



THE MERGING OF SIX SIGMA AND LEAN SIX SIGMA IN DIFFERENT  
SECTORS: A LITERATURE REVIEW

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*Abstract*

*In an increasingly competitive environment, the success of businesses depends on customer satisfaction to a great extent. In order to achieve this, it is necessary to offer a product or service at the desired price, with the features and quality that the customer wants and expect. Variations in processes in product or service production should be reduced and waste should be eliminated to increase speed. In this study, a literature review covering previous years has been conducted for the lean and six sigma approaches, which has emerged by combining lean sigma method into six sigma method in line with the customer-oriented, which tries to eliminate the variability in the processes using statistical tools. The aim of the study is to show that six sigma and lean six sigma approaches can be used in different areas of business.*

*Keywords: Lean sigma, 6 sigma, process improvement, customer satisfaction.*

**I. INTRODUCTION**

Today, the growth of businesses, their ability to stand against the competition in the market and to increase their productivity depends largely on customer satisfaction. Six sigma approach, one of the process improvement methods: increases customer satisfaction by reducing the variability in processes adding to this; it has been widely used by international companies such as General Electric, Whirlpool, Boeing, and Sony in recent years. Six sigma was introduced for the first time in 1985. It has been applied by Motorola and has had great success in the implementation period, as profit increased approximately by 25%, saving a total of 21 billion dollars (Thomas et al., 2008).

Aiming to find and solve problems in current processes, the mounted sigma method aims to select the most appropriate quality control parameters in order to achieve the desired results. DMAIC (Define-Measure-Analyze-Improve and Control) cycle is used to achieve this goal.

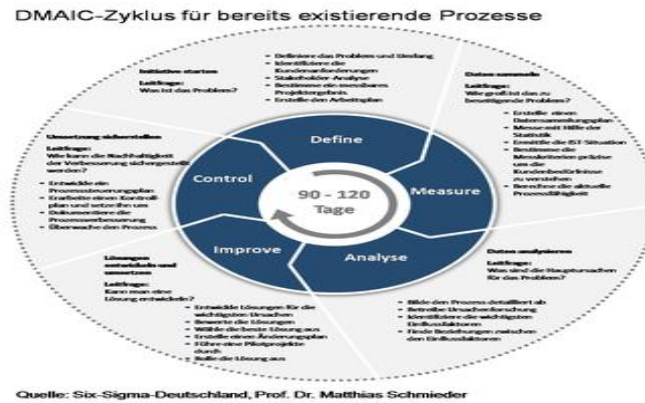


Figure 1. DMAIC Cycle, <https://de.wikipedia.org/wiki/DMAIC>

Considering Six Sigma, the variability of any process can be found by measuring it with sigmas. The variability of the process can be caused by processes such as inputs and suppliers. The normal distribution of a process should be at a distance of  $\pm 3$  sigma. This is a 99.7% scale. In other words, 997,300 per million of the manufactured product or service remain within this  $\pm 3$  sigma limits, the remaining 2700 are errors or defect. However, by improving the process, a design that accepts twice the normal variability of the process will give  $\pm 6$  sigma, 3.4 errors instead of 2700 per million for each product or service. A low sigma level means fewer errors in a production or service process. Thus there is an inverse relationship between the sigma level and the number of errors (Chakravorty, 2009; Naslund, 2008). As seen in Table 1, the increase in the sigma level means the decrease in ppm (part per million) values, which are the indicator of error probability. The ppm value here includes all the defects that were repaired or not repaired but scrapped in the background while producing million products (Drohomeretskiet al., 2014; Shah et al., 2008; Manville et al., 2012; Naslund, 2008)

Table 1. The Relationship Between Sigma Level and Cost of Poor Quality

Cost of Poor Quality	PPM	Sigma ( $\sigma$ )
30-40% of sales	308.537	2
20-30% of sales	66.807	3
15-20% of sales	6.210	4
10-15% of sales	233	5
10% of sales	3.4	6

In order to successfully implement six sigma projects in enterprises, the following basic points should be considered (Chakravorty, 2009):

- Top management should support and be committed to six sigma projects.
- Leadership is essential.
- Six sigma plans should be included in business plans.
- Experienced six sigma practitioners should guide employees.



- The project should be financially approved.
- Trainings should be given by the right people.
- Incentive systems should be established

Six sigma wants to achieve excellence in products and services from 99.5% to 99.9%. A quality of only 99% means the existence of poor quality products and services when considered on an annual or million product basis. This situation corresponds to a 100% error on a customer basis(Lee, Wei and Lee, 2009; Chen and Lyu, 2009)..

The benefits of six sigma can be listed as follows (Snee, 2010).

- It predicts decisions making based on data, not with feelings.
- Aims to dominate outputs by focusing on inputs.
- It is systematic, each step sheds light on the next.
- Solves the problems statistically.
- There is a clear control plan to ensure the continuity of improvements in processes.
- Results are expressed financially.
- Provides a performance goal for everyone.
- Increases the value given to the customer.
- Increases healing speed.
- Increases learning and information exchange.
- Facilitates strategic change.

When lean methods and six sigma principles are examined, it is seen that they are generally compatible with each other. There are many businesses that choose any of these approaches and use them in their activities. However, when only one of these two methods is preferred, some limitations are encountered. For example; while errors are reduced with six sigma, questions about how to make process flows more efficient remain unanswered; when lean methods are applied, not using statistical tools prevents a real process adequacy. However, lean methods and six sigma complement each other very well if used together, it benefits businesses in terms of developing lean processes that create value and ensuring the consistency of the outputs of these processes Rathiet al., 2016).. While lean tools detect problems in the flow and activities that do not create value, six sigma increases the adequacy of each step that creates value and creates a second input to lean production / management techniques. Combining six sigma with lean tools, especially in non-production processes;the correct differentiation of the application, tools and training content for the service sector and support processes is critical. Otherwise, problems are inevitable(Snee and Hoerl, 2007).

Lean six sigma emerges as an approach that combines the strengths of the lean management philosophy and six sigma management. Six sigma uses statistical tools to reduce or eliminate errors in process improvement, focusing on quality and customer satisfaction. In lean management, it accelerates the production process by eliminating all waste (stocks, waiting, etc.) that do not add value to the product. By integrating these two management philosophies, lean six sigma has a significant impact on improving process performance.



Lean six sigma was first applied in 1999 at BAE Systems Controls. Lean six sigma has become a symbol of excellence and a business model for organizations in order to reduce the variability and errors in processes and eliminate waste in recent years. This approach not only provides a key to survive in the global market, but also provides the necessary resources and tools for business development (Welch, 2001; Kumar et al., 2015). For operational excellence; it seeks the best improvement in customer satisfaction, cost, quality, process and speed (Antony et al., 2012; Kaidet al., 2016). Lean six sigma philosophy; Not only does it detect and fix errors, it also ensures that a business process is designed from the very beginning in such a way that no errors can be made. In addition, it offers solutions to eliminate waste and speed up the process. Costs are tried to be minimized by eliminating waste (GamalAboelimged, 2010; Arumugamet al., 2013).

Mahipal& Rajeev (2018) stated that an integrated development program combining lean methods and six sigma tools should not be thought to be developed by including a few lean principles in the six sigma training program or by providing black belt training to people who apply lean principles; They emphasized that an integrated development strategy involves considering the differences, not the similarities between the two management approaches, and making effective use of them. In this context (Mahipal& Rajeev, 2018);

- Lean projects are comprehensible, clear, and usually can be completed in a short time. In contrast, the six sigma project can cover a period of several months. Therefore, lean production activities should be emphasized at the beginning of the deployment phase in order to increase the speed in the integrated approach.
- Lean principles provide improvement by making simple suggestions without using complex analysis or tools. However, these principles may be insufficient for solving complex problems in advanced analysis. For this reason, six sigma method, which includes problem solving techniques, will be needed in the first year of the deployment phase, while creating the roadmap of the integrated approach.
- The integrated approach will require a vision and a series of specific projects that will fill the gaps between the future and the current situation. The Value-stream mapping, or the "material- and information-flow mapping" of lean principles will be the basic tool in filling the gaps and project lists will be created with the six sigma method.
- Lean principles can be taught through personalized short-time studies. However, six sigma trainings will continue throughout the six sigma process, which includes identification, measurement, analysis, improvement and control phases. In other words, short-time studies will not be effective for the six sigma project.

Lean six sigma (Mahipal& Rajeev, 2018);

- It is based on facts and data, and on the statistical support where necessary.
- Since it is a customer-oriented approach, it measures the process performance from the perspective of the customer.
- Although it offers a systematic approach, it is not a fixed plan.
- As a comprehensive set of tools, it needs to be tailored to the process or problem.



- They aim to simplify processes and reduce variability.
- Proves the improvement statistically.
- It focuses on financial return.
- It prevents bureaucracy and supports creativity.
- Creates the necessary procedures to keep improvements under control

For lean six sig to be effective, managers and workers should be given tools to measure process performance and monitor results. Organizations can measure their performance and goals by comparing themselves to successful Lean six sigma programs. Lean six sigma refers to change and/or sometimes every process may need to be redesigned during the implementation phase. Employees may naturally oppose the idea of change, so managers must persuade employees to accept the lean six sigma philosophy. Because the success of lean six sigma applications depends on employee acceptance. Employees should be trained about lean six sigma and this training should be seen as fundamental (Naslund, 2013)..

In this literature review; articles on six sigma first, then lean six sigma were examined in the last ten to fifteen years. The purpose of this is to show the trends of these approaches in the previous years and to encourage their implementation at present.

## II. LITERATURE REVIEW

### 2.1. Six Sigma Related Studies

This literature study in the field of six sigma once again showed that the six sigma approach is being globally rediscovered day by day. Six sigma approach, which has been used extensively in the field of production since 1980s, in the last years; It is seen that it is being used in different service sectors from operating rooms to second-hand auto sales, from training to motivation of employees.

Linderman et al. (2003), pointed out that the six sigma approach is widely accepted in the industry, but that there is no basis other than the quality of six sigma application studies. This study offers suggestions for event-oriented six sigma studies. In general, six sigma philosophy and goals were discussed in the study, and the study was supported with various statistical data (Linderman, et al. 2003)

Laureani and Antony (2017).stated that six sigma is a powerful business strategy that rigorously uses statistical and non-statistical tools to combat process variability. In his study, he examined the pros and cons of six sigma in detail, explaining the future and its connections with statistical thinking. He emphasized that the applications will increase gradually in the coming years due to the statistical thinking principles in six sigma. On the other hand, he argued that the applications in the industry require theoretical support and therefore the academicians have a great responsibility(Laureani and Antony, 2017).

Markarian (2004) in his study; summarized the definition of the six sigma philosophy, the process of taking part in the industry and other sectors, and explained how the six sigma approach can be utilized in both large and small businesses. In addition, the average costs



incurred when six sigma trainings are given in small, medium and large enterprises are given. In the last part Markarian's study, lean manufacturing was discussed and its applications in the plastic industry were discussed also (Markarian, 2004).

Sokovic et al. (2005) applied a six sigma study for process design in a company that manufactures compressor bodies. The authors stated that the primary tools were the process map and cause-effect matrix. The compressor body manufacturing process consists of five stages. These; process flexibility study, process planning, process preparation, process trial and process quality. In this study, Failure Modes and Effects Analysis (FMEA) has been used frequently. In the related article, the implementation of six sigma for the process was examined through key process input variables and key process output variables (Sokovic et al. 2005).

Linderman et al. (2003) build a goal theoretic knowledge of the Six Sigma phenomenon, these notions, when applied to Six Sigma, propose some suggestions for further research when six sigma tools and methodologies are employed in accordance with targets. In this study; It has been argued that quality management practices and various success factors related to them have been examined in studies on six sigma until now, but this concept, which encourages individual work such as motivation to be successful on the mass target, is not emphasized enough in the literature. In summary in other parts of the study; The correlation between concepts such as goals in six sigma, and project management was investigated, then it was supported by a regression study by including different variables. In the conclusion part of the study, it has been discussed and interpreted under the title of theoretical applications and managerial applications (Linderman et al. 2006).

Kwak and Anbari (2006); argued that understanding factors such as the obstacles and shortcomings of the six sigma method helps organizations to direct their strategic moves and increases the need for concepts such as guidance, training and coaching. In the study, the six sigma process has been handled from two different perspectives as statistical and business. In the following parts of the article, the benefits provided and reported by the enterprises using the six sigma method where listed, the key factors for the successful implementation of six sigma are given, and finally, opinions have been made by the authors under the title of the future of six sigma (Kwak and Anbari, 2006).

Unlike normal distribution processes in which six sigma is used, Hsu and Pearn (2008) applied the six sigma method to a process with gamma process. In the study, firstly; gamma distribution was explained and how process capability could be applied to this distribution was discussed. In the application part, a six sigma study was carried out in a company that manufactures integrated circuits, and it was observed with the results that a higher percentage of competence was achieved for the investigated problem (Hsu and Pearn, 2008).

Sahoo et al. (2008) used the six sigma approach to optimize radial forging process variables. The ultimate goal of the study is to minimize the residual stress that occurs after production. Experiment design was made with the help of Taguchi method and relevant / important



parameters were determined. The reaction surface method (RSM) was used to give clearer results of the study (Sahoo et al. 2008)

Kumar et al. (2008) stated in their study that six sigma applications are done very often, but if the correct methods are not used, this results in an increase cost to companies. For this purpose, in this study, two different two-stage optimization models are presented for companies to determine the right methods and tools. In order to examine the results of these optimization models on quality management, proposed in the following sections, a 4-stage problem is discussed and the results are interpreted (Kumar et al. 2008).

In the study conducted by Su and Chou (2008), it is investigated how to determine the critical points and priorities that need to be considered while applying six sigma. For this, they argued that a two-step algorithm should be followed. In the first step; They used Analytical Hierarchy Process (AHP) and failure modes and effects analysis (FMEA) methods, which allow the determination of parameters such as company's goals and policies, customer expectations, and elimination of possible errors of alternative six sigma projects in the second step (Su and Chou, 2008).

In the study by Chakravorty (2009), a six-step implementation of six sigma in a network technology company is described. These steps are; Strategic determination of customer and market needs, establishment of a high-level team that can implement the application, determination of development tools, process mapping and determination of priorities, determination of detailed plans for low-level developers, implementation documentation and control steps (Chakravorty, 2009).

Calia et al. (2009) examined 2096 environmental pollution prevention projects carried out by different organizations in 27 different countries between 1995 and 2007 in terms of cost and impact, and it was predicted that a 62% increase in environmental pollution prevention could be achieved with the help of six sigma studies. After the implementation, the number of such projects has increased 6.9 times and the capabilities of organizations for project management have also improved. (Calia et al., 2009).

Yang and Hsieh (2009) applied six sigma method in an enterprise. They used national quality award criteria and hierarchical criteria evaluation process as criteria. Delphi fuzzy multi-criteria decision making method was used to determine strategic criteria. The sub-criteria are evaluated by the six sigma champion, while the strategic criteria are determined by the management team. The proposed methodology has been applied in a factory that manufactures parts. The results showed that the key performance criterion for the six sigma project is financial gain. It has been observed that the quality of the company where the application is made has also improved significantly. (Yang and Hsieh, 2009).

Radhakrishnan and Balamurugan (2010) mentioned the application of six sigma methods in a company using quality control cards. The starting point of the study was the adoption of the six



sigma approach proposed by the Motorola company in the 1980s, in contrast to the quality control approach that Shewart handled on the basis of three sigma in 1931. In this context, the authors applied the six sigma approach in a 10-month study in addition to the quality control system applied by the company and interpreted the results (Radhakrishnan and Balamurugan, 2010).

Kelly et al. (2010) used the six sigma method to provide rapid reperfusion in (ST-Segment Elevation Myocardial Infarction) STEMI patients. Because rapid reperfusion also decreases the mortality rate. In practice, specific steps in STEMI patient care were decided, time targets were set, and processes were changed to reduce the duration of each step. Then the outputs were monitored and timely feedback was received. After administration, the reperfusion time decreased from 128 minutes to 90. This period was preserved for all STEMI patients during June 2010 and 100% sustainability was achieved as cited in (Naslund, 2013).

Zu et al. (2010) investigated how the six sigma approach affects organizational culture. They analyzed the relationship between four different culture types and 10 TQM / Six Sigma applications by taking data from surveys applied to 226 US companies and using structural equation modeling. The results obtained showed that this relationship is different. They also discussed the effect of the link between them. They argued that understanding the advantages of each type of culture can assist managers in quality management and effective six sigma practices (Zu et al., 2010).

Vinodh, and Swarnakar (2015), stated that the effective use of the six sigma approach helps companies achieve their strategic goals. According to the authors; As a project-oriented approach, it is essential that six sigma prioritizes projects that will provide maximum benefit to the organization, and it is difficult in practice to evaluate critical six sigma projects according to their priorities. In this study, a combined ANP-DEMATEL "Decision Making Trial and Evaluation Laboratory" is proposed that will help companies identify critical six sigma projects and especially enable logistics companies to prioritize these projects. In the proposed new approach; To create the relationship between criteria, DEMATEL, and the weights of the criteria are found with the help of ANP "Analytic Network Process" technique. The authors investigated the effectiveness of this approach in the logistics industry (Vinodh, and Swarnakar, 2015).

In his study, Parast (2011) investigated the effect of six sigma application on innovation and firm performance, and brought different propositions under different scenarios. In the study; He emphasized that six sigma applications do not provide the expected performance, especially in sectors where the speed of technological change is dynamic, and that six sigma programs can be effective in developing innovation. He also argued that since six sigma projects focus on existing customers, they could pose an obstacle to innovation for new customers. The author has made several suggestions for process and quality management (Parast, 2011)

Jin et al. (2011) presented a six sigma-based framework to ensure high product reliability in subcontracting processes. In the study; It is aimed to expand six sigma applications in products designed and developed to respond quickly to market needs. They argued that two important





ways to increase reliability are customer satisfaction and cost reduction. Finally, the proposed control mechanism has been used for system design in an industrial firm (Jin et al., 2011).

In the study conducted by Brun (2011), the six sigma applications of Italian companies were investigated. In the research, two main questions were asked and answers were sought to these questions. First, "Are Italian companies using six sigma as it's used in the original form at Motorola?", the second question is: Are firms in Italy that have implemented six sigma studies using the same critical success factors as in other studies, subject to criticism?. This study also showed that six sigma practices were insufficient in Italian companies (Brun, 2011).

In the study conducted by Goh (2011), the last 25 years of six sigma in the industry were examined with non-mathematical methods and an evaluation was made. In the analysis, "What is six sigma?", "Why six sigma?", "Why six sigma is applied?", "Where is six sigma applied?", "Who implements six sigma?" and "How to apply six sigma?" Each of these questions was examined, and the reasons why six sigma is used with an increasing momentum even today are mentioned. (Goh, 2011)

Hsu et al. (2011) In this study, six sigma studies in the TFT-LCD panel sector, which has a large share in the Taiwanese manufacturing industry, are described. By applying the six sigma method to the main board and screen production processes, which stand out as the determining factor among the companies, it is aimed to achieve a production process with higher quality and less waste. (Hsu et al., 2011).

Saghaei and Didekhani (2011) stated that the process of creating and evaluating projects is the first activity in six sigma applications. The aim of their work is to propose a comprehensive method for the evaluation and selection of six sigma projects. In their study, the literature was examined and the criteria to be considered in the evaluation of the projects are; technological and process criteria, business criteria and financial criteria including eight sub-criteria. To derive the overall program of the projects, an adaptive neural fuzzy inference system, which takes into account the relationship between criteria, is designed. Then, the optimal project is obtained with the fuzzy weighted goal programming model. The proposed model was implemented on a leading company in Iran. (Saghaei and Didekhani, 2011)

Rohini and Mallikarjun (2011) stated that six sigma application in health institutions will give hospital managers a strategic dimension to achieve zero error. In this study, six sigma application was applied to an operating room in Bangalore, India. The aim of the study is to show how six sigma study can be applied operationally in hospitals and how to gain effective decision making and problem solving skills. The study can also be seen as a template that can be used to improve operating room processes in other hospitals. (Rohini and Mallikarjun, 2011)

Cheng et al. (2012) examined fitness centers, which are a service industry, using the six sigma method. In doing so, belonging to the six sigma methodology; They have adopted the objectives of minimizing existing customer complaints, preventing possible future complaints, and maximizing customer satisfaction by following the steps of DMAIC defining the problem, measuring, analyzing, improving and controlling (Cheng et al., 2012) .



The aim of Shafer and Moeller (2012) studies is to investigate the effect of six sigma on corporate performance, by looking at the data of 400 companies in total; 84 of these firms were examined, taking into account parameters such as their profit margins, their sectors and the number of employees. In the research conducted on these 84 companies using six sigma method; the benefits of six sigma application for companies are determined based on parameters such as profit margins, sales, the sectors they are in, total assets, and the number of employees. The results showed that employees who adopted six sigma positively affected organizational performance. Finally, there is no evidence that six sigma adversely affects organizational performance (Shafer and Moeller, 2012).

Falcon et al. (2012) investigated the issue of minimizing energy consumption with the help of six sigma in the distillation industry and thus gaining cost savings. In distillation processes, 25% of the total cost consists of energy expenditures. For this purpose, a gain of 150000 €/year has been achieved in the six sigma study applied in a distillery. In practice, 14 critical inputs were inspected in the analysis stage of the DMAIC cycle and multiple models of indicators for energy efficiency were obtained. These models reproduce the past energy performance of the distillation units. The authors stated that the method used in the study could be improved by improving the consumption optimization of the furnaces in the reaction zone (Falcon et al., 2012)

Mehrabi (2012) investigated the contribution of six sigma practices to change and improve in perception of quality management. The study is in the form of a short literature search on the criteria on which six sigma applications are selected and how these criteria reflect on the success of companies. The authors examined the challenges and benefits of six sigma projects and introduced key and influential elements of this approach. In addition, the information learned from successful projects was combined and the forthcoming improvements in six sigma were evaluated (Mehrabi, 2012)

Yusr et al. (2012) investigated the relationship between six sigma and innovation performance, taking into account the adaptive effect of various parameters. Questions were asked through questionnaires to 80 companies serving in Malaysian with six sigma applications, and a data set was created with the answers from 64 of them. Since the data set is not large enough, the partial least squares method was used in the study. Later, the results obtained were interpreted by testing them with various hypothesis tests (Yusr et al., 2012)

Apak et al. (2012) reuniting authorities of public and private sector in the international strategic planning process by promoting efficient development of the hydrogen economy infrastructure and understanding the contribution of six sigma approach to energy efficiency in their study. The six sigma approach has been applied to a hydrogen power plant to increase energy efficiency and explore sustainable energy sources. The authors highlighted that this practice to encourage governments that support the use of hydrogen energy is an important initiative (Apak et al., 2012)



In their studies, Paramasivam and Muthusamy (2012) aimed to improve the quality of the engineering-educated workforce required for Malaysia's economic and technological global development. In this direction, they applied six sigma on the engineering education curriculum. The authors argued that this study is an attempt to establish the relationship between the popular industrial methodology and the academic environment encompassing the undergraduate engineering program. They also stated that the industry needs engineers who can adapt to innovations and new conditions. In the study, critical success factors required in the education curriculum were determined in order for engineer candidates to acquire these skills. (Paramasivam and Muthusamy, 2012).

Easton and Rosenzweig (2012); conducted a study on how different parameters such as experience on six sigma applications, personal experience, organizational experience, team leader experience and experience of working together affect six sigma studies and the relationships between them. For this purpose, 500 companies that were successful / unsuccessful in six sigma projects were analyzed. Archived data of projects spanning six years were used in the analysis. According to the results obtained, it has been observed that there is a strong relationship between the experience of the team leader and the individual experiences of other people working in the team and the success of the project. According to the results, it was seen that there is a strong relationship between the experience of the team leader and the individual experiences of the other people working in the team and the project success. (Easton and Rosenzweig, 2012)

Firuzan et al. (2012) conducted a six sigma study to increase second hand sales in the automotive industry. While the number of second hand sales was 27 at the beginning of the project, this number reached 47 at the end of the project. However, considering the socio-economic situation of the country, the number of sales at the end of the project corresponds to 37. Thus, an improvement of approximately 28% has been achieved. The authors stated that this ratio depends on the continuation of the project for its stability. Otherwise they said that, the project will lose its importance over time and the firm will take its place among unsuccessful applications (Firuzan et al., 2012).

Krogstie and Martinsen (2013) stated that good tolerance and variation management is required to obtain high value from products with costly processes. They talked about the connection of Engineering tolerance with the lean approach and six sigma, though not always. In this study, the possibilities and limits of these two approaches in Engineering tolerance are discussed. It describes the reciprocal improvement within industry in application, tolerance and variation management. It has also focused on the process of renewing existing drawing and tolerance specifications for the production of products with long lifetimes. (Krogstie and Martinsen, 2013).

Garmsiri et al. (2013) examined the options and benefits of using hydrogen in various types of transportation sector with the six sigma method in Ontario, Canada; It includes a comparison of four types of transport: locomotive, sea, airplane and automobile. In the study, infrastructure requirements, public concern and perception, cost and environmental impacts were used as



performance measures of six sigma. The results showed that locomotive transport has the best advantage in hydrogen utilization. To reduce emissions, the Ontario target of the Kyoto protocol could significantly help. (Garmsiri et al., 2013).

Lin et al. (2013) emphasized that getting information is a part of the performance of the information management system and that an effective performance evaluation mechanism is required to increase its accuracy. However, they stated that there is no such evaluation framework today and that a laboratory-based evaluation of constantly developing / changing information is not appropriate. In this study, an evaluation mechanism using the six sigma methodology is proposed to increase the performance of this process by controlling the information retrieval process. The proposed information retrieval framework uses the DMAIC loop and develops the necessary technologies. (Lin et al., 2013).

### III. DISCUSSION

Lean and Six Sigma approaches can be applied in various processes and sectors where the process need to be done right in the first time without any wastage in money, cost and time. (Hoerl, 2002; GamalAboelmaged, 2010; Arumugamet al., 2013). Therefore six sigma can be seen in health care, in helping to avoid medical mistakes, minimizing waiting time, increasing patient care, etc., it could be seen in the manufacturing industry where it serve as the cornerstone for improvements, as it maximize the number of industries that produces raw material that can be useful to make different things. In this concern six sigma through DMAIC in the manufacturing industries can ensure minimal defects in the manufacturing process. Taking into concern defects are less than 3.4 per million. On the other hand six sigma can be seen in information technology where DMAIC process can be applied the same as can be in the manufacturing industries. (Rathiet al., 2017; Gijoet al., 2014). Noting that six sigma is a project-based method, as it can uses several processes and series for implementing this methodology in industry. Involving several steps in each process during the implementation of six sigma, which in return can make increase employees productivity and create better overall rich experience and increase profitability. Six sigma can be applied in the textile industry, as this industry can be cauterized within the leading industry in terms of both the economy and the place which has lots of defects and variation in the process. Therefore six sigma can fit in this sector as it can increase the sustainability of this industry in the market, and can contribute to increase the reputation of the industry, and to create customer satisfaction and quality improvements. Six sigma can also be seen in the telecom industry, as this industry can work better by implementing this methodology. (Kumar et al., 2009; Zulqarnainet al., 2013; Aldairiet al., 2016) More specifically the table bellow presents the sectors in which the six sigma approach has been used in the previous years in percentage terms. The 45% portion of this table represent the studies done outside the implementation related to the six sigma approach. For example; suggestions and/or recommendations for six sigma applications, comparisons of this method with other process improvement methods, etc. Studies that include topics such as these make up this portion. As can be seen from the table, 29% of the share covers the activities in the manufacturing sector. The segment that appears to be 17% includes all of the studies conducted in many areas such as technology, environmental pollution and innovation. The health sector



has a share of 9% on its own, and the education sector has a 6% share. From here, it can be understood that the six sigma approach has applications in different sectors other than the manufacturing sector.(Snee, 2010; Linderman et al., 2003; Cherrafiet et al., 2017)

Table: Percentage of Usage of Six Sigma Approach by Sectors

Sector	Percentage
General	0.45
Production	0.29
Health	0.09
Education	0.06
Others	0.17

#### IV. CONCLUSION

Six sigma, one of the methods used by organization in process improvement, appears as an approach that focuses on customer satisfaction and utilizes statistical data and techniques for this purpose. The increasing competition in the market makes it necessary to retain customers and gain new customers. Customers want the product or service they want, when they want it and with the quality they want. Increasing product or service quality depends on reducing costs and minimizing variability in processes. To achieve all this, six sigma can be used as an effective tool and high profits can be made. But customer satisfaction is not just about ensuring quality. The customer wants to have the product within the time he wants. This is closely related to increasing the speed of the production process. Lean methods come into play at the stage of increasing the process speed. Lean methods aim to make the process run faster by eliminating all waste in the processes. A production process that meets the expectations and needs of the customer can be achieved by integrating lean methods and six sigma. This integration has created lean six sigma and businesses that implement it have made huge savings.

In this study, several articles in the literature review was conducted on six sigma and lean six sigma methods. There are important studies in the literature in which these approaches are used. In many studies examined, it has been observed that the success of six sigma and lean six sigma approaches largely depends on leadership and employee participation. In recent years, it is noteworthy that such applications have become increasingly widespread in service areas such as health, education, information technology, finance, and military outside the manufacturing sector. Another issue that should be emphasized here is that these approaches are not used sufficiently in the Arab region. However, looking at international studies, it is seen that six sigma and lean six sigma bring significant gains, especially in the fields of health and military. In this context, the most important aim of our study is to encourage the use of six sigma and lean six sigma approaches in different sectors in Palestine.



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