



From 1904 to 2022: A Comprehensive Review of Six Sigma Methodology

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Abstract. Literature Review is a collection of various research journals using the Six Sigma method to improve product quality, whose data is taken from Scopus and includes as many as 2,000 documents dating from 1904 to 2022. The purpose of the literature using the database from Scopus is to provide accurate development information about the metadata in each individual scientific article and provide an overview of the use of Six Sigma methods to improve product quality. The method used is bibliometric analysis with the Six Sigma concept through the Scopus database. The results of the data from Scopus are in the form of data analysis on the use of the Six Sigma method. The results of bibliometric analysis based on subject areas are: engineering with 5113 documents (21.4%), other (18.4%), and business, management, and accounting (11.9%). The development of publications on the topic of Six Sigma was significant in 2011 with 703 documents, then in 2020 with 730 documents, and in 2021 with 760 documents. Further research on Six Sigma needs to be conducted in Chemical engineering (3%), followed by Biochemistry (4.2%) and Medicine (5.6%) to deepen the role of Six Sigma in these sectors. Then, further research also needs to consider the location of the research to find out the development of the role of Six Sigma in existing countries. This research also concluded that the Six Sigma method plays an important role in improving product quality, especially in the engineering and manufacturing fields.

Keywords: Literature Review · Six Sigma · Product Quality

1 Introduction

Quality is the main target when making a product. At this time, businesspeople in the industry in Indonesia are aware of the changing orientation of their customers towards quality. Quality is a product that can be interpreted as the degree or level to which the product or service is able to satisfy the desires of consumers (fitness for use). Better product quality refers to an improved ability to perform its function, such as durability, reliability, and outcome accuracy [1]. Thus, quality is a basic factor in consumer decisions to produce a product because consumers decide to buy a product from a certain company that is of higher quality than its competitors [2]. In the increasingly fierce competition in the industrial world, companies must be able to survive and compete with similar

companies. Therefore, the company must be able to fulfill customer desires and try to retain customers.

Understanding quality is very important in the development of company activities because the growth of a company is largely determined by the quality of the products or services produced. Indifference to quality will lead to a loss of product sales opportunities and market share, which ultimately results in a decrease in company activity and growth. Quality control is one of the techniques that needs to be used starting from before the production process runs, during the production process, and until the production process ends by producing the final product. Quality control is carried out in order to produce products in the form of goods or services that are in accordance with the desired and planned standards, as well as improve the quality of products that are not in accordance with predetermined standards and, as much as possible, maintain the appropriate quality. The main objective of quality control is to obtain assurance that the quality of the product or service produced is in accordance with predetermined quality standards at the lowest possible cost [3]. Because the quality of goods that customers want determines customer satisfaction, quality assurance becomes a top priority guarantee that is used as a benchmark for the company's competitive advantage. To carry out quality control within a company, company management needs to determine how it will be carried out. This is because there are factors that will affect the good or bad quality of a product, which include, among others, several kinds of raw materials, labor, machinery, and the production equipment used. These factors will have a major influence on product quality. Based on the description above, it can be seen that the problem of quality control is important. Six sigma method is a data-based method used to minimize defective products. The Six Sigma method can help with quality control of the products produced by the company. Research in the field of quality control is very important in supporting companies' competitiveness with other companies' products; therefore, a more in-depth study is needed.

2 Methodology

The method used is bibliometric analysis with a six-sigma concept approach through the Scopus database. Scopus is the largest journal that includes abstracts and citations from peer-reviewed literature, namely scientific journals, books, and seminar proceedings. Scopus has also provided a scoring system to measure whether a scientific journal that has been created by the author has a significant impact or not. Therefore, articles that have been indexed by Scopus have a high reputation and credit value for lecturers. In addition, Scopus also provides aggregate data to show the level of influence of a journal (journal impact) or institution (institutional impact) in the world of scientific publications based on citation relationships to and from articles published by a journal or published by researchers from an institution. So Scopus users can easily get information about what has been published by publishers or research institutions from all over the world.

The core literature stored in the Scopus data center consists of articles in scientific journals, books, and conference proceedings. Data processing in this study was taken from Scopus using the keyword "Six Sigma." The data that has been taken is from 1904 to 2022 and comes from various countries around the world. This research uses Scopus to provide information about the use of the Six Sigma method to improve product quality.

3 Results and Discussion

Six sigma (σ) is a structured methodology for improving processes that is focused on reducing variations in processes while reducing defects in products by using statistical approaches and problem-solving tools intensively [4]. The benefits of implementing Six Sigma for each company. The company also has different benefits depending on the business it runs. This usually includes improvements in things such as cost reduction, productivity improvement, market share growth, cycle time reduction, customer satisfaction, defect reduction, work culture change, and product or service development.

Six sigma is a structured, fact-based method that involves the application of statistical methods in business processes to improve operational efficiency, which results in increased organizational value. Six Sigma as a measurement system uses Defect Per Million Opportunities (DPMO) as a measurement. In reality, it is very difficult to realize six sigma because the percentage that must be achieved is 99.99966% with a DPMO of 3.4.

There are several literature review results from various previous studies that use the Six Sigma method. The following is a comparison of the results of previous research, which is the main literature related to research (Table 1).

The following is the development that occurred in six sigma research. Figure 1 shows that the significant development of publications on the topic of Six Sigma began in 2011 with 703 documents. In the following year, there was a decrease in the number of publications, but in 2020, there was a significant increase of 730, and in 2021, there will be as many as 760 documents.

In Fig. 2, shows several countries that published on the topic of Six Sigma. The United States ranked highest by publishing articles totaling 4067 documents, India by publishing articles totaling 1198 documents, and the United Kingdom by publishing articles totaling 997 documents.

Based on the author, which is found in Fig. 3, shows that Antony J has 198 article documents, then Chen, K.S has 50 articles, Does, R.J.M.M, has 37 articles.

Table 1. Literature review of previous research.

No	Author	Title	Research Objective	Method	Results
1	Tambunan et al., 2018 [4]	Analysis of quality control with the six sigma method in an effort to reduce defects in the suitcase production process at PT. SRG.	To determine the quality of products produced from the production process.	Field survey, Interview, Six Sigma method.	There are 4 types of defects in the fabric luggage production process in the period January to March 2018.

(continued)

Table 1. (continued)

No	Author	Title	Research Objective	Method	Results
2	Harahap et al., 2018 [5]	Quality Control Analysis Using the Six Sigma Method at PT. Growth Sumatra Industry)	Knowing the factors that cause the high level of product defects at PT Growth Sumatra Industry, describing and analyzing the results of implementing the six sigma method on the level of product defects at PT Growth Sumatra Industry and providing suggestions for improvement and quality control to reduce the number of product defects at PT Growth Sumatra Industry.	Field survey and using the six sigma method.	The six sigma approach in this study can be concluded that there are 3 causes of the highest product defects, namely ear defects, digestion defects, and cracking defects.
3	Kurniawan, 2019 [3]	Reduction of Defective Products with Six Sigma and Continuous Improvement Methods at PT. Cakra Guna Cipta	Obtain a decrease in clove cigarette defective products at PT Cakra Guna Cipta using the Six Sigma and Continuous Improvement methods, so as to produce truly high-quality products to increase sales of cigarette production (SKT).	Using the six sigma method using the DMAIC stage.	Based on the PDCA stage, the researcher suggested that the company provide operators with srapper tools to flatten the tobacco on the mori cloth, so that the density of cigarettes is obtained according to the specified standard.

(continued)

Table 1. (continued)

No	Author	Title	Research Objective	Method	Results
4	Dewi et al., 2003 [2]	Minimizing Product Defects with Six Sigma Concepts	To produce products with good quality and uniformity by minimizing variations that occur in the production process.	Using six sigma method with DMAIC approach, Pareto diagram, and cause and effect diagram.	From the research results, there is a decrease in DPM and an increase in the sigma value after using the sigma value concept application.
5	Siahaan et al., 2019 [6]	Quality Control with Six Sigma Method to Reduce Defects of Hub New td Bt1917 Products at PT. Braja Mukti Cakra	Determine the type and frequency of product defects, measure the DPMO value based on the resulting sigma level and analyze the causes of product defects with fish bone analysis.	Direct observation in the field, Interview, Six Sigma method.	There are 5 types of defects in the New TD Hub product in the Machining process, namely: Assy Surface, Outer Diameter, Inner Bering, Seat Thickness and PCD.
6	Anthony, 2017 [7]	Proposal to Reduce the Defect Rate of Steel Plate Products with the Six Sigma Method	To analyze the occurrence of product defects that occur in the slab & plate process using the six sigma method. The results are utilized to eliminate the causes of product defects.	Field survey and looking at historical data in the Plate Rolling Department from January to December 2016.	There are types of damage or product defects obtained in 2 places that are quite high, namely in the mill area and shearing & finishing area. It is in these products that there are many product defects.

(continued)

Table 1. (continued)

No	Author	Title	Research Objective	Method	Results
7	Wibowo & Alghifari, 2017 [8]	Implementation of the Six Sigma Method in Analyzing Glucose Product Defects at PT Budi Starch and Sweetener TBK Central Lampung	To determine the quality and percentage of defective products produced by the production process and to describe several types of defective glucose products.	Using the six sigma method with the DMAIC stage.	The sigma level of glucose production in jerry cans in September 2015 has not reached the six sigma level, because the production process has not yet reached zero defects, namely DE, color and Brix defects.
8	Krisnaningsih & Hadi, 2020 [9]	Strategy for Reducing Defective Products in Steel Structure Boiler Painting with the Six Sigma Method at PT. Cigading Habeam Center	To improve quality with the expectation that there are no defects or zero defects that are beneficial to the ideal condition of the company.	Using six sigma method with DMAIC Stages.	7 types of defects that occur in the painting of Boiler Steel Structure have been found. And the factors that cause painting defects due to human factors, methods, materials, and tools.
9	Laili, 2019 [10]	Quality Control Analysis with Six Sigma and Seven Tools Approach	To overcome the problems that occur in the production process which results in decreased production.	Field survey, six sigma with DMIC stages	There were only 2 types of defects. There are dominant factors that cause defects, namely lack of maintenance, less careful operators, and improper machine settings.

(continued)

Table 1. (continued)

No	Author	Title	Research Objective	Method	Results
10	Sari & Vikaliana, 2021 [11]	Quality Control Analysis Using the Six Sigma Method to Minimize Product Defects at PT. Bumiputra Manufacturing Technology	To find out the product quality control carried out at PT Bumiputra Manufaktur Teknologi.	To find out the product quality control carried out at PT Bumiputra Manufaktur Teknologi.	The value obtained is by converting the company's DPMO value into the sigma relationship table with DPMO in the DPMO value to sigma value conversion table, where it is known that the current DPMO of PT. BMT is 5,100 while the sigma value obtained by PT. BMT is 4.07.

Documents by year

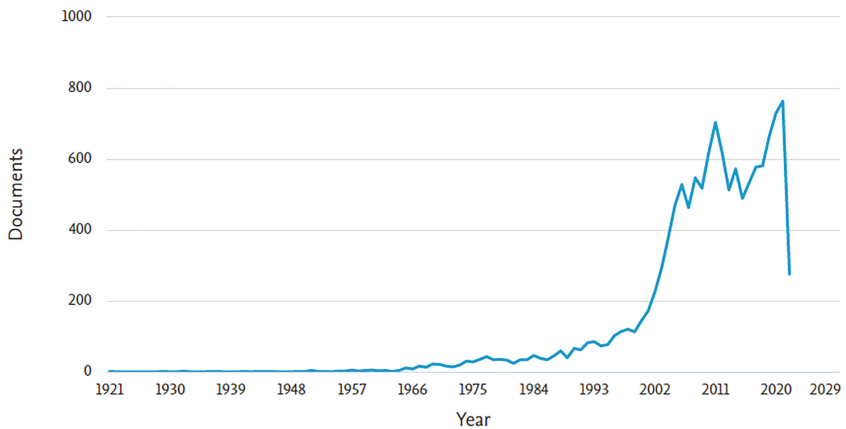


Fig. 1. Six Sigma Document Development Data

Documents by country or territory

Compare the document counts for up to 15 countries/territories.

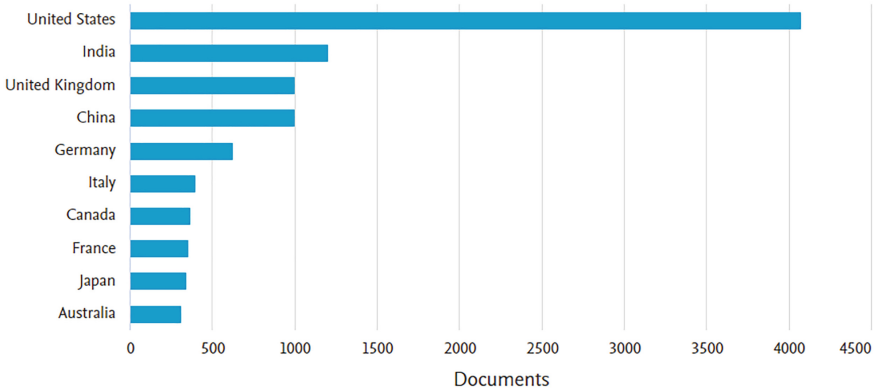


Fig. 2. Country Information Based on the Number of Six Sigma Documents

Documents by country or territory

Compare the document counts for up to 15 countries/territories.

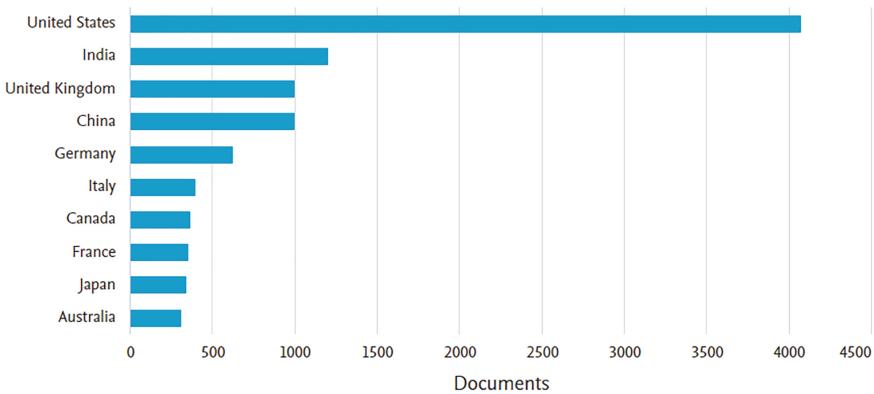


Fig. 3. Number of Six Sigma Article Publications by Author Name

Based on Fig. 3, it shows affiliations that publish articles or documents on the topic of Six Sigma. The CNRS Center National de la Recherche Scientifique published 93 documents and articles, followed by Heriot-Watt University with 106 documents and articles, and the Universiteit van Amsterdam with 81 documents.

Figure 4 depicts the number of documents and articles containing the topic Sigma. Documents with article types amounted to 64.6%. Documents of the type "conference paper" amounted to 23.3%, and those in the form of "review" amounted to 5%.

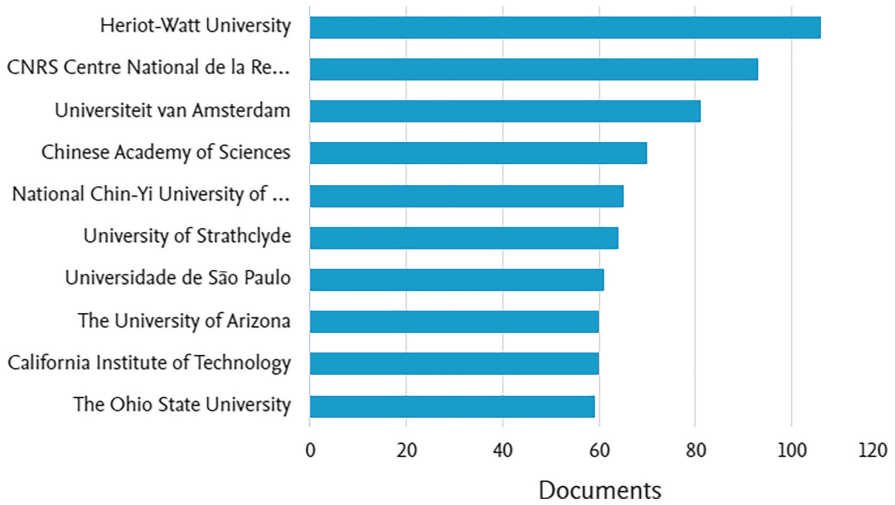


Fig. 4. Number of documents based on Six Sigma article publication affiliation

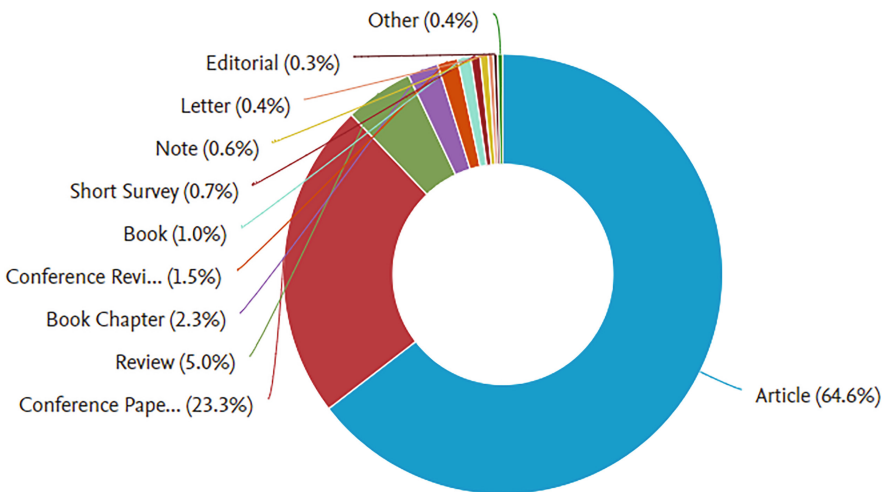


Fig. 5. Percentage of documents with Six Sigma topics

Engineering has the highest use of six sigma methods in various types of research, at 21.4% (5113 documents), followed by other fields at 18.4%, business, management, and accounting at 11.9% (2848 documents), and chemistry at 8.8% (2088 documents).

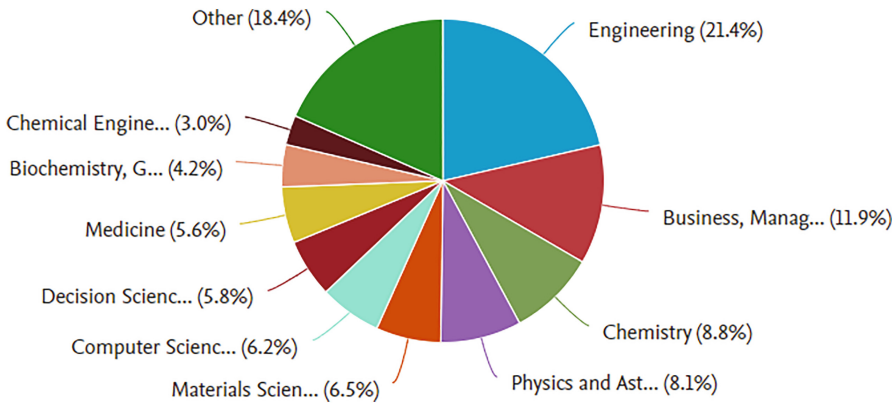


Fig. 6. Number of documents based on Six Sigma article publication affiliation

4 Conclusion

Several conclusions can be drawn based on the results of the data processing and analysis that has been done about how the software can produce analysis data about the use of the six-sigma method in any field. This research was conducted using the six sigma method, with data searches ranging from 1990 to 2022.

The results of the data from Scopus are in the form of data analysis on the use of the Six Sigma method. The results of bibliometric analysis based on subject areas are Engineering with 21.4% (5113 documents), Other with 18.4%, Business, Management, and Accounting by 11.9% (2848 documents), Chemistry with 8.8% (2088 documents). The development of publications on the topic of Six Sigma was significant in 2011 with 703 documents, then in 2020 with 730 documents, and in 2021 with 760 documents. Then the least research was conducted in the Chemical engineering sector (3%), followed by Biochemistry (4.2%) and Medicine (5.6%). Further research on Six Sigma needs to be done in these sectors to deepen the role of Six Sigma. This research shows that the United States has the highest number of publications compared to other countries, but it has not considered the location of the case study conducted in the research. Therefore, further research on the literature review needs to consider the location of the research to determine the development of the role of Six Sigma in existing countries. This research also concluded that the Six Sigma method plays an important role in improving product quality, especially in the engineering and manufacturing fields.

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