https://doi.org/10.38190/ope.13.1-2.5 *Pregledni rad*

ANALYSIS OF APPLICABILITY OF TOOLS AND TECHNIQUES IN TOTAL QUALITY MANAGEMENT CONCEPTS

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ABSTRACT

The Total Quality Management (TQM) emerged as an evolution of the continuous improvement philosophy, emphasising quality as a fundamental aspect of the business to achieve higher organisational competitiveness. As business environments are characterized by dynamic changes, applying various TQM tools and techniques allows a leading edge in the market. Additionally, TQM tools and techniques serve entrepreneurs to improve the quality of their products or services, focusing on customer satisfaction, employee involvement, and continuous improvement. However, in the lack of knowledge and information, entrepreneurs are often unaware of the available methodologies. Hence, the paper shows, describes and systematises a set of tools and techniques available to all business people and their applicability to TQM concepts such as 8D and Six Sigma. The paper provides practical insights, information, and guidance for entrepreneurs and managers to improve the quality of their products or services, the efficiency of operations, and achieve long-term sustained success.

Keywords: *TQM; tools and technics; 8D; Six Sigma*

1. INTRODUCTION

The idea of constant quality improvement in reducing waste and increasing efficiency and effectiveness in all spheres of industrial and non-industrial production took hold primarily among large private companies. They noticed that the desired profit, on the one hand, and increased competitiveness, on the other, would be achieved by reducing costs and mass production. The next step in constant improvement was the period of total quality management (TQM), which focused on strategic priorities, teamwork and the overall working environment (Knowles, 2011). TQM was initially used in the private sector to achieve integral monitoring and estimate an organisation's relevant activities to reach excellent business results (Ruso et al., 2013). According to Kerfai et al. (2016), TQM is one of the most used approaches in organisations to achieve high-quality goods. TQM philosophy enables organizations to produce flawless goods based on continuous improvement and a performance measurement system, achieving customer satisfaction (Ghunaim & Jaaron, 2022). Several authors (Osoko & Muda, 2021; Gupta & Mittal, 2021; Anil & Satish, 2019) agree that the essence is the constant satisfaction of the needs and demands of users and that quality is not only a matter of function in the organization, but that quality depends on each individual and his performance in the organization. The aim of the paper is to analyse the concept of six sigma and 8D method and to make an overview, systematization and structure of all the tools used, which entrepreneurs use and can use for continuous improvement of their business.

2. THE SIX SIGMA CONCEPT

The Six Sigma concept or approach was first developed in Motorola's environment in mass production when the then Motorola struggled to deliver quality in all product segments. It became widely popular at the end of the 90s of the last century when General Electric introduced the Six Sigma concept into its way of working at the beginning of the 21st century, when it grew from a concept and approach to work philosophy. Six Sigma as a strategy has been applied in many industries. It should also be considered that other improvement concepts, such as LEAN production, can coexist with the Six Sigma concept in companies if needed (Knowles, 2011). Six Sigma is a comprehensive and flexible system for achieving, maintaining and maximizing business success (Franchetti, 2015). Six Sigma includes five phases, within which different tools can be applied, depending on the situation. The phases are known by the acronym DMAIC, which stands for the following (Brue, 2002):

1. Define – Identifying problems, goals, users and outputs from the system. Within this phase, there are key steps that we must take into account when processing them (Gopalakrishnan, 2012): Define Key Users, Define Key User Needs, Define Problems, Define Main Processes, Define Goals, Define Projects and Define Outcomes.
2. Measure – Quantification of current process performance. The main idea of the second phase within the DMAIC cycle is to describe improvement opportunities and quantify a process's basic performance (Gupta, 2004). Also, in the measurement phase, process performance data is collected for primary and secondary measure-

ments in order to gain insight and understanding of the root of the problem and to establish the basic performance of the process (Kubiak, 2014).

3. Analyze – Analyze the cause of the problem. The third phase of the DMAIC model, referred to in the literature as the analysis phase, is considered the most important phase in this model of the Six Sigma concept. The existence of a defined problem and knowing why it appears is defined in this phase. However, the biggest problem is that several teams notice the problem and the cause of its occurrence in the earlier stages and immediately move to the improvement stage, which can cause an error during further work, due to which it is recommended that certain efforts be directed towards the analysis phase in order to avoid potential problems during further work (Breyfogle, 2003)
4. Improve – Improving the process to eliminate defects. The improvement phase aims to change the process to eliminate defects, waste, and cost reduction related to the users' needs identified in the first phase (George, 2003).
5. Control – Maintenance of new process performance. In implementing the Six Sigma concept, the management phase is taken as the final phase, while control must be carried out through all the activities of the DMAIC phases. During the control process, all processes related to implementing changes that would lead to improvement are subjected to internal control, where more important processes are clearly distinguished and analyzed to the smallest detail. In the case of less important processes, they analyze only basic activities to maximize effectiveness (Caroll, 2013).

3. 8D METHODOLOGY

In order to take advantage of complaints, organizations must design, build, implement and continuously improve a complaint management system (Bosch & Enríquez, 2005). The value of complaints was also recognized by the International Organization for Standardization, which developed a series of standards related to user satisfaction: ISO 10000. These standards provide guidelines for organizations, but certification is not carried out according to them (Sekulović et al., 2018). Customer satisfaction is one of the most important components of any organization. The case study of a chemical manufacturer shows that customer complaints can be used to identify the causes of problems that lead to customer dissatisfaction (Hallen & Latino, 2003). Moreover, the results showed that eliminating the root of the problem leads to increased user satisfaction. SRPS ISO 9000:2015 defines this term as the user's opinion about the degree to which his expectations have been met (Sekulović et al., 2018). The goal of this method is not to take the place of the quality system but to face the problems and discover the weaknesses in the management systems that allowed the problem to occur. According to Rambaud (2010), applying the 8D methodology in the organization only as a report on the problem on one side of the paper is an abuse of the implementation of this concept. Even more, abuse occurs when the report is required to be completed within 24 hours, as some steps can take a few hours and some take weeks.

The main reasons for applying this method are:

- Structured so that everyone can use it;
- It is transparent and encourages communication;
- Helps teams reach a clear solution to a problem;
- Acts as an excellent "apparatus for extinguishing the pain" when problems arise;
- Documents the process of finding a solution.

4. ANALYSIS OF THE APPLICABILITY OF TECHNIQUES AND TOOLS IN *THE CHOSEN CONCEPT AND METOFOLOGY*

4.1 Analysis of the applicability of techniques and tools in the Six Sigma concept

As mentioned, the Six Sigma concept is based on the DMAIC framework, which uses various methods and techniques (Muralidharan, 2015). The tools and techniques most suitable for the specific phase are used in each phase. The tools and techniques used throughout the phases are not defined and vary depending on the project to which it relates (Plsek & Onnias, 1989).

The following tools can be used in the improvement phase (Franchetti, 2015; Muralidharan, 2015):

– Control Chart as a secondary tool
– Fault Tree Analysis as a primary tool
– FMEA as a secondary tool
– Gantt chart as a secondary tool
– Meeting minutes as a secondary tool
– Pareto diagram as a primary tool
– Scatter plot as a secondary tool
– Kanban as a primary tool
– Tollgate review as a secondary tool
– Tree diagram as a primary tool
– Value stream mapping as a secondary tool
– Analysis of influencing forces as a secondary tool
– Value stream mapping as a secondary tool
– SIPOC model as a primary tool
– Quality Function Deployment as a primary tool
– Run chart as a secondary tool

Table 1. Tools and techniques applicable in the phase of defining the Six Sigma concept

	Quality Improvement Tools								
Steps in problem-solving	Isikava Diagram	Brainstorming	Affinity diagram	Gantt chart	5 Ways	Critical to quality	Flow Diagram	Project monitoring	Quality cost analysis
Define key users		S	S			P		S	
Define the needs of key users		S				P		S	
Define a problem	P	S	S		P	P	S	S	S
Define key processes	P	S		S		P	S	S	S
Define a goal		S	S	S		P	S	S	S
Define projects		S		S		P	S	S	S
Define outcomes	S	S		S		P	S	S	S
Selection of key quality requirements	S	S	S	S	S	P	S		
Defining process performance standards		S			S	P	S		
Building a data collection plan, validating the measurement and data collection system	P	S	P	P		P	S	S	S

P- Primary; S-Secondary

Table 1 shows the main tools used in each of the phases of concepts of TQM. It is seen that:

- The Ishikawa diagram can be the primary tool for defining problems, the main problem's process and outcome;
- Brainstorming is suitable as a secondary tool for all steps in the phase „Define";
- An affinity diagram is suitable as a secondary tool for defining key users, problems and goals;
- The Garnet diagram is suitable as a secondary tool for displaying the main processes, goals, projects and outcomes;
- The five whys method can be the primary tool for defining problems;
- CTQ is the primary tool used for all steps in the "Define" phase;
- A flow diagram is suitable as a secondary tool for displaying problems, the main one's processes, goals, projects and outcomes;
- Project monitoring is essential to all steps in each phase of the Six Concept Sigma;
- Quality cost analysis is a convenient tool that can be used as a secondary tool for presenting problems, main processes, goals, projects and outcomes.

Table 2, which was made based on the table from (Quality Improvement Tools, 1989), shows the tools and techniques applicable in the measurement phase of the Six Sigma concept (Plsek & Onnias, 1989).

Table 2. Tools and techniques applicable in the measurement phase of the Six Sigma concept

	Steps in problem-solving		
Quality Improvement Tools	Selection of key quality requirements	Defining process performance standards	Building a data collection plan, validating the measurement and data collection system
Isikava Diagram	S		P
Brainstorming	S	S	S
Statistics	S		P
Value Stream Mapping	S		P
5 Whys	S	S	
Critical to quality	P	P	P
Project monitoring	S	S	S
Analysis of the measurement system			S
Confidence intervals			S
A “scattered” dot plot			S
Random sampling			P
Systematic sampling	S	S	S
Methods and Techniques for sample selection			S
Data collection			P
Stratification			S
Cluster sample			S
Process Capability Analysis	P	S	
Multivoting	S	S	S
Pareto diagram	S	S	S
Process Capability Analysis		S	

P- Primary; S-Secondary

Various tools and techniques can be employed throughout the requirements selection and construction steps (Plsek & Onnias, 1989):

- An Ishikawa diagram proves valuable in identifying and addressing root causes;
- Brainstorming serves as an effective method in every phase, fostering creative thinking;
- Statistics play a crucial role in selecting requirements and constructing a robust plan;
- Value stream mapping aids in streamlining processes during requirement selection and construction planning;
- The 5Whys technique helps in uncovering underlying issues and defining standards, as well as assessing process performance;
- Critical to quality acts as a primary tool across all steps, ensuring adherence to quality objectives;
- Project monitoring serves as a secondary activity, providing ongoing oversight;
- Measurement system analysis assists in data collection and validating measurement systems;
- Confidence intervals are helpful in gauging the reliability of collected data;
- Scatter plots aid in visualizing data and validating measurement systems;
- Random and systematic sampling are secondary activities used throughout the phase;
- Methods and techniques for sample selection act as secondary tools in building data collection plans and validating measurement systems;
- Data collection itself is a core activity in the planning phase, ensuring the availability of accurate information;
- Stratification and cluster sampling are secondary tools employed in building data collection plans and validating measurement systems;
- Process Capability Analysis serves as a primary tool for defining process performance standards and as a secondary tool for selecting quality requirements;
- Multivoting facilitates decision-making, while Pareto charts aid in prioritization in each phase step.

Tables 3 show the tools used in the Analyze and Improve phases (Juran, 2004) (Gupta, 2004) (Brue, 2002): In the analysis phase, the Tree diagram and Fault Tree Analysis can be used as primary tools, which shows chronologically and hierarchically the causes of the problem, while secondary tools and/or activities include Histogram, Scatter diagram, Statistics, Ishikawa diagram, Tollgate review, Activity network diagram, SIPOC model, Flow diagram, Scatter diagram and process capability analysis.

Table 3. Tools and techniques applicable in the stages of improvement and analysis of the Six Sigma concept

	Quality Improvement Tools											
Steps in problem-solving	Control Chart	Fault Tree Analysis	FMEA	Histogram	Gantt chart	Meeting minutes	Pareto diagram	Scatter diagram	Statistics	Ishikawa diagram	Kanban	Tollgate review
Analyse		P		S				S	S	S		P
Improve	S	P	S		S	S	P	S			P	P
Quality Improvement Tools												
Steps in problem-solving	Activity network diagram	Tree diagram	Value Stream Mapping	Process Capability Analysis	Analysis of influencing forces	Value Stream Mapping	SIPOC model	Flow chart	Scatter diagram	Quality Function Deployment	Run chart	
Analyse	S	P		S			S	S	S			
Improve		P	S		S	S	P			P	S	

P- Primary; S-Secondary

Finally, in phase Control, Table 4 shows which quality improvement tools are primary and which are secondary.

Table 4. Tools and techniques applicable in the control phase of the Six Sigma concept

	Steps in problem-solving			
Quality Improvement Tools	Discipline	Documenting progress	Monitoring results	Development of a process management plan
5S	P			
Statistics			P	
Analysis of the measurement system			S	
Data Collection		S	S	S
Total productive maintenance	S	S		
Project monitoring			P	P
Meeting minutes		P		
Tollgate review	S	S	S	S
Kanban	P			
Control chart	P	P	P	P

4.2 Analysis of the applicability of techniques and tools in the 8D methodology

In the 8D methodology Schade (2020) uses a structural approach and teamwork, and outlines nine steps:

- D0- Project planning and information gathering. The first step in creating a report for this method is project planning, where the main goal is to create a plan and create a framework in which the activities will be carried out.
- D1- Formation of the team. Forming a team is a step in which it is necessary to form a team of people who have adequate knowledge about the product, project or process in which the problem arose, as well as experience in solving specific problems (Kaplík et al., 2013).
- D2- Defining and describing the problem. This activity is key to problem-solving in this concept, it is also one of the most important activities because a wrongly defined problem would slow down or prevent the way to improve or solve the problem (Carter, 2012).
- D3 - Development of corrective measures - Temporary measures to contain the problem. ISO 9000:2015 standard defines correction as a measure to eliminate nonconformity and adds that it can be performed before the corrective measure, as the corrective measure or after it. An example of correction can be refinement or reclassification. The application of this step depends on the nature of the matter. Its purpose is to establish, verify and implement temporary measures that will temporarily contain the problem until permanent corrective measures are implemented.
- D4- Determination and verification of the leading cause. This step aims to isolate and verify the main cause of the defined problem and locate it in the process. The root cause is determined by testing all possible causes based on the collected data (Kaplík et al., 2013). Several concepts can be used to determine the root cause of a problem, such as 5 Why, Brainstorming, Ishikawa diagram, FMEA or Pareto principle.
- D5- Selection and verification of permanent corrective measures. The fifth discipline of the 8D concept aims to select the best permanent corrective measures to eliminate the root cause and location of the bottleneck. Their verification is necessary for effectiveness and to see whether their implementation will lead to certain side effects. The ISO 9000:2015 standard defines a corrective measure as a measure to eliminate the cause of nonconformity and prevent its recurrence. It emphasizes that there may be more than one cause of nonconformity.
- D6- Application and validation of corrective measures. This step's purpose is planning, implementing and validating selected permanent corrective measures. Before their implementation, it is usually necessary to remove implemented corrective measures to temporarily contain the problem (Kaplík et al., 2013).
- D7- Prevention of the recurrence of problems. The goal of this phase is to review the implemented activities and check if there are any other processes in the organisation where there is a risk of similar problems occurring. It adds that the acquired knowledge should be applied to education in order to avoid the old way of thinking and to prevent future non-conformities.

D8- Congratulations to the team. This step aims to summarise all the experiences and knowledge of the team and complete the documented information for the 8D report (Kaplík et al., 2013). The last step of the 8D concept may seem like a formality, but it is very important. It consists of congratulating the team for their efforts and work to solve the problem. Punishments and monetary rewards are not the only factors of motivation (Carter, 2012).

Below is Table 5 showing activities and tools used throughout each activity.

Table 5. Activities and tools used throughout each activity in 8D

	Activities in 8D methodology								
Tools and technique	D0	D1	D2	D3	D4	D5	D6	D7	D8
Data collection	P		P						
Sample size determination					S				
Random sampling					S				
Systematic sampling					S				
Stratification					S				
Cluster sample					S				
Measurement System Analysis					S				
Brainstorming	S	S	S	S	S	S	S	S	
Multivoting	S	S	S	S	S	S	S	S	
Affinity diagram			S						
Tree diagram			S						
Critical to quality tree				P					
Activity Network Diagram			S	S	S	S			
Quality Cost Analysis	S	S	S						
FMEA	P		S	S					
Fault Tree Analysis	S								
Value Stream Mapping				S		S	P		
Basic Statistic					P				
Confidence intervals					P				
Histograms			S	S	S				
Pareto Chart			P		S	S			
Flowchart	S								
Gantt Chart	S								
Force Field Analysis			S						
Ishikawa Diagram			P		P				
Quality Function Deployment			S	S	S				
Run Chart			S						

	Activities in 8D methodology								
Tools and technique	D0	D1	D2	D3	D4	D5	D6	D7	D8
Control Chart			S						
Process Capability Analysis			S	S		S			
5S model								S	
SIPOC model	P	S	P	S	S	S	S	S	S
Total Productive Maintenance								P	
Project Tracking			S	S	S	S	S	S	
Meeting Minutes	S	S	S	S	S	S	S	S	S
Kanban						S	P	P	
Tollgate review	S	S	S	S	S	S	S	S	S

P- Primary; S-Secondary

5. CONCLUSION

It is straightforward to conclude that total quality management concepts and methodologies can achieve a strong competitive advantage and overall improvement. Large companies such as Toyota, General Motors, Siemens, Ford and others use total quality management tools and techniques to improve their operations and achieve their main goal, which is customer satisfaction. Several experts, who advocated different approaches and theories in total quality management, agree that the essence is the constant satisfaction of the needs and demands of users and that quality is not only a matter of function in the organization but that quality depends on each individual and his performance in the organization. Also, top management must ensure that quality is present throughout the organization and starts from the top because, as Juran (1986) said, managers and workers speak different languages. Workers understand the language of tangible things, and management understands the language of money. The task of management is to make people more responsible. It would be best if you did not ask what rights belong to me - but what I am responsible for. The task of management in a knowledge-based organization is not to make everyone a boss. The task is to make everyone a contributor. It should be noted that the tools and techniques used in total quality management do not always have to be used, but that it is up to the top management and the situation in which the organization finds itself to choose which technique or tool to use. All tools and techniques outlined in this paper apply to large, small and medium organizations.

The tables are made to show the essential tools used throughout the phases of the total quality management concept and are designed based on tables created by the Juran Institute team. The paper offers valuable insights, knowledge, and advice to entrepreneurs and managers seeking to enhance their product or service quality and operational efficiency and to achieve enduring success in the long run.

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