanti Jasani, the president of Performance and Technical Textile Consulting, Lean and Six Sigma concepts are essential for sustainable production processes.
6	"Improving Performance In Romanian Garment Industry By Using The Lean Six Sigma Methodology"	(Dinulescu & Dima, 2019)	The authors conducted research about applying the DMAIC process to provide pertinent proposals for the Romanian garment industry. The industry will utilize the Lean Six Sigma methodology to represent a data-driven approach for identifying the root causes of the problems and using DMAIC to coordinate the operating activities. Using LSS the authors found that there is an increase in the defection rate, then after the DMAIC process, authors created improvement proposals.
7	"A new lean Six Sigma hybrid method based on the combination of PDCA and the DMAIC to improve process performance: Application to clothing SME"	(Nedra, Nejib, Yassine, & Morched, 2019)	The SME in Tunisia has test implemented the new proposed Lean Six Sigma to improve the process performances indicators. The methodology is the combination of PDCA (Plan, Do, Check, and Act) and DMAIC.

8	"Exploring The Applications of Lean Manufacturing Practices in Textile Industry"	(Marri & Katri, 2020)	In the yarn manufacturing industry, Lean Six Sigma is a popular method of analysing defects and waste.
9	"A framework for lean manufacturing implementation in Indian textile industry"	(Prasad, Dhiyaneswari, Jamaan, Mythreyan, & Sutharsan, 2020)	In the textile supply chain, Lean design can be implemented. The process begins with spinning, dyeing, weaving, processing, and finishing with customer clothing. The industry is also possible to implement Six Sigma and Lean Six Sigma to create Lean speed and Six Sigma quality.
10	"Improving the Cutting Process Through Lean Manufacturing in a Peruvian Textile SME"	(Alanya, Dextre, Nuñez, Marcelo, & Alvarez, 2020)	The Peruvian Textile SME reduced reprocessing by default from 13.12% to 4.23%, reduced delayed processes from 18.49% to 9.61%, and increased the cutting area's productivity index from 0.38 to 1.16. This improvement is realized because of the application of Lean Manufacturing tools (VSM and SMED).
11	"Will Your Size Fit This Time? Finding Root Causes of Fit Variation In Manufacturing Denim Jeans"	(Hergeth, Khairnar, & Rothenberg, 2021)	The company used Lean Six Sigma tools to identify the causes for the fit variation in a denim jeans manufacturing process and how to solve the problem.
12	"Modeling Supply Chain Sustainability-Related Risks and Vulnerability: Insights from The Textile Sector Of Pakistan"	(Hashim, Nazam, Zia-ur-Rehman, Abrar, & Baig, 2022)	This study was done in the Pakistan textile industry to develop a risk mitigation model that mitigates sustainability-related risks and vulnerabilities in a textile manufacturing supply chain. To mitigate or prevent the excessive product waste, the authors conclude various practices or recommendation and one of them is to apply lean six sigma.

5.2 The critical success factors in the implementation of Lean Six Sigma in textile industry

In order to successfully implement Lean Six Sigma, there are critical success factors (CSFs), (Table 2) which are the key factors for the success of using the Lean Six Sigma in the process. There are many factors that are needed or critical for the success of the implementation of Lean Six Sigma in the textile industry. In the company that produces polyolefin and bi component fibre, some factors for the success are the support of the upper management and also in investing some money for the project. (Adikorley, Rothenberg, & Guillory, 2017). In other case study, management commitment, employee's knowledge on the implementation, and the acceptance of Lean Six Sigma in the company's culture were the most important factor for the implementation of Lean Six Sigma. (Nedra, Nejib, Yassine, & Morched, 2019).

From the research done by (Lande, Shrivastava, & Seth, 2016), they conclude that the five CSFs that have the highest occurrence frequency when implementing the Lean Six Sigma in small and medium enterprises are training, management involvement also commitment, customer contentment, leadership, and project prioritization and option or selection. The following is the CSFs table that has been sorted according to the frequency of occurrence in descending order:

Table 2. The Order of 22 Critical Success Factors in Accordance with The Frequency of Occurrence

No	Critical Success Factors
1	The training (Employees Involvement)
2	Management involvement and commitment
3	Customer contentment
4	Leadership
5	Project prioritization and option

6	Cultural change or adaptation
7	Understand LSS methodology
8	Strategic quality planning
9	Process management
10	Product design
11	Connecting LSS to customers
12	Connecting LSS to business strategy
13	Employees satisfaction or contentment
14	Employees reward
15	Inventory control or management
16	Communication
17	Connecting LSS to employees
18	Connecting LSS to suppliers
19	Employees relation or empowerment
20	Quality measurement system or quality data
21	Benchmarking
22	Role of quality department

Source: (Lande, Shrivastava, & Seth, 2016)

From the research done by (Yadav, Shankar, & Singh, 2021), they concluded stated that there are eighteen CSFs for Lean Six Sigma under Quality 4.0 framework. Out of those factors, seven were exclusive to the Quality 4.0 framework and eleven others could be applied without it.

Table 3. Eighteen Critical Success Factors for The Implementation of Lean Six Sigma

No	Critical Success Factors	Applicable With/Without Quality 4.0
1	Top Management Commitment	Without
2	Availability of Funds or Resources	Without
3	Training	Without
4	Employee Involvement	Without
5	High Volume and Low Variety Set-Up	Without
6	Project Management Skills	Without
7	Use the ERP System	With
8	Bar-Coded and/or RFID-Enabled Inventory Management	With
9	Feedback on processes and corrective actions based on data analysis	Without
10	Competent Employees	Without
11	Automation	With
12	Use of Data-Analysis and Prediction System	With
13	Utilization of Quality Management Systems in the Past	Without
14	Use of Line Balancing and Production Levelling Practices	Without
15	The use of software or applications with the ability to automatically adjust process settings based on process information	With
16	Change Management Culture	Without
17	Availability of real-time and accurate data	With
18	Utilization of a software or application for data processing	With

Source: (Yadav, Shankar, & Singh, 2021)

From those statements about the CSFs in the implementation of Lean Six Sigma, researcher can conclude that several most important CSFs are top management commitment, training about Lean Six Sigma, funds, and acceptance or adaptation of Lean Six Sigma in the company's culture. (Table 3)

5.3 The effects of the implementation Lean Six Sigma in textile industry
Lean Six Sigma provides a practical and systematic framework to identify a problem, propose a feasible solution, and make sure improvements are maintained. (Sodhi, Singh , & Singh , 2019). A Lean Six Sigma approach can be employed by textile and clothing companies for improving the quality of their goods and operations, reducing the number of errors and defects, and developing new products. (Dinulescu & Dima, 2019).

There are various effects in many cases in the implementation of Lean Six Sigma in the textile industry. In one company, the effect from the implementation is the process in the company become more efficient that they become more profitable and become more competitive in the competition. (Adikorley, Rothenberg, & Guillory, 2017). The other company, the company successfully reduce the defect created from the percentage of 8.25 to 2.63. (Ajmera, Umarani, & Valase, 2017). With this the company managed to reduce lead time of the productions and the cost for the products.

There is also the Peruvian Textile SME that has saved $105,448.39 which is equivalent to 17.81% of the total sales by implementing the Lean Manufacturing tools. After the implementation, the economy impact of the SME also reduced from $120,865.14 to $35,692.10. The increase in the productivity in the cutting and production makes the company have more effective processes. (Alanya, Dextre, Nuñez, Marcelo, & Alvarez, 2020).

From the article by (Nedra, Nejib, Yassine, & Morched, 2019), utilizing the Lean Six Sigma (LSS) methodology has proven that the proposed approach can be used to improve process performance effectively and efficiently. For instance, the sigma level was increased from 1.45 to 3.85. Furthermore, cycle time and lead time metrics have also improved. The denim jeans company used DMAIC methodology to reduce the fit variation of the denim jeans. Using the DMAIC, the company managed to introduce new testing protocol that will reduce the fit variation for men's waist of 23.1% and for women's waist of 12.5%. (Hergeth, Khairnar, & Rothenberg, 2021). This conclude that using the Lean Six Sigma tools with DMAIC has made the company achieved its goal.

6. Conclusion

Textile companies need to keep improving their quality and be more flexible to the changes in the market to compete and survive amid fierce and fast competition. Competitive advantages also somethings that are needed to be able to compete with other competitors. To solve the common problems in the textile industry, such as high defect rate, non-standardized products, delayed processes, and others. The company may use Lean Six Sigma.

The implementation of Lean Six Sigma in the textile industry varies from each company. The compiled literature indicates that many textile industry cases use the DMAIC methods of Lean Six Sigma to solve problems within the company. Lean Six Sigma is usually implemented in the textile industry during the production process. The purposes are usually to improve the production process performance and also to reduce waste of the production. In order to implement Lean Six Sigma successfully, some critical success factors are needed to be taken into consideration. Several most significant critical success factors are the top management commitment, training about Lean Six Sigma, sufficient funds, and acceptance or adaptation of Lean Six Sigma in the company's culture. If the company can implement the Lean Six Sigma in accordance with the critical success factors, then it can increase the success probability in the implementation. If the implementation Lean Six Sigma succeed, it may result in improved products quality, lowered defects rates, more efficient processes, cost savings, and others depending on the purpose of using Lean Six Sigma.

From the compiled literatures, the researcher concludes that the implementation of Lean Six Sigma in the textile industry is possible and bring many benefits if used correctly. The implementation of Lean Six Sigma will bring competitive advantages to textile companies that need to become more competitive in the marketplace. For the company who have problems, especially in the high defect rate of the products, can also try to implement Lean Six Sigma in the processes of the company.

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