INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 13, Issue 6, (2023) E-ISSN: 2222-6990

Why Do You Need to Invest in Quality Control Tools? Smart Analytical Six Sigma DMAIC Model Continuous Improvement on Measuring Teacher's Performance

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v13-i6/17210 DOI:10.6007/IJARBSS/v13-i6/17210

Published Date: *21* June 2023

Abstract

Quality control tools in Six Sigma have not been extensively explored in systematic improvement for quality improvement in education. Therefore, this conceptual paper aims to introduce five quality control tools such as Suppliers, Inputs, Processes, Outputs, and Customers (SIPOC), the Pareto diagram, the fishbone technique, Failure Mode and Effect Analysis (FMEA), and Statistical Process Control (SPC) in each phase of the Six Sigma DMAIC model to improve the quality of teacher teaching. The Six Sigma DMAIC model consists of five phases, namely identify, measure, analyze, improve, and control. Quality control tools are generally presented for improving the quality of teaching and learning in schools. As such, quality control tools are applied by educational institutions for a deeper understanding of the educational process and methods to be improved to meet the desired quality goals. Quality improvement and enhancement through the Six Sigma DMAIC model with the use of various quality control tools in the field of education has a high potential in transforming the quality of education. In addition to reducing non-value-added activities, this effort is also able to increase operational efficiency. The idea behind this conceptual paper is to introduce sustainable quality control tools that can be considered by future researchers to solve problems and issues faced in teaching quality. Additionally, the implications of this study can increase a person's thinking power to be more dynamic, deep, and creative in facing a problem. Teachers can also use quality control tools in Six Sigma to evaluate their teaching, either among colleagues or independently. Ultimately, this idea can be developed further through studies across fields and institutions. This effort also encourages educational institutions to be more open in training their academic staff to use quality control tools in Six Sigma to transform teaching quality.

Keywords: Quality Control Tools, Six Sigma, DMAIC, Teaching and Learning Process

Introduction

Six Sigma is a systematic approach to quality improvement, which is used in profit-driven industries to improve the quality of products and services (Costa et al., 2021; M.Levine, 2006; Pyzdek & Keller, 2018). The evolution of Six Sigma began in the mid-1980s and was developed at Motorola (Costa et al., 2021; LeMahieu et al., 2017). Six Sigma has since expanded to various fields such as manufacturing, finance, tourism, and healthcare (Cudney et al., 2014; Levine, 2006), and now it is widely used in the field of education to improve the efficiency and effectiveness of the field (Aziz, 2021; Latifa Rahman, 2022; MacIel-Monteon et al., 2020; Sandu & Sharma, 2020). Moreover, Six Sigma has also been identified as one of the effective quality improvement methods to improve quality in the field of education (Arafeh et al., 2021; Cano et al., 2016; Davis & Fifolt, 2018; Fortunata, 2021; M.Alkoot, 2019; Wang, 2022).

As evidenced in the literature, Six Sigma has been successfully applied in the field of education (Cudney et al., 2014; LeMahieu et al., 2017). Six Sigma began to be used in the field of education in 2000 (Hargrove & Burge, 2002; Kaushik & Khanduja, 2006). According to Arafeh, (2016) among the areas of education that can be improved by using Six Sigma are curriculum, quality of teaching and learning, infrastructure, academic achievement, and learning community. The implementation of the Six Sigma approach in the education sector is more geared towards a flexible and comprehensive system to achieve and meet customer needs by identifying problems, using quality control tools to analyze, and making improvements to solve problems to improve the quality of education (Hariharan et al., 2015; Mazumder, 2014; Sandu & Sharma, 2020).

However, most studies have shown that the Six Sigma approach in education is more popular in Higher Education Institutions (Abdulla & Kavilal, 2022; Cudney et al., 2020; Laux et al., 2017; M.Alkoot, 2019; Mazumder, 2014; Sandu & Sharma, 2020), while its implementation in education at the school level is rather limited (Arafeh, 2016; Arafeh et al., 2021). In addition, the Six Sigma approach for the evaluation of teacher teaching quality is also still limited compared to that of the improvement of the quality of lecturers at Higher Education Institutions, where the Six Sigma approach is used more frequently (Al Kuwaiti & Subbarayalu, 2015; Vijay, 2013; Sunder, 2014; Wang, 2022; Yu & Ueng, 2012). Therefore, these issues must be given serious attention because the quality of teacher teaching in schools is also important and must be emphasized in order to ensure that the teaching and learning process runs effectively and achieves the goals set in quality education. In this vein, the application of Six Sigma to improve the quality of teacher teaching is highly necessary and appropriate to help teachers improve their teaching quality.

Six Sigma Terminology and Operational Definitions

Statistically, Six Sigma is defined as a unit of measurement that can reduce a problem to 3.4 records per million opportunities (DPMO) (Alkoot, 2019; Pyzdek & Keller, 2018). Therefore, to achieve the level of Six Sigma, the probability of the process to produce an error is only 3.4 out of 1,000,000 units where 99.99966% of the results are perfect (Harry & Schroeder, 2000; Levine, 2006; Stamatis, 2002). In this regard, to achieve Six Sigma, the process is so accurate and precise that it can make six standard deviations between the average achievement and the specification limit set by the customer (Pyzdek & Keller, 2018). Graphically, Six Sigma is represented as a bell-shaped curve or standard deviation from the mean in a normal distribution. Bloom (2018); Pyzdek and Keller (2018) detailed a bell-shaped curve as a

measure showing the deviation of a characteristic from the mean, i.e., six times the standard deviation from the mean, i.e., +6σ and -6σ in both to the left and right, as shown in Figure 1.

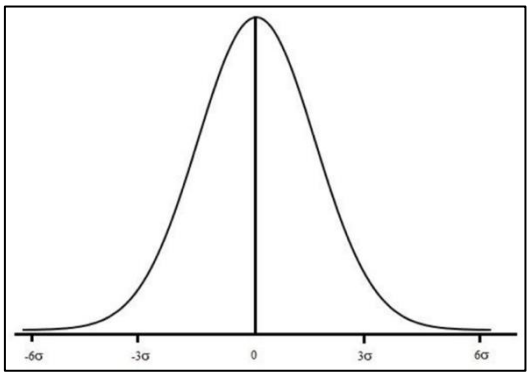

Figure 1 Normal Distribution of Six Sigma

Technically, the sigma value refers to the efficiency of the process; the higher the sigma value, the better the process. In other words, the higher the value of sigma, the less a process experiences variation and, thus, fewer defects will occur. Therefore, if Six Sigma is achieved, then the productivity process successfully runs in an optimal manner (Bloom, 2018; Jacobs & Chase, 2016). On the one hand, to achieve the level of Six Sigma, the Six Sigma methodology is used to ensure that an organization is able to achieve optimal customer satisfaction. On the other hand, in educational institutions, this sigma concept has been expanded to ensure that the field of education is able to optimally meet the demands of its customers in order to strengthen the quality of education towards the success of quality and dynamic human capital (Kremcheeva & Kremcheev, 2019; LeMahieu et al., 2017).

Six Sigma DMAIC Model

Most Six Sigma tools and procedures involve statistics (Levine, 2006). Pyzdek and Keller (2018) stated that Six Sigma is one of the methods used to improve business or service processes by using data and quality control tools to make statistical analyses in order to help organizations improve their ability to produce maximum
products and services. Pochampally & Surendra (2014) also supported this assertion and stated that Six Sigma is a data-based approach that uses various quality control tools to analyze and make improvements in order to solve issues or problems so that processes and quality can be improved. Therefore, existing quality control tools used in Six Sigma can assist in the systematic analysis of problems for quality improvement (Costa et al., 2021; Mazumder, 2014).

The Six Sigma DMAIC model consists of five phases, namely identify, measure, analyze, improve, and control (Hollingshed, 2022; Shinta Rizki et al., 2021). The main goal of the Six Sigma DMAIC model is to understand and fulfil customer needs by putting into practise solutions that are intended to address the underlying causes of quality and process issues. It also establishes best practises to ensure that the solutions are long-lasting and replicable in other business operations (Montgomery, 2009). Accordingly, the Six Sigma DMAIC model cycle will be used in the development and improvement of teacher teaching quality, in addition to evaluating teachers' teaching and learning and helping teachers manage the teaching and learning process based on the data and analysis made. Furthermore, based on the facts and information obtained, improvements to existing problems will also be overcome and continuous efforts will be implemented to monitor teacher performance so that

corrective action can be taken immediately. A process flow chart of the Six Sigma DMAIC Model is provided to describe the processes implemented, as can be seen in Figure 2.

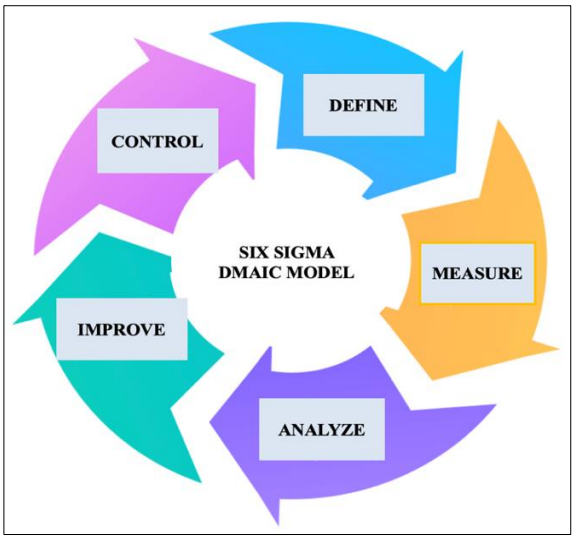

Figure 2 Six Sigma DMAIC Model Cycle

Identify - Suppliers, Inputs, Processes, Outputs, and Customers (SIPOC)

Problems and issues will be identified in this phase (Pochampally & Surendra, 2014). Specifically, the achievement of the desired goal begins with a clear and deep understanding of the issues and problems encountered. Therefore, the SIPOC quality control tool is used to identify

each element in the improvement process before the actual process is implemented (Jacobs & Chase, 2016). SIPOC is an acronym for Suppliers, Inputs, Processes, Outputs, and Customers. In technical terms, SIPOC is a process mapping and improvement method that summarizes the inputs and outputs of one or more processes using diagrams (Montgomery, 2009).

In the field of education, SIPOC is used to strengthen teachers' and evaluators' understanding of the teaching and learning process as well as to identify elements that affect the quality of teaching and learning. As such, SIPOC is an effective quality tool to help teachers improve their teaching quality. SIPOC also helps teachers analyze the teaching process by making assessments, allowing teachers to identify where improvements can be made to enhance their teaching quality. Teachers can also improve teaching strategies, identify the most effective teaching techniques, and take steps to improve their teaching process as a whole. Figure 3.

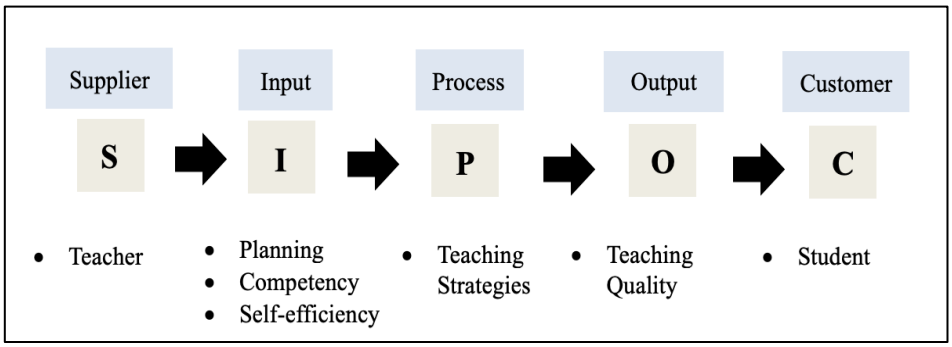

Figure 3 Analysis of SIPOC

Measure – Pareto Diagram

In this phase, current process performance is measured (Pochampally & Surendra, 2014). The measurement involves the collection and analysis of data found in the identify phase. The data in this phase will be used to see the comparison in terms of whether there is an increase or otherwise in the control phase. The Pareto diagram quality control tool is used in this phase, and this quality control tool is particularly used to identify and determine the main issues that contribute to the root cause of the problem (Jacobs & Chase, 2016; Ryan, 2011). In other words, the Pareto diagram is basically a quality control tool used to determine the dominant factor that has the most influence, i.e., the cause of the problem that causes the biggest negative impact (Pochampally & Surendra, 2014). Meanwhile, Mohamed (1998) added and highlighted the advantages of the Pareto diagram by which it can compare data before and after improvements are made and further confirm the effectiveness of the improvement actions made.

The Pareto diagram is a combination of two types of graphs, namely bar graphs and line graphs (Jacobs & Chase, 2016). In the diagram, the Pareto bar graph is formed in descending order of largest to smallest frequency, while the graph is plotted according to stacking frequency from left to right (Mohamed, 1998; Ryan, 2011). In the context of measurement, the Pareto diagram is used to identify the root cause of the main problem that affects the quality of teaching. For example, if 80 percent of the main cause that affects the teaching quality is teacher competency, then the cause will be identified and action will be taken for improvement. This can help teachers achieve their learning goals in the classroom more effectively. Hence, this shows that data analysis using Pareto can help improve the efficiency of classroom teaching.

Analyze – Fishbone Technique

This phase involves analyzing the process to identify the cause of a problem (Pochampally & Surendra, 2014). In this phase, the data will be analyzed and the main factors affecting the quality of teacher teaching are identified. The quality control tool using the fishbone technique, which involves brainstorming, is used to highlight key issues as well as to discover more structural causes and identify the root cause of defects in a process or procedure so that corrective action can be taken and implemented immediately (Jacobs & Chase, 2016; Ryan, 2011). Furthermore, the literature has also shown that the fishbone technique is popular in more thorough problem-solving situations because this technique explains all the reasons for a problem being sought in the form of a diagram (Arafeh et al., 2021; Sandu & Sharma, 2020).

One of the advantages of the fishbone technique includes listing as many reasons as possible for a problem that has been identified, which causes the cause of the problem to be detected quickly so that corrective action can be taken (Arini, 2017). In other words, to determine the causes of problems in the teaching and learning process, brainstorming methods are used through the fishbone technique by categorizing them into the fish head, the fishbone, and the fishbone branches. Analogously, the head of the fish is the problem faced by the teacher, while the big fish bone is the cause of the problem, and the fishbone branches depict more accurate details so that the real cause of the problem in the teaching and learning process can be identified.

Improve - Failure Mode and Effect Analysis (FMEA)

According to Yu and Ueng (2012), after the identifying, measuring, and analyzing processes are completed, the main issue, which is the cause of
teacher teaching quality not reaching the standard, is identified. Pochampally and Surendra (2014) stated that in this phase, recommendations are made to minimize or eliminate the cause of the problem identified and those recommendations are then implemented so that corrective action can be taken immediately. Therefore, in this phase, the quality control tool of Failure Mode And Effect Analysis (FMEA) is used to improve the teaching and learning process. FMEA generally has the potential to identify defects that may occur, determine the cause of failure, assess the impact of the defect, and determine the actions that need to be taken to reduce or eliminate the defect (Elfanda, 2021; Montgomery, 2009).

In the field of education, FMEA is used to identify the cause of failure in the teaching and learning process that does not meet the standard and how the failure affects the quality of teacher teaching. Next, corrective actions will be recommended to overcome them and FMEA will ensure that the teaching process becomes more effective and quality. The analysis in this phase is completed when the main causes impeding teacher teaching have been presented and some concrete improvements in teaching activities to improve the teaching quality have been taken.

Control - Statistical Process Control (SPC)

This phase ensures that the improved quality of the process is controlled so that it does not return to previously encountered problems (Pochampally & Surendra, 2014). Basically, the procedure in this phase is carried out after presenting and implementing some improvement actions to improve the quality of teaching. To confirm that improvements have been made, the analysis process will return to the measure and analyze phases (Yu & Ueng, 2012). In other words, the control phase generally involves prevention, particularly by ensuring that defects do not recur and that the improvements proposed in the previous phase continue.

The quality control tool of Statistical Process Control (SPC) is used in this phase. SPC is a quality control tool that uses statistical analysis to monitor and control processes (Jacobs & Chase, 2016). In the context of teaching measurement, SPC can help improve the quality of teaching by monitoring the work of teachers and identifying improvements to be made. In SPC, teacher teaching data are collected regularly and analyzed using statistical control graphics, which are used to monitor the quality of teacher teaching from time to time in order to reach the standard. By monitoring the work of teachers, SPC can help identify changes in the quality of teaching and learning as well as help teachers to take appropriate corrective actions immediately.

Discussion

The quality control tools involved in each phase of the Six Sigma DMAIC model have long been used to help improve the quality of products and services by making data-driven improvements through statistical analysis (Jacobs & Chase, 2016). As a result, the use of these quality control tools has reduced the possibility of errors in the improvement and quality improvement process to be carried out (Pande et al., 2014). These tools have also been used in the field of education to improve quality by prioritizing teaching and learning (Arafeh et al., 2021; Sandu & Sharma, 2020; Yu & Ueng, 2012). In this regard, the quality of teaching is treated as the main focus of measurement in the field of education since it is most effective in transforming education, especially at the school level, which simultaneously increases the

success of students. Therefore, the application of various quality control tools can help identify and further eliminate defects in each phase of the Six Sigma DMAIC model cycle (Laux et al., 2017; Milosavljevic et al., 2018).

The variety of quality control tools discussed in this study can be used to identify factors that affect the quality of teaching and resolve the causes and issues identified. The quality control tools suggested for quality improvement are SIPOC, the Pareto diagram, the fishbone technique, Failure Mode and Effect Analysis (FMEA), and Statistical Process Control (SPC). Accordingly, the use of these tools can help teachers improve their teaching quality by identifying problems, improving the quality of teaching, monitoring the quality of teaching over time, understanding the needs of students, ensuring that important aspects of teaching have been implemented, and thinking creatively to find improvements in teaching quality. This can help teachers provide more effective and meaningful lessons for their students. Moreover, Mazumder, (2014) also opined that data analysis using these quality control tools provides guidance on how to overcome issues and the main causes of the problems identified. Among the advantages of using these quality control tools are that they are more systematic in finding weaknesses or inefficiencies that affect output defects (Mazumder, 2014; Milosavljevic et al., 2018; Sandu & Sharma, 2020). Thus, the application of various quality control tools can assist in the effort to identify and eliminate defects in each phase of the Six Sigma DMAIC model cycle. In fact, this comprehensive analysis can also meet the needs and demands of customers. According to Laux et al., (2017), previous data collection and measurement only involved a limited scope that could not fully represent the customers' voices. Therefore, quality control tools are used along with the Six Sigma DMAIC model as a guide and success strategy in improving and maintaining the quality of teaching at the set standard whilst achieving a better performance level. As a result, customer satisfaction may be met and the set quality standards may be achieved.

The use of various quality control tools also helps teachers improve their teaching quality to achieve the desired quality standards. By using quality control tools in each phase of the Six Sigma DMAIC model, teachers can identify the source of problems, analyze their teaching process, take appropriate action, and increase their awareness of teaching quality. Thus, the main goal of the Six Sigma approach, which is to eliminate defects in every process that starts from manufacturing to output production, will be achieved. In this regard, the new concept of implementing the Six Sigma approach in the field of education through the Six Sigma DMAIC model as well as the variety of quality control tools that will be used serves as a new dimension in measurement to improve the quality of teacher teaching. This improvement effort is beneficial to all parties, as this approach focuses on a comprehensive effort to improve defects that occur during the teaching and learning process and produce quality output.

Conclusion

This conceptual paper has explained the role of five quality control tools such as Suppliers, Inputs, Processes, Outputs, and Customers (SIPOC), the Pareto diagram, the fishbone technique, Failure Mode and Effect Analysis (FMEA), and Statistical Process Control (SPC) in each phase of the Six Sigma DMAIC model to improve the quality of teacher teaching. Fiqure 4.

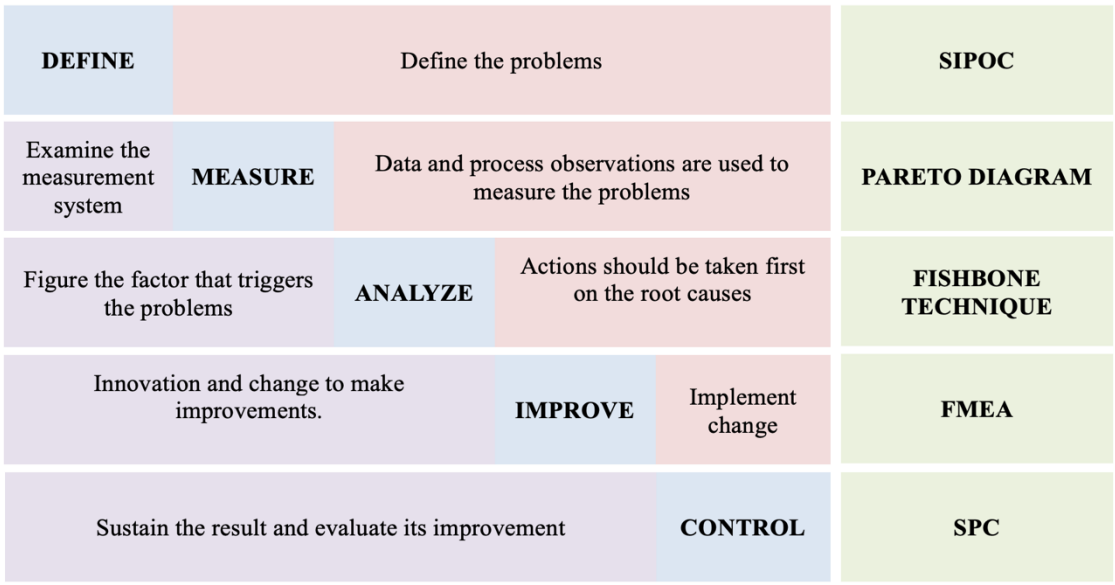

Figure 4 : Six Sigma DMAIC Model Flow with Quality Control Tools

The new concept of implementing the Six Sigma DMAIC model in education will benefit all parties, especially teachers, to diagnose issues related to teaching problems more deeply and plan interventions to further improve the quality of teaching. The use of quality control tools will also produce a reform in the education sector such as new methods of brainstorming, critical analysis, and a new style of thinking that focuses on the shift in the quality of teacher teaching, in addition to
having a significant impact on teaching and learning through a systematic improvement in the quality of pedagogy among teachers. When the teaching quality improves, student success will achieve an optimal level in terms of academic achievement. Nevertheless, this conceptual paper can be improved through the introduction of many more quality control tools other than those explained. The idea of the DMAIC model in Six Sigma can also develop the corpus of contributions to the body of knowledge pertaining to teaching quality, which has always stayed within its comfort zone through conventional methods. Therefore, it is imperative that the education community explores the idea of Six Sigma because, in the 21st century, teaching requires educators to think outside the box. The element of surprise in the idea of such improvement is, therefore, necessary so that educators are continuously thinking in order to improve the quality of teaching.

Recommendations

Further research can also be carried out by examining the impact of the DMAIC model in Six Sigma on the improvement of teacher competence. In addition, the study can be extended to areas other than education such as management, infrastructure, curriculum, and evaluation. If such an idea is ignored, then the effort to shift the quality of teaching will be difficult to

achieve and this will also make it difficult for the Ministry of Education Malaysia to compete with countries that have great teacher teaching quality such as the United States, Finland, and Singapore. So long as we are still lagging behind, the idea of the Six Sigma DMAIC model will not be achievable by Malaysians in another five years and may consequently be buried forever.

Acknowledgment

My supervisors, Associate Professor Ts. Dr. Mohd Effendi @ Ewan Mohd Matore and Associate Professor Dr. Siti Mistima Maat, deserve a lot of credit for the work they put into this task, and I would want to use this opportunity to thank them and appreciate them. I'm also very appreciative of the authors who reviewed and approved the completed manuscript.

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