Prosiding Seminar Nasional Mercu Buana Conference on Industrial Engineering
Vol. 3, Juni 2021, 1-10

Lean Six Sigma: Literature Review and Implementation for Textile and Textile Product (TTP) Industries

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Abstract

The Textile and Textile Product (TTP) industry starts from the preparation of fibers to become yarn rolls (Spinning Mills), fabrics (Weaving and Knitting), and Garments (Garments). There is a defect or productionprocess waste in the process, so it needs continuous analysis and improvement to produce high productivityand improve quality by applying the Lean Six Sigma (LSS) method. However, research in the textile industry does not all use LSS. Some companies still use other ways, for example, Plan-Do-Check-Action (PDCA) and Quality Control Seven tools. This literature review aims to collect systematically from several studies, especially in the TTP sector, and to explain in the existing literature and identify the segments that produce the most publications. This research work is obtained from Google Scholar, Elsevier, Science Direct, and other publications in the world. This paper is based on a study of 30 LSS Sigma articles published from 2013 to 2020 in the world's leading journals. Journal collection is based on the textile industry segment and based on the country of origin of the journal publisher and year of publication. This literature review shows that 46% of journals are from the Garment segment, 40% of journals are from Indonesia, and in 2019, most publications.

Keywords: Lean Six Sigma, DMAIC, Textile, and Product Textile, Garment Industries

1. Introduction

Six Sigma is a practical method for reducing costs, improving quality, and fostering continuous improvement in a product or process. Companies were looking to achieve higher levels of customer satisfaction and profitability (Radziwill 2014). Many manufacturing and service industries have used Lean Six Sigma in overcoming waste and defect problems in companies around the world, including the textile industry. The textile industry starts from fiber preparation to yarn (Spinning Mills), fabric manufacturing (Weaving and Knitting), and apparel (Garment). In the process stages, there are often defects or waste in the production process, so it needs continuous analysis and improvement so that productivity can be achieved according to company targets by using the application of the Lean Six Sigma method, which has been widely used by the manufacture and service industry. The textile industry is one of the main economic sectors, which has an essential role in everyday life. Six Sigma can be used to improve product quality (Imkrajang, 2016). All kinds of companies often experience quality problems, including. For example, PT XYZ frequently encounters defective cloth on the finished goods. To cope with that problem, the company should optimize quality control to minimize the number of faulty goodsand ensure the finished goods meet the company's quality standards (Shafira & Mansur, 2018).

Six Sigma has revolutionized the world of business and has offered a new measure of success in customer satisfaction and quality. For companies in the textile industry to compete with others and remain in the market, they had to improve quality and minimize their defects (Hayajneh et al., 2020). The lean tools are well suited for reducing and managing apparel manufacturing waste. In this paper, lean tools' effectiveness is substantiated systematically with various systems, such as

Value Stream Maps, SMED, JIT &, etc. (Mothilal & Prakash, 2019). The literature on LSS in small- and medium-sized businesses is limited (Adikorley et al., 2017). The literature on the use of LSS in the textile and apparel industry is even more limited. Six Sigma is a quality control method that aims to minimize defective products to the lowest point or achieve operational performance with a sigma value of 6, yielding 3.4 defective products of 1 million products (Kurniawan & Prestianto, 2020). Green Manufacturing has to be implemented to focus the attention on the environmental impact and resource consumption and time, cost, and quality (Erdil, 2019). Controlling the quality of raw materials and controlling the quality of the process harms the number of defective products and quality (Cost of Quality) (Sihombing & Sumartini, 2017).

The quantity of faulty products has a positive effect on the cost of quality, and no specific statistical data is not found about the implementation of Six Sigma in the Indian Textile Industry; only a few are found about the scope of implementing Six Sigma in the Indian Textile Industry, (Bharath et al., 2017). Apprehensive of this issue, this work walks around using the DMAIC methodology of Six Sigma to lessen the defect rate in the sewing section of FCI (BD) LTD. Throughout the five phasesof DMAIC methodology, Define, Measure, Analyze, Improve, and Control, this approach minimizes defects analytics (Zaman & Zerin, 2017). Cause-effect diagram and Failure mood and effect analysis (FMEA) is applied to get the root causes of the problems and prioritize severe risks. Considering all information and condition of the production system, feasible solutions are proposed to improve the design and maintain the development (Dey et al., 2020). The analytical findings show that the application of total quality management programs, tools, and techniques of the Six Sigma DMAIC approach has been expanded beyond the traditional quality concepts and has im- proved process performance by 57.96% (Ahmmed & Ayele, 2020). The DMAIC technique of SIX SIGMA had been employed to reduce these defects (Khan et al., 2020).

2. Method

This paper's purpose of exploring more deeply the implementation of Lean Six Sigma in the TTP industry. Learn to search and find several journals starting from the nearest year until 2013 in all international publications. Studies carried out by men notice databases famed, including Google Scholar, Elsevier, Science Direct, and another publisher. The keyword in the search for the paper used is "Lean Six Sigma in Textile, and Textile Products or Garments Industries." For this paper to be explicitly structured, clearly, and with direction, it is necessary to carry out the following stages. First, this paper's purpose of elaborating on knowledge about the value of Lean Six Sigma in the TTP industry, consider Lean Six Sigma as an organizational strategy and search for ways to get more insight into Lean Six Sigma.

In doing a literature review, several steps must be executed so that systematic and directed implementation. The first step is to formulate the problem. In this stage, the writer is required to choose a topic that matches the issue taken. Questions must be written entirely and accurately. Then the second step is looking for literature and journals. At this stage, the writer looks for literature relevant to the research and then looks for an overview of the research topic. After that, review according to topic based on research sources. The third step is to evaluate or identify the literature. Search results are sorted as case studies or industry focus theory, focus number ofdistribution by country, focus year of publication, and several publishers. The data collected, analyzed and the results are presented in graphical form. At this stage, look for the similarities and inequalities of the literature obtained. Then compare from various perspectives, then make a summary (summarize). The fourth step concludes the identification of all the literature obtained. The last stage is publishing in national and international journals. More details can be seen in Figure 1.

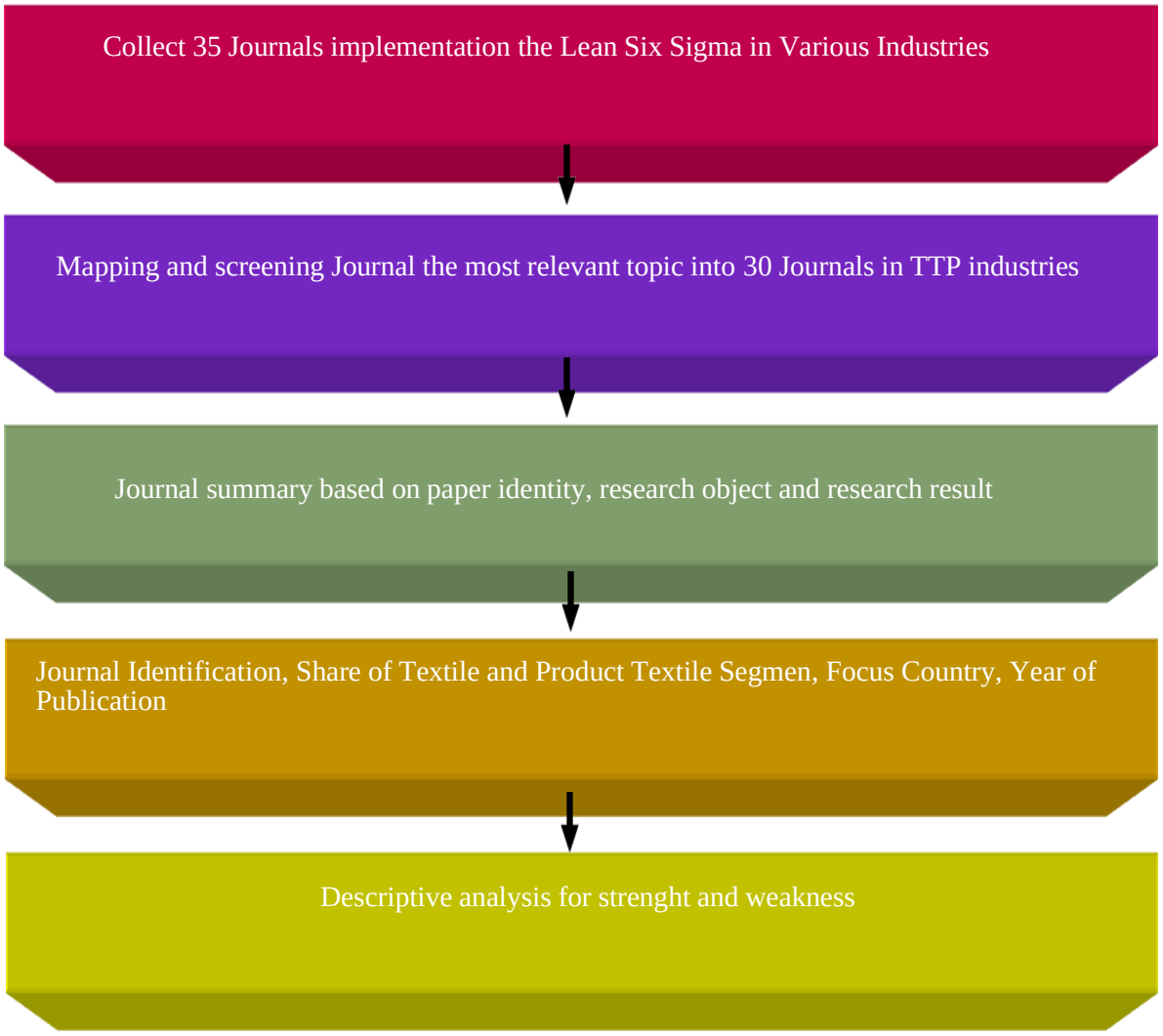

Figure 1. Study Framework

In the first step, the researcher collected 35 journals related to the Lean Six Sigma method. They were selected into 30 journals because five other journals were not associated with the research theme, namely two journals about the literature review and three more journals related to Lean Six Sigma outside the Textile and Textile Product or Garment sector. The researcher decided five journals were not included in this study. Therefore, this paper identifies 30 journals related to the implementation of Lean Six Sigma in the TTP industry. The selected journals or articles will be analyzed. The analysis was carried out based on the researcher and year, research object, and research results.

3. Result and Discussion

3.1. Journal Summary

The collection of journals that have been obtained according to the Textile and Textile Product or Garment industry can be seen in Table 1.

Table 1. Existing Literature Review of the Lean Six Sigma in TTP Industries

No	Paper Identity	Research object	Result
1	(Kurniawan & Prestianto, 2020)	Minimize defective product on baby clothes	Sigma value of 4.14 meaning a possible defect product of 4033.39 opportunities per million products
2	(Dey et al., 2020)	Improve the system and maintain the development	This probabilistic approach provides a reliable sigma level estimated at 3.12.
3	(Ahmmed & Ayele, 2020)	Defect reduction for Ethiopian cotton	Process performance by 57.96% and decreased the percentage of defects generated in the ring-spinning, roving frame, draw frame, carding sliver, and blow room
4	(Khan et al., 2020)	Reduce their cost of production	The sigma level had also represented a sharp increase; with considerably shifted from 2.78 to 2.91
5	(Hayajneh et al., 2020)	To reduce production defects in textile manufacturing	The application of the Six Sigma methodology resulted in a reduction in the overall quality level from 7.7 % to 2%
6	(Fithri, 2019)	Fabrics quality control of the textile industry	The Defect per Million Opportunity value obtained was 181.67, and the Sigma value was 5.07
7	(Yame & Ali, 2019)	Optimization performance characteristics	Using these methods, the development of the current and future state value stream map will be completed.
8	(Dinulescu & Dima, 2019)	Improvement the production process of the Garment	The fabric has 2.88 sigmas for the moment, with a value for the defects per million opportunities (DPMO) of 84.476.
9	(Erdil, 2019)	The development of quality management in the textiles industry	Assessed on the framework of quality, robust and environment-oriented production such as green production
10	(Lajoie et al., 2019)	Resolve potential issues related to process variability in the textile industry	Framework in three steps, which includes the definition and the characterization of the industrial process, predictive modeling, and prescriptive analytics
11	(Nørup et al., 2019)	Improved reuse and recycling.	Average of 14 ± 3.9% and 16 ± 8.7% of the Clothing and Household textiles in small combustibles
12	(Ahmed, 2019)	Reducing cost and increasing productivity	Sigma level is 2.9562 with DPMO is 72,660

No	Paper Identity	Research object	Result
13	(Mothilal & Prakash, 2019)	Increasing quality levels at the lowest possible cut-rate demand the apparel manufacturing	The effectiveness of lean tools is substantiated systematically with the help of various systems, such as Value Stream Maps, SMED, JIT &, etc
14	(Abbes et al., 2018)	Improve the quality of products	The new set of this optimum combination was applied to lay carriage and yields to improve Sigma from 0.7 to 2 and Cp from 0.2 to 1.47.
15	(Shafira & Mansur, 2018b)	Production quality improvement analysis of grey cambric	Based on the measurement obtained average sigma value is 3.32. The sigma value is included in the sigma 3, and it will cause losses of 25-40% of sales.
16	(Roesmasari et al., 2018)	Quality improvement in leather Garment	Open grain with a value of 576 and the second highest RPN value of 448 for fish eye defects. The type of cracking defect also has an RPN value of 448
17	(Bakar et al., 2017)	Increase fabric productivity	Input from the average index value of productivity, materials (98.85%), and energy (95.11%)
18	(Sihombing & Sumartini, 2017)	Defective product quantity in textiles	Defective products as well as on the cost of quality (Cost of Quality) while the quantity of faulty products has a positive effect on the cost of quality
19	(Nurprihatin et al., 2017)	Reduction of waste in the Garment	The values of Defect per Million Opportunities (DPMO) and Sigma are 2150 and 4.36 sigma
20	(Syafwiratama et al., 2017)	Reducing the nonconforming product a polyester short cut fiber	Reduce 77.4 percent over the length and process capabilities increase from 2.2 sigmas to 3.1 sigma.
21	(Adikorley et al., 2017)	To explore Lean Six Sigma (LSS) project and program success in the textile and apparel industry	The reduction in increased sigma level to 3.74. Contamination was reduced on the third line resulting in a 4.32 sigma level
22	(Bharath et al., 2017)	Minimize the occurrences of rework, and eliminate time in the textile industry	The total defective percentage was 5.66 %, and it can be reduced to 3 % by implementing the remedial actions

No	Paper Identity	Research object	Result
23	(Zaman & Zerin, 2017)	Reduce production cost as well as improve the quality.	In the past, the sigma level was 2.69. After Improve phase, it has been upgraded to 2.8
24	(Imkrajang & Chansiri, 2016)	Improvement to be significant causes of defects in the weaving process	Warp beam at 101 cm, 5 cm. height of backrest roller, and 13.3 cm. height of harness frames
25	(Pratiwi et al., 2016)	Increase quality grey fabrics	The DPMO value is 20.028 and is at the 3.57 sigma level.
26	(Wardana et al., 2015)	Quality improvement in Garment	Sigma value after corrective action implementation 3,31σ
27	(Alkatiri et al., 2015)	Reduce loss product grey fabric textiles	Value average DPMO and sigma value after implementation amount is 4.753,80 and 4,09 Sigma
28	(Hamdi et al., 2015)	Improvement delivery delays to the customer in the apparel industry	The workshop's average completion rate is ten orders/day, then the lead time to accomplish 55 orders will be five days and a half.
29	(Mukhopadhyay, 2015)	Reduction of yarn packing defect	The bottom line benefit in monetary terms was estimated to be about Rs. 87,000 per month.
30	(Saragih et al., 2013)	Reduce waste in the production process of Underwear Rider R333B	Defect Per Million Opportunities before implementation is as big as 4.732, and after implementation is as big as 2.373. Process Cycle Efficiency increase from 28,55 % become 31,87 %. Lead Time Process decrease from 5,092 become 3,823.

3.2. Journal Identification

The identification of literature will be identified from various perspectives. The perspective includes the focus of TTP segmentation, the direction of the number of distribution by country, and the focus of the year of publication. For example, figure 2 informed that Lean Six Sigma is more widely implemented in the Garment segment (46%) and weaving segment (27%). More details can be seen in Figure 2.

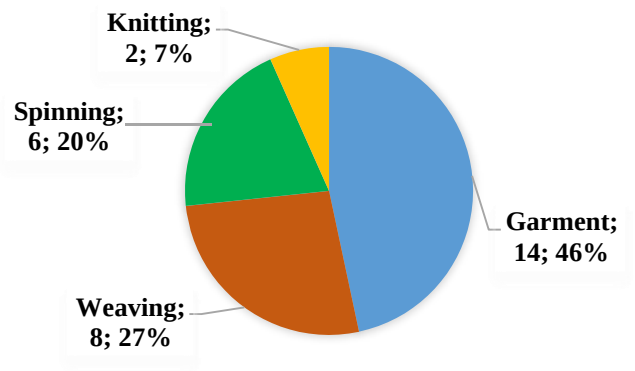

Figure 2. The Focus of TTP Segmentation

Figure 3 analyzes the distribution of Lean Six Sigma publications in TTP manufacturing companies. In Indonesia is the most frequently implemented Lean Six Sigma. In this case, Lean Six Sigma neglects especially in developed and developing countries. Growth in Indonesia is in the figure of 40 % from the total publisher, which is the projected increase in the economy's complexity. Reports have indicated that Indonesia has many opportunities that have not been utilized in the TPT industries and encourage growth and fieldwork creation. More details can be seen in Figure 3.

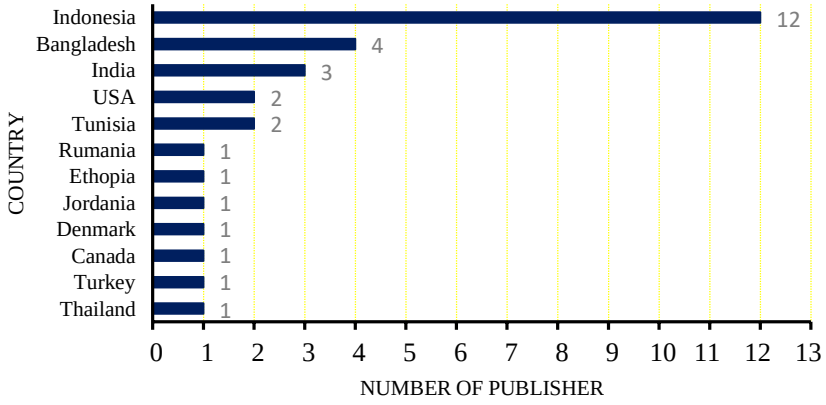

Figure 3. The focus of distribution by country

Figure 4 shows that 2019 is the year of publication most frequently searched during the 2013-2020 period of 8 articles. This is evident in identifying the journal. For several years, almost every year, many journals have entered international publications. More details can be seen in Figure 4.

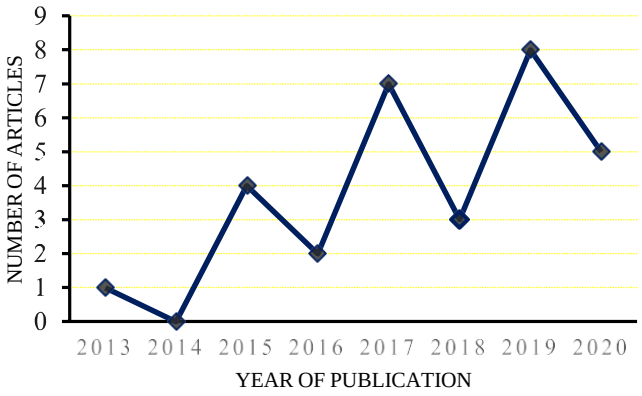

Figure 4. The Focus of Year of Publication

3.3. Strength Analysis

The authors found the strengths of all the journals that have been analyzed, namely:

a) Actual journal, and complete from abstract, introduction, literature review, methodology, results & discussion, and conclusion.
b) Benefits for business people to apply Lean Six Sigma method to get poor results, reduced cycle times, reasonable costs, and minimum costs.
c) Provide new references for future researchers on implementing the Lean Six Sigma approach, especially the Textile and Textile Product industries.

3.4. Weakness Analysis

The authors also found several weaknesses, including:

a) The journal format is not well organized, making it difficult for the writer to identify the literature.
b) It takes systematic steps to get the best results and needs to be monitored regularly to implement Lean Six Sigma.
c) Researchers have many choices in solving problems. As a result, the Lean Six Sigma approach is neglected, especially in TTP industries.

3.5. Gap in Literature Review on LSS and Future Research Agenda

The authors have identified the gaps in the current literature on Lean Six Sigma in TTP and Garment industries. This gap has been grouped and prioritized as follows. First, there has been a gap between researchers' research in the knitting and Garment section of the study using the LSS method. There is very little research in the knitting section because there are very few knitting factories in Indonesia. Meanwhile, in the Garment section, a lot of research has been done using the LSS method. The researcher will then continue the literature review on the theme of industry 4.0 because the government is also promoting the implementation of industry 4.0 in the TTP or Garment section and other sectors such as food and beverage, automotive, chemical, and electronics. In future research, the textile industry 4.0 can provide a guide that makes easier, faster, more reliable, and satisfied decisions with data to improve processes. For more details, can be seen Figure 5.

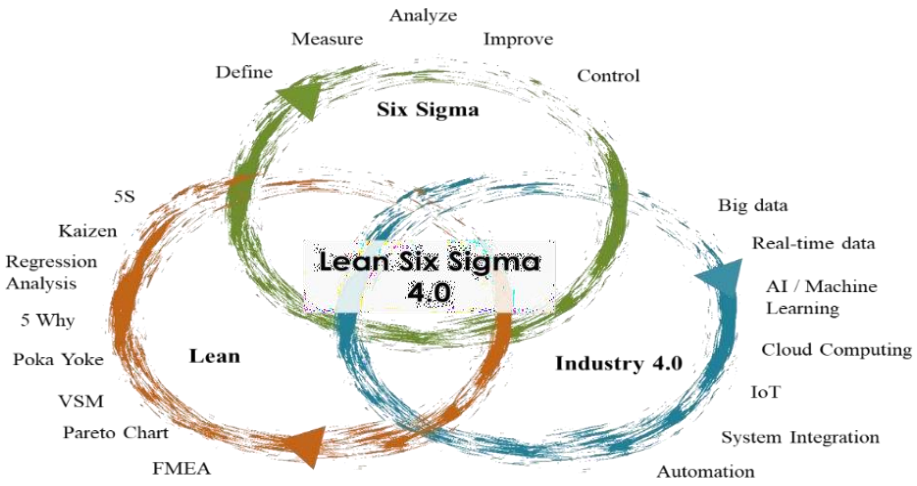

Figure 4. Future Research Framework

4. Conclusion

After conducting a review of the studies from 30 selected journals, this research can be concluded: (a) It was found that Lean Six Sigma (LSS) is more widely implemented in the Garment segment (46%). This is in line with the growth trend of the one sector. The LSS method is also familiar in

various kinds of industries in Indonesia. This method is widely used in continuous improvement, especially in the Garment segment, (b) From publications in the world, the country of Indonesia has the most published papers related to TTP and Garments by 40%, meaning that thereare also quite a lot of researchers in Indonesia who are interested in research in the field of TTP and Garment. (c) Based on the publication year taken during the period 2013-2020, 2019 was theyear that saw eight articles published, which is evident in the identification of journals. For several years, many journals have entered national publications, (d) This paper references to research to help facilitate the expected journal references and develop a plan for future research and the timeline and readership of Six Sigma research subjects.

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