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KINGA RATAJSZCZAK

kinga.ratajszczak@put.poznan.pl
Poznań University of Technology. Faculty of Engineering Management
2 J. Rychlewski St., 60-965 Poznań, Poland
ORCID ID: https://orcid.org/0009-0008-7324-8097

AGNIESZKA MISZTAL

agnieszka.misztal@put.poznan.pl
Poznań University of Technology. Faculty of Engineering Management
2 J. Rychlewski St., 60-965 Poznań, Poland
ORCID ID: https://orcid.org/0000-0003-4439-4198

ROMA MARCZEWSKA-KUŹMA

roma.marczewska-kuzma@put.poznan.pl
Poznań University of Technology. Faculty of Engineering Management
2 J. Rychlewski St., 60-965 Poznań, Poland
ORCID ID: https://orcid.org/0000-0002-5473-4689

Classification of Quality Management Methods and Tools in a Functional Approach

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Abstract

Theoretical background: The evolution of the instrumentation of quality management makes the list of methods and tools constantly open and inexhaustible. The problems of dividing and classifying quality management instruments are very often discussed in the literature. The need to have a variety of methods and tools is due to the fact that the development of modern competitive strategies, affecting the strengthening of market position, the need for rapid decision-making, as well as progress, mainly in the field of information technology and continuous changes in markets, pose qualitatively new challenges to managers.
Purpose of the article: The purpose of this article is to present selected quality management instrumentation by process group.
Research methods: In this article, literature review was the starting point for empirical research. Finally, a set of fifty new and classic quality management methods and tools in relation to their main functions was analysed. Based on this, data tables were generated.
Main findings: In a large collection of methods, tools and solutions, new concepts appear that are multi-disciplinary and require interdisciplinary knowledge. The choice of appropriate quality instruments is determined by the specificity of the organization and many other variables. The correct use of quality management instruments contributes to solving problems at the management and executive levels of production enterprises, while enriching knowledge about processes.

Introduction

Quality management is timeless, and is rooted in quality being inherent in human development. When considering definitions of the concept of quality, a certain difficulty arises caused by its subjective nature. The premises from which the problems arise concern (Bugdol, 2008):

– quality assessment dependent on experience, knowledge, demand for the product,

– the concept of quality undergoing transformation as a result of the development of mankind and the quality changes taking place,

– the level of awareness of employees and superiors and the degree of implementation of quality concepts in enterprises affecting quality assessment and practical approach to product quality,

– customer requirements determining the level of quality of products,

– multidimensionality and interdisciplinarity.

Management by quality requires the active cooperation of all employees of a company to ensure the highest quality of products and services, and to take care of increasingly better relations based on mutual trust between the manufacturer, the seller and the customer (Hebda-Grodzka, 2002). Hamrol and Mantura point out "that it is difficult to date the various phases of development of quality management, since they proceeded differently in different countries, regions, industries, enterprises, and in theory and practice" (1998, pp. 90–98). Determining the precise dates of the emergence of the various stages of development of management by quality is difficult and conventional. In the literature, until recently, four basic stages of development were most often mentioned: quality inspection, quality control, quality assurance and quality management (Dahlgaard et al., 2004, p. 17), however, the development of

new technologies has changed the approach to quality. In recent years, the concept of Quality 4.0 has begun to appear in the literature as an adaptation to the developing Industry 4.0. The new digitalized quality management takes advantage of modern technologies such as the Internet of Things (IoT), artificial intelligence (AI) and Big Data. What follows is the use of automated sensors, advanced data analysis, and improved communications to monitor production processes in real time, identify defects, and improve productivity. Intelligent systems can automatically and autonomously collect data and consequently obtain information about production cycles, quality requirements and waste production (Salimbeni et al., 2023). They also allow modeling, simulation and forecasting of process and product quality, which supports informed decision-making in this regard (Zonnenshain & Kenett, 2020; Antony et al., 2022).

The reorientation of the world to sustainable development, including a focus on people and the environment with the use of IT and automation, has become the crux of the introduction of Quality 5.0. Optimization of production processes is currently being treated in an expanded scope of influence, as advanced data analysis can help improve production processes, not only reducing production times and eliminating unnecessary waste, but also optimizing the use of raw materials and energy, which corresponds to greener processes (Tadić Stanić, 2022).

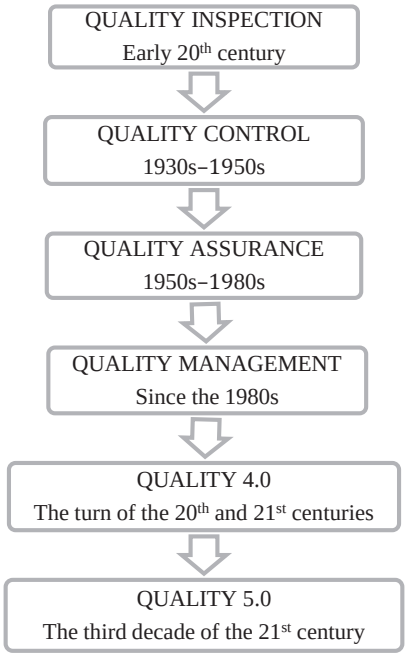

Figure 1. Stages of development of quality management

Source: Authors' own study.

Fundin et al. (2020) identify five areas that will concern quality in the current decade. These are: system perspectives, stability of change, models of intelligent self-organization, integration of sustainable development and higher purpose as support for quality management. Challenges nato-have included providing systematics and methodologies to explore and understand root causes and diversity, as well as knowledge about developing organizational capacity for learning, change and adaptation (Fundin et al., 2020). The stages of evolution of the quality approach are shown in Figure 1.

Literature review

The very small number of studies on the classification of quality management methods and tools prompted to focus on this topic in the article. The literature review began with a search for entries in the Scopus database.

Table 1. Search results for key terms in the Scopus database in 2024

Searching		
Searched phrase	Number of results in keywords	Number of results in the title
Classification of quality methods and tools	160	1
Classification of quality management methods and tools	20	0
Functional division of quality methods and tools	0	0
Functional division of quality management methods and tools	0	0

Source: Authors' own study based on Scopus database.

Analyzing the data from Table 1, it can be concluded that the topic of classification, methods and tools is discussed in the literature. However, the issue of functional divisions is much worse, which is confirmed by the lack of any sources in the extensive Scopus database. For more sources of articles, the Google Scholar and ResearchGate databases were used. In total, the literature review included nearly fifty sources on which the author's own research was based. Most of them were published after 2010.

A review of the literature confirms that the practice of quality management is to be based on scientific evidence that combines the achievements of qualitology and management organization science, creating a theory of quality management. This management is supposed to be the study, review, mutual adaptation and growth of the relationship between quality and management issues in organizations. Hence, quality management is titled the realization of management functions according to the quality of the managed system. This management includes the quality of the system taken as a whole, as well as all its components. In the cyber context, quality management functions can be evaluated by comparing the ratio of quality at the output to quality at the input of the process (Hamrol & Mantura, 2005, pp. 99–103).

Moreover, quality management is the substrate of effective leadership implemented through (Łańcucki, 2003):

– a commitment to continuous improvement and management of improvement systems,

– a philosophy of doing things right the first time,

– modern supervised and coached management processes through teamwork,

– training in understanding the nature and essence of the supplier–customer relationship,

– improvement of communication,

– development and systematic implementation of TQM.

The successful implementation of quality management in an organization depends on the fulfillment of many aspects, such as the involvement of top management and all employees, continuous training, education and the use of quality methods and tools (Skrzypek & Hofman, 2010).

The instrumentation of quality management includes quality principles, methods, techniques and tools. The difference is the range of impact of each instrument. The characteristic feature of the principles is the long-term impact and influence on the development strategy of the enterprise. Principles do not provide ready-made solutions or a scheme of conduct, but serve to guide and motivate efforts to improve and enhance quality in enterprises. As for the methods, they make it possible to indicate medium-term impact, shaping the design quality and performance quality of products. On the other hand, short-term in impact are tools, the effective use of which can be seen in combination with other methods. The last group is made up of techniques, which are components of principles, methods or tools and are used to achieve specific goals within the entire instrumentation (Hamrol & Mantura, 2002; Mazur & Gołaś, 2010). The integration of several quality management instruments shows data in different ways while creating a comprehensive analysis of information. Each instrument is equally important because of its diversity (Bamford & Greatbanks, 2005, pp. 378–379).

The evolution of the instrumentation of quality management makes the list of methods and tools constantly open and inexhaustible. The problems of dividing and classifying quality management instruments are very often discussed in the literature (Jękal & Małysa, 2022, pp. 2–6; Tomaszewska, 2022, pp. 117–130; Winkowska & Winkowski, 2018, pp. 370–381; Frąś et al., 2017, pp. 175–188; Hamrol, 2017, pp. 153–206; Wolniak, 2019, pp. 15–23; Marzec, 2017, pp. 79–90; Wawak, 2013, pp. 37–49).

One of the classifications indicated is QT&T (quality tools and techniques) based on the SIPOC (suppliers, inputs, process, outputs, customers) diagram. The first rationale for this classification was the diversity of functioning quality management instruments, i.e. methods, tools, principles, concepts, ideas and approaches. The second was the diversity of environments, as well as the orientation towards the formulation of organizational knowledge resources (Starzyńska & Grabowska, 2010, pp. 515–524).

Another of the classifications that has been popular with employees of companies in various industries for years distinguishes seven new and seven traditional quality tools. It serves to engage in problem solving, promote creative thinking, graphical presentation of results, search for causes of various undesirable events and areas for improvement (Mazur, 2023, p. 106). New management approaches improving the development of new quality concepts and tools are being identified. Some sources state that combining traditional quality methods with the use of Big Data and artificial intelligence will accelerate and improve operations within organizations in the near future (Broday, 2022, pp. 368–382). It is possible to see the positive impact of the use of methods and tools supporting quality management in conjunction with the concept of lean management, which have a significant impact on reducing the occurrence of production problems (Jękal & Małysa, 2022, pp. 2–6).

The use of quality management instruments contributes to solving problems at the management and executive levels of manufacturing enterprises, enriching process knowledge. Quality management instruments are designed to (Starzyńska & Grabowska, 2010, pp. 515–524):

– collect data and process it into information about events and processes occurring in the production system and its environment,

– support decision-making on the basis of verified data and information,

– improve the work of an individual employee and motivate teamwork.

Among the factors that have led to a huge variety of quality management instruments (especially at the level of implementation of executive processes) are the following (Starzyńska & Grabowska, 2010, pp. 515–524):

– the long history of the development of quality management concepts,

– the dissimilarity of the cultures in which they were developed,

– approaches emphasizing different elements of the concept,

– interpenetration of "quality" concepts with production management concepts,

– assignment to different organizational levels of the enterprise,

– placement in different phases of the product life cycle.

A prerequisite for the effective use of quality management instruments is the understanding of the need for their use and the full involvement and support of top management, the planning and organization of functions related to the implementation of the instruments, the involvement and participation of employees based on teamwork, and a properly conducted training program (Mazur & Gołaś, 2010, p. 28). The need to have a variety of methods and tools is due to the fact that the development of modern competitive strategies, affecting the strengthening of market position, the need for rapid decision-making, as well as progress, mainly in the field of information technology and continuous changes in markets, pose qualitatively new challenges to managers. The implementation of new management principles is a lengthy, difficult, and conflicting process. It is recommended to create programs in organizations for the comprehensive implementation of both concepts and a variety of methods (Pałucha, 2012, pp. 260–261).

Research methods

The main methodology in this article was a literature review. In addition to quality management methods and tools, the literature review also included those from lean management and contemporary management. The reason is its increasing use in the area of quality management. Based on the indicated attempts to expand the classical approach to quality management methods and tools, a decision was made to use a complex set of instruments in the article.The literature review, as mentioned earlier, involved finding various classifications and divisions of quality management methods and tools (Jękal & Małysa, 2022, pp. 2–6; Tomaszewska, 2022, pp. 117–130; Winkowska & Winkowski, 2018, pp. 370–381; Frąś et al., 2017, pp. 175–188; Hamrol, 2017, pp. 153–206; Wolniak, 2019, pp. 15–23; Marzec, 2017, pp. 79–90; Wawak, 2013, pp. 37–49; Starzyńska & Grabowska, 2010, pp. 515–524). In enterprise quality management, quantitative and qualitative methods, tools and techniques are used to improve key quality elements (Vernon, 2002, p. 172).

The selection of quality management methods and tools that will bring the most benefitsarebased on various criteria, depending on the needs. They are used both during quality improvement, checking and analysis of results after implementation (Winkowska & Winkowski, 2018, pp. 370–381). A hypothesis was put forward stating that, based on the literature review, a set of quality management methods and tools can be identified, divided into functions.

Results

The analysis of the literature on quality management instrumentation made it possible to identify directions for their use, and in the next step to subjectively group the fifty instruments selected during the literature review around the functions:

A) organization of production processes,
B) product design and improvement,
C) data identification and analysis,
D) process management,
E) organization design,
F) organizational performance evaluation,
G) continuous improvement,
H) engaging employees.

The continuous emergence of new instruments related to TQM, lean, modern process management, knowledge management, enterprise sets a comprehensive basket of 50 methods and tools that serve quality management. It is interesting and valuable to summarize quality management methods and tools from the perspective of their use, where the key is the functions and management processes they support (Tables 2–9). Each instrument has been assigned to a category of functions indicating

the main functions performed. In the case of methods corresponding to more than one function, the primary consideration was their original use.

A) organization of production processes (purpose: to ensure appropriate process conditions)

Table 2. Set of methods/tools/techniques assigned to functional group A

No.	Method/tool/technique	Action
1	5S	Systematic and sustainable order at workstations
2	Kanban	Inventory control
3	Poka Yoke	Detection and elimination of errors
4	SMED (single minute exchange of die)	Reducing changeover times of machines, equipment and production processes
5	TPM (total productive maintenance)	Use of available machine time to produce products
6	Process validation	Confirmation by providing proof of meeting a specific requirement
7	JiT (just in time)	On-time production, reduction of inventory
8	Statistical quality control	Observation of processes, response to nonconformities

Source: Authors' own study based on: (Salwin et al., 2019, pp. 137–151; Szwedzka & Jasiulewicz-Kaczmarek, 2015, pp. 408–414; Osada, 1991; Konieczka & Konieczna, 2019; Łangowska, 2008, p. 7; Chan et al., 2005; Belu et al., 2015, Danielak & Pujer, 2017; Kołakowska, 2018, pp. 91–92).

In the first area organization of production processes there is a huge amount of management-related instruments, but not all of them are related to quality. A limited number of management methods, tools and techniques related to quality are indicated here. Some of them were developed in Japan for the purpose of improving production processes while maintaining the highest quality standards. They constitute the basis for techniques and detailed solutions used in the design of work stations, cells and production lines.

B) product design and improvement (purpose: to transform input assumptions into product specifications and then manufacturing processes, taking into account the possibility of achieving design quality within existing technical and financial constraints, analyzing performance, identifying opportunities and making incremental changes)

Table 3. Set of methods/tools/techniques assigned to functional group B

No.	Method/tool/technique	Action
1	FMEA (failure mode and effects analysis)	Identify potential risks and impacts that may occur during project implementation
2	QFD (quality function deployment)	Transmission of information from the market on consumer requirements, technical parameters used by designers in the organization
3	SERVQUAL	Service quality assessment combining service quality design simultaneously from the point of view of the enterprise and the customer
4	Valuing quality	Evaluating product quality and solving decision-making problems
5	Taguchi method	Designing parameters aimed at finding optimal values for controllable factors

Source: Authors' own study based on: (Macura et al., 2022, pp. 103–118; Taguchi & Clausing, 1990, pp. 65–75; Mazur & Gołaś, 2010; Urbaniak, 2013, pp. 29–38; Mantura, 2012, pp. 37–24).

Within the design and improvement function, methods and tools related to material products, design and improvement of services have found their place. The oldest of the methods mentioned in this function is FMEA, which identifies potential threats and effects that may occur during the implementation of the project/process.

C) data identification and analysis (purpose: to generate knowledge about a given phenomenon, to check, organize, transform and model data in order to gain useful information, develop conclusions)

Table 4. Set of methods/tools/techniques assigned to functional group C

No.	Method/tool/technique	Action
1	Control chart	Monitoring and control of process variability
2	Affinity diagram	Arranging information in groups
3	Relationship diagram	Demonstrating the relationships that exist between factors that affect difficulties
4	Matrix diagram	Showing the relationships between selected elements in the form of a matrix
5	Pareto–Lorenz diagram	Solving problems by prioritizing them according to the most important causes
6	Analysis sheet	Collecting data with simultaneous ordering of data
7	Histogram	Detecting outliers, skewness, bimodality and other shape features in the distribution, as well as for comparing subgroups in the data
8	Ishikawa diagram	Identifying problems and their causes
9	Scatter diagram	Investigating relationships between two factors

Source: Authors' own study based on: (Kowalik, 2018, pp. 15–17; Detyna, 2011, pp. 164–165; Bachman, 2017, pp. 46–47; Mazur-Dudzińska & Dudziński, 2015; Łuczak, 1994, p. 11; Miller, 2011, p. 449; Stefanów, 2007; Krechowicz, 2022; Łuczak & Matuszak-Flejszman, 2007, pp. 248–249).

The quality management instrumentation includes methods and techniques that use statistics, observation, and reasoning. Also, in the first half of the 20th century, the first production quality control systems were introduced, along with methods that are still popular today.

D) process management (purpose: to increase the efficiency of the organization)

Table 5. Set of methods/tools/techniques assigned to functional group D

No.	Method/tool/technique	Action
1	Six sigma	Monitoring and continuous control to eliminate nonconformities in processes and products
2	SPC (statistical process control)	Observation of processes and response to nonconformities
3	Process capability analysis	Determining the degree to which quality requirements are met
4	Skills matrix	Charting the existing and missing skills in the team of employees
5	Bernaténé–Grün chart	Analysis and evaluation of procedures
6	Clark chart	Analysis of the entities of the procedures
7	Network diagrams	Presentation of interconnections between entities reducing the process execution time
8	Flowchart	Presentation of the next steps in the algorithm

Source: Authors' own study based on: (Parab et al., 2016, pp. 85–97; Szerszunowicz, 2013, pp. 153–161; Bielińska, 2017, pp. 155–169; Czekaj, 1975; Ćwiklicki & Alcouffe, 2013; Grześ, 2014, pp. 196–214).

The process management function includes methods for describing processes and research tools that take into account statistics and improvement. The 20th century first brought statistical methods, and then diagrams, on the basis of which IT solutions are proposed. In the past, these systems were implemented in large corporations, now there are generally available applications for smaller and medium-sized enterprises on the market.

E) organization design (purpose: to identify elements of structure and ties)

Table 6. Set of methods/tools/techniques assigned to functional group E

No.	Method/tool/ technique	Action
1	Process decision program chart	Analyze events using simulations, determine preventive actions
2	Quality planning	Identify and implement actions necessary to ensure that customer expectations for a product or service are met
3	Benchmarking	Comparison of processes and practices used by own organization to those used by organizations considered best in a particular field
4	Decision tree	Graphic decision support

Source: Authors' own study based on: (Hamrol & Mantura, 2005; Małyszko & Wielgosz, 2016, pp. 318–323; Podgórska, 2013, pp. 325–337; Xu et al., 2018, pp. 79–102).

Over the years, a number of methods and techniques have been developed to support the design of organizations. Some of them were created for dedicated management fields.

F) evaluation of the organization's performance (purpose: to evaluate the effectiveness and efficiency of the organization)

Table 7. Set of methods/tools/techniques assigned to functional group F

No.	Method/tool/technique	Action
1	The Deming Application Prize	Evaluating the organization according to the criteria: organization's policies and goals, organization and its operational activities, knowledge education and dissemination, data collection, communication and its use, analysis, standardization, control, quality assurance, results, future plans
2	Malcolm Baldrige National Quality Award	Evaluate the organization according to criteria: leadership, strategic planning, customer and market focus, information, analysis and knowledge management, human resource management, process management, business performance
3	The European Foundation for Quality Management	Identification of where the organization is on the path to excellence
4	Customer Satisfaction Survey	Identification, diagnosis and classification of stakeholders
5	ISO 9004 Self-Audit	Charting guidelines for self-assessment and improvement
6	Cost of quality	Presentation of progress and quality issues in the organization

No.	Method/tool/technique	Action
7	Management review	Collection, summary of information and analysis made on the basis of the process measurements made
8	Internal audit	Independent advisory and verification activities, improving the organization

Source: Authors' own study based on: (Sułkowski & Wolniak, 2013; Kacała & Kołaczyk, 2013, pp. 145–154; Czernyszewicz, 2012, pp. 57–70; Imai, 2007; Szczęśniak, 2016; Kolman et al., 1996, pp. 24–25; Szczęśniak, 2016; Nowicki, 2015, pp. 284–315).

The group of methods indicated here allows for the collection of feedback on the functioning of the enterprise, some of them concern the current assessment, while the rest assess the entire organization. The first part consists of internal audits, management reviews, customer satisfaction surveys, the second part defines self-assessment models and the assessment of the organization according to the criteria of national and international awards.

G) continuous improvement (purpose: continuously achieving small improvements in process quality, product quality, delivery capability and service quality)

Table 8. Set of methods/tools/techniques assigned to functional group G

No.	Method/tool/technique	Action
1	Zero defects	Identification of nonconformities and formulation of improvements for nonconformity level 0
2	Kaizen	Continuous improvement of product and organizational quality
3	PDCA (plan, do, check, act) cycle	Optimization of processes, seeking solutions to increase operational efficiency and financial effectiveness
4	DMAIC (define, measure, analyse, improve, control) cycle	Problem solving, identification of requirements

Source: Authors' own study based on: (Nowosielski, 2014; Szczęśniak, 2016; Gupta, 2021, pp. 79–81).

Moving on to discuss the instruments of continuous improvement, it is important to note the multiple changes and evaluations of this concept. Currently, continuous improvement is identified with the Japanese philosophy of kaizen, which assumes the improvement of social, personal and work life.

H) engaging employees (purpose: to build trust in superiors, the organization and co-workers, appropriate working conditions and a well-thought-out incentive system)

Table 9. Set of methods/tools/techniques assigned to functional group H

No.	Method/tool/technique	Action
1	Quality circle	Group identification and development of an effective way to improve the studied phenomenon
2	Hoshin Kanri	Goal planning and implementation by all employees
3	Quality Audit Meeting	Group solution of current problems
4	Empowerment	Increasing employee empowerment

Source: Authors' own study based on: (Rodriguez et al., 2021, pp. 105–111; Konieczka, 2021, pp. 227–237; Kolman et al., 1996, p. 138; Krawczyk-Bryłka, 2012, pp. 313–330).

Another of the indicated functions is engaging employees – a key factor in the success of pro-quality programs. Without employee engagement in quality improvement activities, one cannot count on the success of implementing a quality management system. Considering the individual functions of the methods/tools/techniques in Tables 2–9, there is no doubt that all the indicated instruments in such a view can be used to a greater or lesser extent in different enterprises. The requirement to improve quality management processes implies the selection of various concepts, methods or techniques of organization. The selection of appropriate quality instruments is determined by the specifics of the organization and many other variables. In addition to well-known solutions, new concepts are emerging that have a multidisciplinary character and require interdisciplinary knowledge.

Discussions

Over fifty analyzed sources allowed to identify important quality management methods and tools. Eight basic functions were identified, i.e. organization design, process management, data identification and analysis, product design and improvement, organization of manufacturing processes, engaging employees, continuous improvement, and evaluation of organization performance. In the case of methods and tools corresponding to more than one function, the primary consideration was their original application. Some of them were indicated in other previously mentioned classifications, such as QT&T or seven new and seven traditional quality tools. However, none of the analyzed sources contained a functional division that could constitute a starting tool for working with quality management instruments.

The use of appropriate methods and tools of quality management is intended to maintain the correct quality of the product, as well as to reduce defects and inconsistencies already at the stage of production, and not during operation. When choosing an instrument or set of instruments to implement in the organization, it is worth paying attention to the indicated classification of functions, on the basis of which it is easy to adapt the desired instruments to the current needs of the organization.

Conclusions

The article analyzes a set of new and classic quality management methods and tools around their main functions: organization of manufacturing processes, product design and improvement, data identification and analysis, process management, organization design, evaluation of the organization's functioning, continuous improvement and employee involvement. The hypothesis was confirmed, and a set of quality methods and tools defined by function was created.

In a large collection of methods, tools and solutions, new concepts appear that are multi-disciplinary and require interdisciplinary knowledge. The choice of appropriate quality instruments is determined by the specificity of the organization and many other variables. The correct use of quality management instruments contributes to solving problems at the management and executive levels of production enterprises, while enriching knowledge about processes.

The considerations presented in the article contained a comprehensive analysis of the problem and theoretical considerations. It should be emphasized, however, that this article does not completely exhaust the issue of divisions and classification of quality management methods and tools. It, therefore, seems reasonable to continue research on this multi-aspect and multi-dimensional issue. Mainly in the direction of an attempt to examine the application and usefulness of these quality management methods and tools. Another important aspect of further research that should be undertaken in the future should be to determine the boundary conditions for the use of quality management methods and tools for manufacturers of medical devices. An interesting direction also seems to be the examination of forms of support for the possibility of electronic improvement of the functioning of quality management methods and tools.

References

Antony, J., Sony, M., Furterer, S., McDermott, O., & Pepper, M. (2022). Quality 4.0 and its impact on organizational performance: an integrative viewpoint. *The TQM Journal*, *34*(6), 2069–2084.

Bachman, P. (2017). Jakość w procesach produkcyjnych. *Problemy Inżynierii Bezpieczeństwa i Nauk o Pracy*, *5*, 46–47.

Bamford, D.R., & Greatbanks, R.W. (2005). The use of quality management tools and techniques: A study of application in everyday situations. *International Journal of Quality & Reliability Management*, *22*(4), 376–392.

Belu, N., Ionescu, L., Misztal, A., & Mazăre, A. (2015). Poka Yoke system based on image analysis and object recognition. In *IOP Conference Series: Materials Science and Engineering* (Vol. 95, article No. 012138). IOP Publishing.

Bielińska, N. (2017). Matryce kompetencji jako narzędzie wspomagające zarządzanie zasobami ludzkimi w przedsiębiorstwie produkcyjnym. *Przedsiębiorczość i Zarządzanie*, *Nauka dla praktyki gospodarczej i samorządowej: aplikacyjne walory teorii i instrumentów zarządzania*, *18*(3/2), 155–169.

Broday, E.E. (2022). The evolution of quality: From inspection to quality 4.0. *International Journal of Quality and Service Sciences*, *14*(3), 368–382.

Bugdol, M. (2008). *Zarządzanie jakością w urzędach administracji publicznej. Teoria i praktyka*. Difin.

Chan, F.T.S., Lau, H.C.W., Ip, R.W.L., Chan, H.K., & Kong, S. (2005). Implementation of total productive maintenance: A case study. *International Journal of Production Economics*, *95*(1), 71–94.

Czekaj, J. (1975). Wykres Clarka w badaniu i usprawnianiu pracy administracyjnej metodą analizy wrażliwości. *Organizacja – Metody – Technika*, *7*.

Czernyszewicz, E. (2012). Samoocena jako element oceny skuteczności systemu zarządzania jakością i doskonalenia organizacji ukierunkowanej na wyniki. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu. Orientacja na wyniki – modele, metody i dobre praktyki*, *264*, 57–70.

Ćwiklicki, M., & Alcouffe, A. (2013). The Dissemination of management innovations through consultancy in the postwar period. In *MPRA Paper 48310*. University Library of Munich.

Dahlgaard, J.J., Kristensen, K., & Kanji, G.K. (2004). *Podstawy zarządzania jakością*. PWN.

Danielak, W., & Pujer, K. (2017). *Nowoczesne zarządzanie organizacją ze szczególnym uwzględnieniem orientacji zasobowej*. EXANTE.

Detyna, B. (2011). *Zarządzanie jakością w logistyce*. Wyd. Państwowej Wyższej Szkoły Zawodowej im. Angelusa Silesiusa.

Frąś, J., Frąś, T., & Frąś, M. (2017). Model instrumentów zarządzania jakością w procesach produkcyjnych. *Problemy Nauk Stosowanych*, *6*, 175–188.

Fundin, A., Lilja, J., Lagrosen, Y., & Bergquist, B. (2020). Quality 2030: Quality management for the future. *Total Quality Management & Business Excellence*. **https://doi.org/10.1080/14783363.2020.1863778**

Grześ, A. (2014). Wykres Gantta a metoda ścieżki krytycznej (CMP). *Optimum, Studia Ekonomiczne*, *4*(70), 196–214.

Gupta, A.K. (2021). Kaizen costing: A system of cost reduction through continuous improvement. *International Journal of Research in Engineering, Science and Management*, *4*(3), 79–81.

Hamrol, A. (2017). *Zarządzanie i inżynieria jakości*. PWN.

Hamrol, A., & Mantura, W. (1998). *Zarządzanie jakością. Teoria i praktyka*. PWN.

Hamrol, A., & Mantura, W. (2002). *Zarządzanie jakością. Teoria i praktyka*. PWN.

Hamrol, A., & Mantura, W. (2005). *Zarządzanie jakością. Teoria i praktyka*. PWN.

Hebda-Grodzka, M. (2002). *Kompleksowe zarządzanie jakością (TQM) jako możliwość zmian w oświacie*. Wyższa Szkoła Administracji Publicznej w Białymstoku.

Imai, M. (2007). *Klucz do konkurencyjnego sukcesu Japonii*. Kaizen Institute Polska MT Biznes.

Jękal, A., & Małysa, T. (2022). Zastosowanie wybranych narzędzi lean manufacturing i jakości w zakresie poprawy organizacji produkcji. *Zarządzanie Przedsiębiorstwem*, *25*(1–2), 2–6.

Kacała, J., & Kołaczyk, E. (2013). Wdrażanie modelu doskonałości EFQM – determinant. *Zarządzanie i Finanse*, *4*(2), 145–154.

Kolman, R., Grudowski, P., Meller, A., & Preihs, J. (1996). *Wybrane zagadnienia zarządzania jakością*. Wyższa Szkoła Administracji i Biznesu.

Kołakowska, D. (2018). Walidacja a weryfikacja metody pomiarowej. *Zeszyty Naukowe Wydziału Elektrotechniki i Automatyki Politechniki Gdańskiej*, *59*, 91–92.

Konieczka, K. (2021). Solving problems in hoshin kanri system approach using quality management tools. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie*. **https://doi.org/10.29119/1641-3466.2021.153.16**

Konieczka, K., & Konieczna, M. (2019). Bariery i ograniczenia przy wdrożeniu metody 6s: studium przypadku. *Zeszyty Naukowe Politechniki Poznańskiej. Organizacja i Zarządzanie*, *79*, 119–131.

Kowalik, K. (2018). Diagram Ishikawy w teorii i praktyce zarządzania jakością. *Czasopismo Archiwum Wiedzy Inżynierskiej*, *3*(1), 15–17.

Krawczyk-Bryłka, B. (2012). *Empowerment* – strategia zarządzania oparta na zaufaniu. *Zarządzanie i Finanse*, *4*(*1*), 313–330.

Krechowicz, M. (2022). Towards sustainable project management: Evaluation of relationship-specific risks and risk determinants threatening to achieve the intended benefit of interorganizational cooperation in engineering projects. *Sustainability*, 2–20.

Łangowska, D. (2008). Zastosowanie japońskiej filozofii pracy Kaizen na przykładzie suwalskiej grupy Litpol Malow. In *Polska Wschodnia – Zarządzanie Rozwojem* (pp. 593–607). Wyższa Szkoła Administracji Publicznej.

Łańcucki, J. (2003). *Podstawy kompleksowego zarządzania jakością TQM*. Wydawnictwo uczelniane AE.

Łuczak, J. (1994). Nowe narzędzia w zarządzaniu jakością. *Problemy Jakości*, *6*, 11.

Łuczak, J., & Matuszak-Flejszman, A. (2007). *Metody i techniki zarządzania jakością. Kompendium wiedzy*. Quality Progress.

Macura, D., Laketić, M., Pamučar, & Marinković, D. (2022). Risk analysis model with interval type-2 fuzzy FMEA – case study of railway infrastructure projects in the Republic of Serbia. *Acta Polytechnica Hungarica*, *19*(3), 103–118.

Małyszko, M., & Wielgosz, M. (2016). Wykorzystanie metody drzew decyzyjnych w systemie wspomagania decyzji kapitana statku w sytuacjach awaryjnych. *Autobusy: Technika, Eksploatacja, Systemy Transportowe*, *17*, 318–323.

Mantura, W. (2012). Wybrane zastosowania kwalitologii. *Zarządzanie i Finanse*, *3*(1), 37–24.

Marzec, P. (2017). Klasyfikacja metod zarządzanie współczesnymi organizacjami. *Organizacja i Zarządzanie*, *2*(38), 79–90.

Mazur, A., & Gołaś, H. (2010). *Zasady, metody i techniki wykorzystywane w zarządzaniu jakością*. Wydawnictwo Politechniki Poznańskiej.

Mazur, A. (2023). *Siedem tradycyjnych i siedem nowych narzędzi zarządzania jakością*. Wydawnictwo Politechniki Poznańskiej.

Mazur-Dudzińska, A., & Dudziński, J. (2015). Zastosowanie kart shewharta do kontroli jakości produkcji elementów uzbrojenia. *Mechanik*, *7*. **https://doi.org/10.17814/2015.7.268**

Miller, P. (2011). *Systemowe zarządzanie jakością: koncepcja systemu, ocena systemu, wspomaganie decyzyji*. Difin.

Nowicki, M. (2015). Six Sigma. In K. Szymańska (Ed.), *Kompendium metod i technik zarządzania. Technika i ćwiczenia* (pp. 284–315). Oficyna a Wolters Kluwer business.

Nowosielski, S. (2014). Ciągłe doskonalenie procesów w organizacji. Możliwości i ograniczenia. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, *340*, 303.

Osada, T. (1991). *The 5S's – Five Keys to a Total Quality Environment*. Asian Productivity Organization.

Pałucha, K. (2012). Nowoczesne metody w zarządzaniu przedsiębiorstwem. *Zeszyty Naukowe. Organizacja i Zarządzanie, Politechnika Śląska*, 259–279.

Parab, A., Teli, S.N., & Jagtap, M.M. (2016). Statistical process control and six sigma an integrated approach to improve process in medical device industry. *International Journal of Mechanical and Aerospace Engineering*, *4*(5), 85–97.

Podgórska, M. (2013). Istota jakości w zarządzaniu projektami. *Zeszyty Naukowe Politechniki Śląskiej*, *63*, 325–337.

Rodriguez, A.T., Vasquez Calampa, C., Altamirano E., & Del Carpio C. (2021). Management model for improving the quality of glazing by applying lean manufacturing tools in a ceramics plant. In *ACM International Conference Proceeding Series* (pp. 105–111).

Salimbeni, S., Redchuk, A., & Rousserie, H. (2023). Quality 4.0: Technologies and readiness factors in the entire value flow life cycle. *Production & Manufacturing Research*, *11*(1), *2238797*. **https://doi.org/10.1080/21693277.2023.2238797**

Salwin, M., Lipiak, J., & Wałachowski, P. (2019). Production improvement by using the smed method-case study. *Research in Logistics & Production*, *9*, 137–151.

Skrzypek, E., & Hofman, M. (2010). *Zarządzanie procesami w przedsiębiorstwie*. Wolters Kluwer Polska.

Starzyńska, B., & Grabowska, M. (2010). Klasyfikacja instrumentarium zarządzania jakością na potrzeby doskonalenia procesów w przedsiębiorstwach. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, *588*, 515–524.

Stefanów, P. (2007). Wyznaczanie współczynników wagowych w procedurach klasyfikacyjnych. *Zeszyty Naukowe AE w Krakowie*, *764*, 81–95.

Sułkowski, M., & Wolniak, R. (2013). Przegląd stosowanych metod oceny skuteczności i efektywności organizacji zorientowanych na ciągłe doskonalenie. *Zeszyty Naukowe Politechniki Śląskiej, 67*(1900), 63–74.

Szczęśniak, S. (2016). Proces ciągłego doskonalenia przedsiębiorstwa. *Journal of Modern Management Process*, *2*(1), 54.

Szerszunowicz, M. (2013). Analiza zdolności procesu o zależnych charakterystykach. *Studia Ekonomiczne UE w Katowicach*, *152*, 153–161.

Szwedzka, K., & Jasiulewicz-Kaczmarek, M. (2015). Kanban jako metoda zarządzania zapasami studium przypadku. *Logistyka*, *6*, 408–414.

Tadić Stanić, D. (2022). The role of consulting organizations in the introduction of quality 5.0. In *International Conference "Industrial Engineering And Environmental Protection" IIZS.* https://www.researchgate.

net/publication/364302137_THE_ROLE_OF_CONSULTING_ORGANIZATIONS_IN_THE_INTRODUCTION_OF_QUALITY_50

Taguchi, G., & Clausing, D. (1990). Robust quality. *Harvard Business Review*, *68*(1), 65–75.

Tomaszewska, K. (2022). Wykorzystanie narzędzi zarządzania jakością do identyfikacji problemów w procesie produkcyjnym wybranego przedsiębiorstwa. *Akademia Zarządzania*, *6*(4), 117–130.

Urbaniak, A.M. (2013). Zastosowanie metody SERVQUAL do oceny jakości usług rekreacyjnych. *Zeszyty Naukowe Uczelni Vistula*, *32*(3), 29–38.

Vernon, M. (2002). *Business: The Key Concepts*. Routledge.

Wawak, S. (2013).Wybrane koncepcje klasyfikacji metod zarządzania jakością. *Zeszyty Naukowe UEK*, *910*, 37–49.

Winkowska, J., & Winkowski, C. (2018). *Przegląd metod i narzędzi jakości wykorzystywanych w przedsiębiorstwie produkcyjnym*. Oficyna Wydaw. Polskiego Towarzystwa Zarządzania Produkcją.

Wolniak, R. (2019). Miejsce metody QFD na tle innych metod i narzędzi zarządzania jakością. *Zarządzanie i Jakość*, *1*(1), 15–23.

Xu, Y., Tiwari, A., Chen, H.C., & Turner, C.J. (2018). Development of a validation and qualification process for the manufacturing of medical devices: A case study based on cross-sector benchmarking. *International Journal of Process Management and Benchmarking*, *8*(1), 79–102. **https://doi.org/10.1504/.2018.10009237**

Zonnenshain, A., & Kenett, R.S. (2020). Quality 4.0 – the challenging future of quality engineering. *Quality Engineering*, *32*(4), 614–626. **https://doi.org/10.1080/08982112.2019.1706744**