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Implementation of Six Sigma Tools in Malaysian Manufacturing Industry

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Abstract: Six Sigma is a measure of quality that strives for near perfection. The fundamental goal of Six Sigma is to apply continuous improvement to meet customer expectations. Six Sigma as a business strategy can significantly help companies to gain a competitive edge. Although Six Sigma business management strategy has been exploited by many world-class organizations, there are still very few documented evidences of Six Sigma tool usage in the Malaysian manufacturing industry. This paper reports the implementations and the effects of the usage of Six Sigma tools in Malaysian manufacturing industry.100 surveys were distributed and a total of 55 responses received indicates a response rate of 55% with a total of 33 companies that use Six Sigma, and most of these companies were from automotive and electronics manufacturing industries, which fall under large size categories companies. The results of the study are based primarily on descriptive statistics, presenting that most companies in Malaysia are using 100% control chart, 93.9% check sheet and 90.9% process mapping for their process improvement. It was also found, the low usage of the design of experiment 42.4%, regression 30.3% and hypothesis test 24.2%. Through the use of DMAIC (Define, Measure, Analyze, Improve, and Control), organizations can reduce waste in their processes. However, there is little implementation of Six Sigma tools to improve and control the phase of DMAIC due to lack of statistical research, which tools is mostly used by manufacturing industry. Hence, linking Six Sigma to customers and to businesses are the most critical factors for the successful deployment of Six Sigma in the manufacturing industry.

Keywords: Six Sigma; quality tools; Malaysian manufacturing industry; DMAIC

1. Introduction

In recent decades, many manufacturing organizations are aware of quality problems in every aspect of their operations. Continuous quality improvement process assumes that a team of experts in the field actively uses quality tools in their improvement activities and decision-making process. Quality tools can be used in all phases of the production process, from the beginning of product development up to product marketing and customer support.

Tools and techniques are practical methods, skills, means or mechanism that can be applied to a particular task [8]. A tool is a device with a clear role, but narrow in focus and is usually used on its own. A technique has a wider application where the effectiveness needs more thought, skill and training. Ahmed and Hassan argued that quality management could not be ensured without the application of the appropriate tools and techniques, and firms that use these tools and techniques can improve their business results [1]. They recommend the use of quality tools and techniques to any firm, irrespective of its size.

In recent years, manufacturing companies have been adopting Six Sigma as the continuous quality improvement model for achieving zero defect manufacturing [17]. Six Sigma (6σ) is a set of techniques and tools for a process improvement. It is a systematic approach to eliminating errors and uses statistical methods to improve quality by minimizing variability in business processes. Six Sigma was created at Motorola in the 1980s and Motorola managed to reduce their poor-quality costs and decrease variation in many processes [3]. As a result, Motorola became the first recipient of America's Malcolm Baldrige National Quality Award in 1988 [15]. Besides, Six Sigma makes use of statistical thinking to integrate established management and statistical tools into the Define-Measure-Analyze-Improve-Control (DMAIC) approach to customer-oriented quality improvement [6]. DMAIC approach also enables the organization to gauge the cause of the problem. It is a never-ending cycle of the continual process improvement and that the objective is to use the results obtained from such tools for decision making, to achieve continual improvement and therefore satisfy the customers'ever ending needs and requirements. Hence, this paper contributes to the implementations and the effects of the usage of Six Sigma tools in the Malaysian manufacturing industry.

This paper reports the key findings of usage of Six Sigma tools in the manufacturing industry in Malaysia. The study gathered data from the quality managers on the usage of Six Sigma tools in their company. The findings could determine the usage level of the Six Sigma tools and techniques in manufacturing companies. This finding can reveal the readiness of these companies to move towards Total Quality Management and whether these techniques and tools support the values of the companies

2. Literature Review

Six Sigma, a statistically based quality improvement program, helps to improve business processes by reducing the waste and costs related to poor quality, and by improving the efficiency and effectiveness of operations [5]. Six Sigma functions as an improvement program for reducing variation, which focuses on continuous and breakthrough improvement [16]. The fundamental idea of Six Sigma is to improve performance, quality, capacity, cycle time, inventory levels, and other critical factors as reducing waste, energy sources and environment [2]. Improvement projects are driven in a wide range of areas and at different levels of complexity, to reduce variation. Although many world-class organizations have exploited the Six Sigma business management strategy; however, very few documented evidences are available on the Six Sigma tools usage in the manufacturing industry. It also appears to be a lack of discussion relating to the inadequate levels of application of these tools, particularly in the manufacturing sector. Dale and Mc Quater report that the use of tools and techniques is not as widespread and effective as might be expected, and suggest that part of the problem is due to insufficient training in the use and application of these approaches [4]. It is evident that many of the tools and techniques used do require a sound basis of training and education.

2.1 Six Sigma Phase

Over the years, companies have included numerous tools in the Six Sigma approach to make them more effective and to eliminate possible gaps after its application. The phases of the Six Sigma are structured as define, measure, analyse, improve and control. The tools of Six Sigma are most often applied within a simple performance improvement model known as DMAIC as summarized in Table 1 [10].

Table 1**.** Six Sigma phase

Phase	Definitions
Define	Output characteristics are selected and key process input and output variables are identified.
Measure	Performance standards are defined, and the measurement system is validated.
Analyse	Product capability is established, the performance objectives defined and the sources of variation identified.
Improve	Potential causes are screened, the variable relationships are discovered and the operating tolerances are established.
Control	On-going measurement system is validated, improved process capability is determined, and on-going process controls are implemented.

2.2 Six Sigma Tools

The Six Sigma program offers a wide range of procedures that are intended to assist the project leader in attaining intermediate results. Some of these tools and techniques are linked to particular steps of the strategy, and others function in a more general phase. To achieve success, the implementation of Six Sigma requires a systematic and disciplined application of tools and techniques [7]. This aids in defining the problems and the situations that need improvement. Appropriate use of analysis tools can impact the productivity and profitability of a firm at a large extent [18]. Although tools and techniques are not new to the Six Sigma, adopting them may add considerable value to the program [13]. Some tools are statistical such as the design of experiments, regression, hypothesis test and capability study while others are non-statistical as summarized in Table 2.

Table 2. Six Sigma tools

Tools	Definitions
Histogram	A graphic display of the number of times a value occurs.
Pareto chart	A bar chart that organizes the data from largest to smallest to direct attention on the important items.
Matrix diagram	A tool that allows a team to identify the presence and strengths of relationships between two or more lists of items.
Process mapping	A graphical illustration of the actual process.
Check sheet	A form used to collect, organize, and categorize data so it can be easily used for further analysis.
Time series plot	A graphical display of data over time to understand what the process is doing based on the pattern of the data.
Cause and effect diagram	A schematic tool that lists the causes as they relate to a concern - also Fishbone diagram, Ishikawa diagram.
Failure mode effect analysis	A structured approach to identify the way the product or process can fail and eliminate or reduce the risk of failure to protect the customer.
Measurement system analysis	Statistical and graphical analyses to determine whether the measurement system precisely measure the characteristic in question.
Capability study	A calculation used to establish the proportion of the operating window taken up by the natural variation of the process.
Regression	A measure of the relation between the mean value of one variable (output) and corresponding values of other variables.
Hypothesis test	Data driven tests that answer the question: “Is there a real difference between A and B?” using relatively small sample sizes to answer questions about the population.
Design of experiment	A systematic set of experiments that permit the evaluation of the effect of one or more factors on a response.
Control chart	A graph of time-ordered data that predict how a process should behave.

3. Methodology

The survey questionnaire was mailed to the randomly selected quality managers from 100 manufacturing companies in the Klang Valley, Malaysia. This study polled the sample companies from a list obtained from the Federal Malaysian Manufacturers (FMM) Directory 2020. The managers were selected for their familiarity with the implementation of Six Sigma. Since there is no certification for Six Sigma, ISO 9000 registered companies from automotive and electronics were set as the criteria to meet this requirement. The data in this study were analyzed using the statistical package SPSS version 26.

4. Analysis and Results

This study collected a total of 55 responses, indicating a response rate of 55%. The responses were from 33 companies that use Six Sigma, and these companies were from the manufacturing industries. Most companies responded were from the automotive and electronic sectors. Companies were also categorized by their size (medium: from 51 to 150 employees; large: over 151 employees). The majority is large companies (63.6 per cent) and consistent with the literature that indicates that Six Sigma is applied more frequently in large companies [9].

Table 3 presents the level of use of Six Sigma tools in manufacturing companies in Malaysia. This table displays the following descriptive statistics: the mean use of Six Sigma tools (in a five-point Likert scale) and the companies’ rate that expressed very frequent-frequent, moderate and little-no use of Six Sigma tools.

Table 3. The level of use of Six Sigma tools

Phase	Six Sigma tools	Mean value*	Very Freq. use - Freq. use (%)	Moderate use (%)	Little - no use (%)
Define	Histogram	4.27	84.8	9.2	6.0
	Pareto chart	4.33	84.8	15.2	0.0
	Matrix diagram	3.88	63.7	30.3	6.1
	Process mapping	4.55	90.9	6.1	3.0
Measure	Check sheet	4.58	93.9	6.1	0.0
	Time series plot	3.73	60.6	24.2	15.2
	Cause and effect diagram	4.21	78.8	21.2	0.0
	Failure mode effect analysis	4.06	78.8	12.1	9.1
	Measurement system analysis	4.12	75.8	15.2	9.1
	Capability study	4.12	81.8	6.1	12.1
Analyse	Regression	2.91	30.3	36.4	33.3
	Hypothesis test	2.67	24.2	36.4	39.4
Improve	Design of experiments	3.18	42.4	18.2	39.4
Control	Control chart	4.73	100	0.0	0.0

Notes* 1 = no use, 2 = little use, 3= moderate use, 4 = frequent use, 5 = very frequent use.

The criterion for high usage of Six Sigma tools specifically using the rate of very frequent use-frequent use, we conclude the following: tools such as control chart are highly used by the majority of the companies. Check sheet and process mapping are used by approximately ninety percent of the company. Four-fifths of the companies used Pareto, histogram and capability study. Failure mode effect analysis, cause and effect diagram and measurement system analysis seem to be used by three-quarter of the companies. Two-third of them used matrix diagram and time series plot. Importantly, the study found that fewer companies seem to use tools such as design of experiments (42.4%), regression (30.3%) and hypothesis test (24.2%).

5. Conclusion

In conclusion, Six Sigma is a business strategy that can provide a breakthrough improvement in the competitive era of manufacturing industries. The key strategy for successful implementation of Six Sigma is that the industry should follow a correct methodology and use of tools and techniques to improve the quality of the output. Six Sigma involves teams and leaders who take responsibility for the Six Sigma processes. Thus, the people on the teams need to be trained in Six Sigma's methods, including the Six Sigma measurement methods and improvement tools that will be used to identify errors or defects in a business process and eliminate them.

Since Six Sigma is project driven, proper usage of the tools and an innovative approach to problem-solving is required [10]. The improvement tools used in the Six Sigma approach help evaluate the effectiveness of the initiative. Strong linkages between the company's strategic objective(s) and Six Sigma implementation need also to be developed. Cross-functional teamwork and the empowerment of middle managers are necessary to enhance the company's network, capabilities and performance. Undoubtedly, Six Sigma can help Malaysian manufacturing companies maintain the highest quality of thought. By integrating to existing management procedures of companies, Six Sigma can help to fight and control variation from the manufacturing process with the help of its tools such as DOE, regression, hypothesis testing and capability study [13].

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