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A SYSTEMATIC LITERATURE REVIEW OF SIX SIGMA IMPLEMENTATION'S BENEFIT TO THE ORGANIZATION

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ABSTRACT

Six sigma is a methodology which started in manufacturing sector that focuses in reducing the product variation, reducing defect and increasing customer satisfaction. This research is based on literature research to review and observe all the findings, facts and research result around the world regarding to the six sigma implementation. The result shown that Six sigma is being popular and has been adopted in many organizations across the industries as well as the organization sizes around the globe, where it successfully delivered many benefits from the quality improvement, increase productivity, increase job satisfaction, deliver cost saving, improve on time delivery and improve customer satisfaction that leads to more business growth, higher profit and building the great foundation for the business sustainability.

INTRODUCTION

Six Sigma is widely used across the globe, it is a rigorous, focused, with effective proven method of quality principles and techniques, six sigma incorporates all elements in the organizations, and it aims for error-free business performance (Pyzdek & Keller, 2010). Six Sigma is a popular management philosophy for many years. It started in Motorola in the 1980s, continue to embraced in Allied Signal in the early 1990s and made more popular in General Electric (Eckes, 2003). Six Sigma has three meanings; firstly, it can be viewed as method to measure the quality which measures the variation of a process. Secondly, Six Sigma can be seen as a business improvement strategy and a philosophy of continuous improvement. Thirdly, it is a problem-solving methodology to eliminate defects or mistakes both in business processes or manufacturing processes with focus on improving customers satisfaction (Antony et al., 2016). Six Sigma is implemented through the DMAIC cycle (Define–Measure–Analyze– Improve–Control), the DMAIC methodology takes a problem that has been identified by the organization and employed a set of tools and techniques in a logical phases to provide a sustainable solutions (Shankar, 2009). Six sigma is also called as a statistical concept that measures a process capability in terms of sigma level that represents the defects number, at the six sigma level, there are only 3.4 million defects per million opportunities while at one sigma level means there are about 691.462 defects per million opportunities (Brue, 2002). Six Sigma breakthrough

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strategy is one of the most compelling and successful management strategy since the last quarter century, this happened due to its strong focuses on business processes and its components that comprises those processes (Harry & Schroeder, 2000). Nowadays, Six Sigma is combined with Lean Manufacturing and it's called as Lean Six Sigma (LSS) that supports both the short term need to survive strategy by safely and rapidly reducing the costs and the longer term road strategy to high business performance by transforming into a fast and agile enterprises (M. O. George, 2010). Lean Six Sigma (LSS) is focusing on three simultaneously works those are quality, speed and cost because it blends Lean manufacturing, with its primary focus on the process speed, and Six Sigma, with its primary focus on the process quality by reducing the variation and increase process capability (M. L. George, 2003)

Starting the six sigma implementation will require some infrastructures and its support both from top management as well as from the whole employees in the organization. A clear six sigma leadership system, strategy and the business goals that's completed by the comprehensive change agents starting with deployment champion, the six sigma experts (Black Belts, Green Belts and Yellow belts) are the prerequisite to ensure the six sigma are well implemented (Gygi et al., 2005). Another challenge in implementing six sigma is how to turn the skeptic or resistant people into the believers. As most the new thing including the six sigma where people will be skeptics in the beginning and it requires a clear strategy as part of continuous improvement strategy to turning the skepticism become the believer (Burton & Sams, 2005). It definitely would take some times and need some persistent work, resiliencies and extra effort especially from the change agents with full support from management to remove barriers and the roadblock.

RESEARCH METHOD

This study is considering of 4 stages as described on the figure 1. It consists of collections of the predefined papers, journal and some textbooks, some quick reviews and made the shortlisted papers to continue to in dept review, summarized and concluded

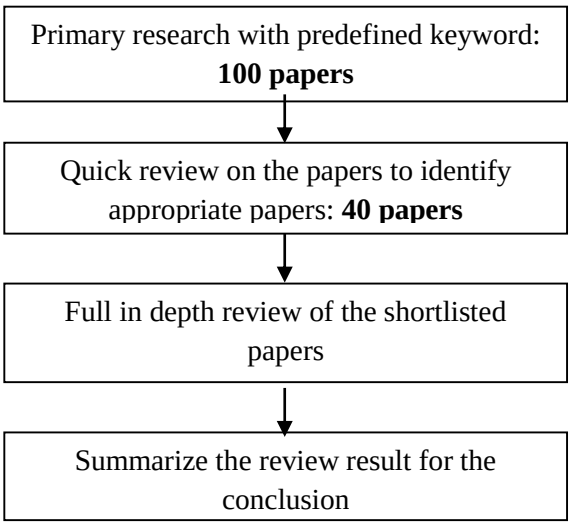

Figure 1. Study framework

The 40 papers has been collected and completely reviewed. Those papers came from multi industries sectors as well as spreading globally to cover the global view of Six Sigma implementation comprehensively and gain more perspectives and evidences. The full list of papers can be seen in Table 1 below.

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Table 1. List of literature review of Six Sigma's papers

No	Paper Identity	Research object	Result
1	(Ahmed et al., 2018)	Hospital	Six Sigma can optimize process and add value of private hospitals by improving the quality and overall business performance
2	(Al zain et al., 2018)	Hospital	Six sigma is well implemented and it improved the sigma levels as well as reduced the waiting time with range more than 69%
3	Singh & Bakshi, 2014	Manufacturing	Increased the mileage mean from 2.17 to 3.72 units per liter. Reduced process variance (Standard deviation) within the process from 0.68 to 0.22
4	Noori & Latifi, 2017	Automotive	Reduced DPMO and improved process yield from 27% to 93.3% (on grinding process)
5	Bulgaru et al., 2015	Manufacturing	Reduced scrap (reject part) coefficient from 1.69% to 0.69%
6	Cardiel-Ortega et al., 2017	Textile	Improved sigma level from 1.3 to 1.9 and increased capacity from 238 to 317 garment/day
7	Chen et al., 2016	Multi industries	The values of indices indicate the level of quality achieved for a given quality characteristic
8	Chiarini & Kumar, 2020	Manufacturing	Lean Six Sigma (LSS) concept can be integrated with industry 4.0
9	De Freitas & Costa, 2017	Multi industries	The organizations that use the Lean Six Sigma are able to enhance the achievement of more sustainable management.
10	García-Alcaraz et al., 2018	Manufacturing	Managerial commitment is the basis for Six Sigma success, but requires an adequate implementation strategy focuses on customers and their needs, which must integrate an investment plan in human resources that is focused on training and teamwork
11	Garza-Reyes et al., 2016	Manufacturing	Reduced the ship loading commercial time by 30%
12	Gheysari et al., 2016	Hospital	Significantly reduced the cancellation case from 31 (3.6%) cases of cancellation to only 12 (1.4%) cases
13	Gupta et al., 2018	Manufacturing	Six sigma improved the process performance capability index (Cpk) value from 0.94 to 2.66
14	Improta et al., 2019	Hospital	Six sigma increased the percentage of lead time accuracy of fracture operated between 48 hours from 4% become 60%
15	Mareček-Kolibiský & Kučerová, 2020	Manufacturing	Reduced the level of calibration from 78% to only 10.7% with cost saving 21,400 Euro

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16	Matusova, 2016	Manufacturing	Reduced production leadtime about 3 minutes per batch product and increase productivity with cost saving up to 66,000 Euro
17	Mishra & Rane, 2018	Manufacturing	Reduced iron casting rejection from 53.8 per heat to 0.66 per heat where it also improved the delivery rate from 80% become 99.78% with cost saving up to 90,000 USD
18	Noriega et al., 2016	Manufacturing	Improved the process by reducing downtime 50%, and improve the uptime from 97.53% to 98.8%
19	Nurcahyo et al., 2017	Automotive	Improve the sigma level from 3.8 to 4.8 where it reduced the total defect from 6% to 0.5%
20	Shamsuzzaman et al., 2018	Telecommunication	Reduced lead time order fulfilment from 10.3 to 5.9 days and increase the sigma level for from 0.73 to 2.66. this lead to a financial benefit savings up to $600,000 per year
21	Srinivasan et al., 2016	Manufacturing	DMAIC implementation improved the sigma level of drilling a hole in a component called 'furnace nozzle' from 3.31 to 3.67
22	Su et al., 2019	Electronic	Reduced defect rate from 15.73% become <1%, reduced cost up to $ 2 million
23	Sunder, 2016	Banking	Successfully reduced the rejects percentage from ~10 to 3.4% which lead to cost saving up to $ 200,000
24	Sunder & Antony, 2015	Banking	Improved process yield from 58.7% to 65.41%. This resulted in an annual save of $ 270,000
25	Swarnakar & Vinodh, 2016	Automotive	Six sigma successfully reduced cycle time by 7% which lead to increase output/day from 8,00 become 12,000 pieces, while increase yield from 99% to 99.9%
26	Thomas et al., 2016	Aerospace	Improved on-time-in-full delivery to customer by 26.5%, reduced Non-value added time by 44.5%. Delivered annual financial savings up to £2 Million
27	Takao et al., 2017	Small medium enterprise (SME)	Reduced the forecast error from 57% to 31% and reduced order fulfillment lead time by 2.5 days which corresponded to sales increase of US$167,591
28	Sunder & Kunnath, 2019	Healthcare	Successfully reduced the error percentage from 1.5% to 0.12%, provided cost saving up to 0.53 Million USD
29	Westgard et al., 2018	Laboratory	Six sigma can be used in laboratory to reduce total error, calculate their Sigma metrics, and control materials, reagent, and calibrators
30	Stankalla et al., 2018	Manufacturing	Critical success factor in implementing

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			six sigma are: Management involvement and commitment, linking to business strategy and linking to customer priority
31	Kuvvetli et al., 2016	Multi industry	Critical success factor in implementing Six sigma are: top management support, project selection and the quality culture
32	Lucato et al., 2015	Manufacturing	Six Sigma approach was capable of improving the eco-efficiency level of the process area under study by 11%.
33	Kaushik et al., 2012	SME	Six Sigma project increases the process of sigma level to 5.46 from 1.40
34	Lang Cheng, 2012	Multi industry	Six Sigma training has impact on organizational job satisfaction and employee morale
35	Monreal et al., 2017	Hospital	Six Sigma project has reduced the alert of fatigue by 28%
36	Shokri, 2019	Manufacturing	Improved yield from 98.3% to 99.03%, sigma score increase from 3.65 to 3.85. and leads to a saving £98,000 annually
37	Akbulut-Bailey et al., 2012	Aerospace	Implementation of holistic Lean Six Sigma improved their manufacturing operations, productivity, and customer service in order to successfully compete in the global business, it increased the sales more than 500%
38	Laureani et al., 2010	Call center	Six sigma project reduced unresolved queries by 3 percent, it approximately reduced 36,000 call issues from 1.2 million calls annually
39	Raju et al., 2014	Manufacturing	The implementation of Six Sigma successfully decreased the rejection rate from 11380 PPM to 489 PPM and improved sigma level from 3.86 to 4.20
40	Elbireer et al., 2013	Laboratory	Six sigma help to reduce the errors by 257 errors per month and saved up to $50,115 per year

Those 40 papers were analyzed by the paper's object (industries sector). As can be seen on figure 2, manufacturing sector was the most paper's object being collected which we can guess since six sigma is starting in manufacturing and also being popular in manufacturing sector. However, the other sectors also contributed such as hospital, banking, and telecommunication until the Small Medium Enterprise (SME). This validates that six sigma is successfully implemented not only in manufacturing industry but also in non-manufacturing industries.

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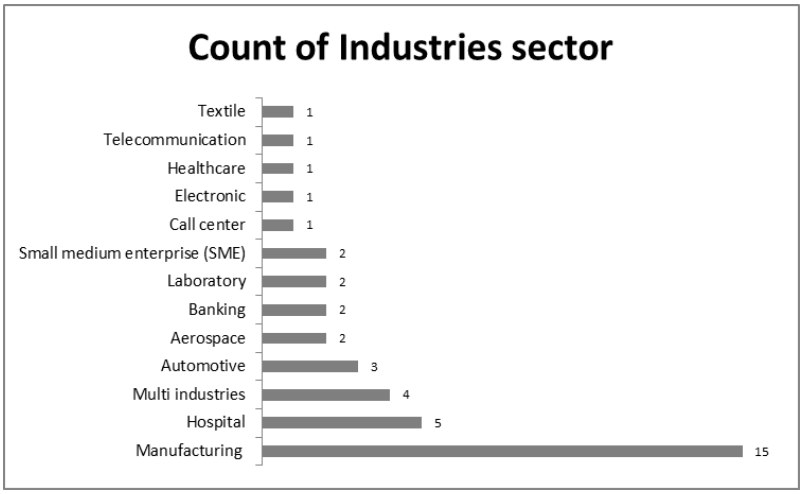

Figure 2. Papers by industries sector

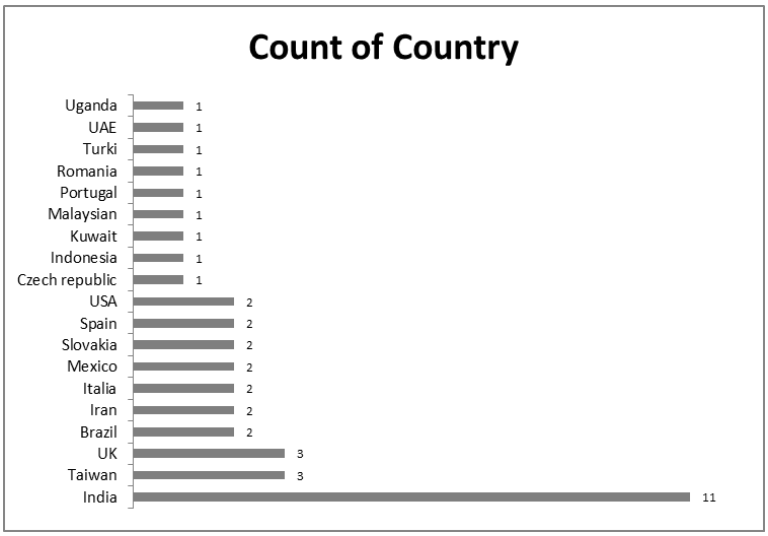

Figure 3. Papers by country of origin

The papers also spread from over 19 countries where the most countries are India, Taiwan and the UK as can be seen on figure 3. However, since the paper selection is purely random based on the content of the paper which is not concentrated on the country of origin of the paper itself. On figure 4, it can be seen where the papers were come from 4 different regions (continents). Most papers came from Asia and Europe where America and Africa were also been selected.

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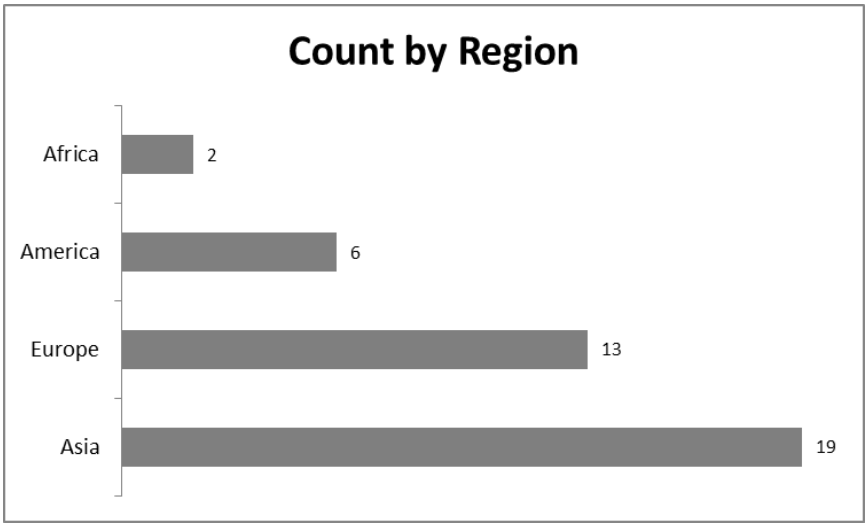

Figure 4. Papers location by region

RESULTS AND DISCUSSION

Six sigma is widely used around the globe where we can validate by the papers location which is representing all regions and many countries from emerging-developing countries such as Indonesia, Mexico and Brazil to the developed – advance countries such as USA & Italia as it shown on Figure 3 & 4. Interestingly, in India, six sigma even seems very popular where so many papers has been published with many different research object across the industries sector that's exhibit how six sigma is being implemented massively thanks to their industrialization that significantly increase in recent decades. Meanwhile, in Figure 2 it shown how six sigma is applied in many industries and sectors, it implemented well in manufacturing as the original area of six sigma came from as well as it being implemented in non-manufacturing such as in telecommunication sector, hospital, call center, laboratory and banking. Recently, six sigma also being adopted by small medium enterprise (SME), as we know SME sector is even so many compared to big enterprise (Count by number of company).

The main application of six sigma focuses on reducing the process/product variations that making it more popular in manufacturing sector and it's widely used with many of benefits can be achieved by the organizations. Its benefits start with a better quality products, increase productivity, reduced machine downtime, improve delivery rate with the final result is improving customer satisfaction that means increasing the business growth, adding more revenue and for sure it creates more value add and increases the profit. The first benefit in reducing product variation (it's called rejection rate) was successfully validated by the research in the manufacturing sector in Rumanian where by using the Six Sigma method, organization can reduce the scrap (reject part) from 1.69% to 0.69% or it almost reduced up to 70% (Bulgaru et al., 2015), other research also in manufacturing company in India showed that six sigma method successfully reduced the iron casting rejection from 53.8 per heat to 0.66 per heat with estimated cost saving up to 90,000 USD (Mishra & Rane, 2018), another research in Europe showed that DMAIC project can reduce the level of tool calibration (due to improving in product variation) from 78% to only 10.7% with estimated cost saving up to 25,000 USD (Mareček-Kolibiský & Kučerová, 2020).

Referring to the name of six sigma, many of implementations are to achieve the increase in sigma level with some examples from many researches in the past. In Automotive industry, Six Sigma method is employed to increase the process sigma level from 3.8 to 4.8 where it equals to defect reduction from 6% to only 0.5% (Nurcahyo et al., 2017). Other research in UAE at the telecommunication sector, the use of six sigma method successfully increased the sigma level of order fulfillment rate from 0.73 to sigma level at 2.66 which lead to a financial savings up to 600,000 USD per year (Shamsuzzaman et al., 2018). Another research in Textile

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industry in Mexico also concluded that six sigma is able to improve the process performance with increasing in the sigma level from 1.3 to 1.9 (This is recognized as a big improvement since the research object are the manual processes which have very high variation), this improvement directly increased the capacity from 238 to 317 garment/day, its equals to 33% capacity improvement (Cardiel-Ortega et al., 2017)

The most benefit that will make all the management happy definitely is coming from the financial benefit resulted from the six sigma project. Many of six sigma project were successfully delivered the financial benefit through the cost saving, cost avoidance or reducing in production cost. One research in Slovakia at manufacturing sector is successfully delivered up to 70,000 USD cost saving as the result of production lead time improvement about 3 minutes per product batch that increased the productivity (Matusova, 2016). In India, the implementation of six sigma in health care industry is successfully gained financial benefit up to 500,000 USD that being calculated from the error/defect percentage reduction from 1.5% to only 0.12% (Sunder & Kunnath, 2019). Another biggest financial benefit saving gained through six sigma project was showed by another research in aerospace industry in the UK where it totally saved up to 2,500,000 USD thanks to an improved in on-time in full (OTIF) delivery to customer by 26.5% (Reduced the penalty cost) and reduction in Non-value added time by 44.5% that increased the productivity (Thomas et al., 2016)

Apart from the above benefit of six sigma implementation that related to reduce rejection (variation), increase sigma level and gain financial benefit, there are many other of six sigma benefit that not related to those 3 benefits such as helping people life as showed by the research in the hospital in Italia where the using of six sigma able to increase the percentage of lead time accuracy of fracture operated that must be handled within 48 hours from 4% to 60%, it helping to save many patients from serious injury/fatality (Improta et al., 2019). Another six sigma benefit related to the people lives is showed in Kuwait also in the hospital where six sigma methods reduced the waiting time of patient handling significantly more than 69% that bring to the faster respond in handling the patient to get medical treatment as soon as possible (Al zain et al., 2018).

The last benefit topic of the six sigma benefit is related to business continuity or sustainability where it must be one important aspect in today's situation on how to make the business survives and sustain. The research in Taiwan showed that implementation of six sigma will improve the employee satisfaction and employee's morale that will create better performance, better working environment and stable office politics as the prerequisite of internal factor of business sustainability (Lang Cheng, 2012). In Portugal, another research found that six sigma is able to enhance the achievement of a more sustainable management (De Freitas & Costa, 2017). Last but not least, six sigma also can be aligned with the industrial revolution 4.0 where it validated by the recent research in Italia that concluded the six sigma concept is definitely can be integrated with the revolution of industry 4.0 (Chiarini & Kumar, 2020)

CONCLUSIONS

The six sigma methods is widely used in many organizations around the globe and it's very popular not only in manufacturing sector but spreading to the non-manufacturing sectors such as banking (financial sector), hotels, hospitals, telecommunications etc. The business scope is not only applicable for the big enterprises or the established organization; six sigma can be implemented to the new business sectors, new startup business including the small medium enterprises (SME). This validated that six sigma is a flexible and adaptable methodology that will help the organization to improve their business through the quality improvement, reducing defect or variation, reducing downtime, increasing productivity, increasing capacity, improving delivery performance, improving employee satisfaction and more over it also delivering the financial benefit saving with the ultimate goals to deliver customer satisfaction that will increase to adding more sales and revenue that lead to add more profit with mainly preparing for the business survival, business continuity and the more important is contributing to the business

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growth. With this research, it's concluded that six sigma is still and continuing delivering the benefit to the organization

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