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Quality 5.0: Towards sustainable quality improvement in organizations

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Abstract

The concept of Quality 5.0 in management sciences has emerged relatively recently. It is an attempt to respond to the limitations attributed to Quality 4.0, which focuses on industry and the use of advanced technologies mainly in production processes. Quality 5.0 goes beyond this framework and introduces an equally strong human and social factor. The article defines the concept of Quality 5.0 in relation to quality improvement in organizations and presents the author's conceptual model of Quality 5.0 as a sustainable concept for quality improvement. The proposed model consists of 12 attributes of Quality 5.0, divided into four categories: (1) Balanced Techno-Human Centric Management System: agile and aware leadership, real-time data decision making, continuous improvement; (2) Human: empowerment, creativity, diversity; (3) Process: integration, efficiency, flexibility; (4) Technology: analytics, connectivity, and scalability. In the Quality 5.0 model, the organization supports the Triple Bottom Line of Sustainable Development through value co-creation, problem-solving, cooperation, and innovation.

1. Introduction

The dynamically changing organizational environment, including the development of advanced technologies and the sensitivity to social and ecological values, has a direct and increasingly noticeable impact on the activities of organizations. Currently, organizations are paying greater attention to achieving Sustainable Development Goals (SDGs). In the context of management, managers are recognizing the consequences of their actions, not only in terms of potential economic benefits for shareholders, but also in terms of their impact on society and the environment. The changes occurring in the early 21st century have been referred to as the Fourth Industrial Revolution. The pandemic period reinforced the shift in this approach to a fifth industrial revolution that goes beyond strictly technocratic values such as efficiency and productivity to strengthening the role and contribution of industry in leading positive social transformations, while respecting the limits of planetary production.

The transformations that are taking place are reflected in the way quality is managed in organizations. The turn of the millennium, in the evolution of quality improvement, is the time of Total Quality Management (TQM), including the adaptation of concepts and methods such as Lean, Six Sigma, as well as the continued use of quality management standards and techniques. Researchers agree on four distinguishable stages in the evolution of quality improvement, which in the 20th century included: quality inspection, quality control, quality assurance, and quality management. Questions arise in the contemporary context: can we distinguish and name the current stage of quality improvement evolution, and how? Recent attempts to frame the prevailing paradigm refer to the concept of Quality 5.0.

The concept of Quality 5.0 (Q5.0) has emerged relatively recently in the field of management sciences, aiming to address the limitations associated with Quality 4.0 (Q4.0). While Q4.0 focuses on the utilization of advanced technologies, particularly information technology, in organizational production processes, Q5.0 surpasses this framework. It broadens the scope of organizational management to encompass social aspects, reshaping our perception of the relationship between social sustainability and organizational sustainability. Presently, researchers are actively working towards conceptualizing Q5.0, yet diverse and multidimensional perspectives persist. Considering the evolving state of knowledge in this domain, studies that identify the essential attributes of Q5.0 can provide valuable insights.

Accordingly, this paper aims to present research findings that define the concept of Q5.0 in the context of organizational quality improvement. Additionally, the authors introduce their conceptual model of Q5.0 as a sustainable approach for enhancing quality within organizations. The research methodology employed includes a critical review of relevant literature and logical inference tools.

2. Theoretical framework of the research

2.1. Quality 4.0: Taking advantage from the Fourth Industrial Revolution

In 2011, the term Industry 4.0 (I4.0) emerged to describe the observed trend within manufacturing companies, characterized by an increased utilization of new information technologies. These technologies include big data analytics, Internet of Things, cloud computing, additive manufacturing, artificial intelligence, blockchain, augmented reality, virtual reality, and cyber-physical systems (Kagermann and Wahlster, 2022; Ranjith Kumar et al., 2022). The emergence of I4.0 has sparked interest among researchers in various management domains, including services, logistics, healthcare, and quality management. These researchers have begun to explore the application of information (electronic) technologies within their respective areas of interest, leading to the emergence of terms such as Service 4.0, Logistics 4.0, and also Quality 4.0.

The term Quality 4.0 was first used in an American Society for Quality report in 2015 in the context of referring to the TQM area for the next stages of industry development and the I4.0 concept (ASQ, 2015; Radziwill, 2018). The first article published in 2016 in this field by Foidl and Felderer (2016) started a discussion on integration and the importance of Quality Management in the I4.0 context, as well as its success factors. In publications on Q4.0 that have since been published, the concept is understood in different ways:

- Q4.0 as the application of the new digital technologies indicated in I4.0 to improve processes, products, organization (ASQ, 2023; Radziwill, 2020; Sony et al., 2020, Sony et al., 2021). In this approach, there is no distinction between I4.0 and Q4.0.

- Q4.0 as an integral part of I4.0, necessary for I4.0 to be implemented (Radziwill, 2018; Küpper et al., 2019; Zonnenshain and Kenett, 2020).

- Q4.0 as an integration of TQM principles with new digital technologies (new technologies as a benefit element), primarily with evidence and data-based decision-making (Salimova et al., 2020; Zonnenshain and Kenett, 2020).

- Q4.0 as the digitalization of TQM and its effect on quality technology, processes, and individuals (Carvalho et al., 2021).

- Q4.0 as a concept for improving organizational culture, collaboration, and leadership through the use of new technologies (Jacob, 2017). Seen as an element of integrating new technologies with people management.

One significant model that has attempted to comprehensively define Q4.0 is the work of Jacob (2017). In this work, it is assumed that “Quality 4.0 isn’t really a story about technology. It’s about how that technology improves culture, collaboration, competency and leadership”. Q4.0 does not replace traditional quality

management, but augments it with technological tools. The author identified three dimensions of Q4.0: people, processes, technology and, within these, there are 11 axes that describe the key elements of Q4.0: leadership, culture, compliance, management system, competency, collaboration, scalability, analytics, data, app development, connectivity (the connection between business information technology and operational technology) (Jacob, 2017).

In another Q4.0 model presented by Ranjith Kumar et al. (2022), the authors adopted three quality dimensions (people, processes, technology) and assigned to them Q4.0 attributes respectively: (1) People: leadership, culture, competency; (2) Processes: integration, management system, compliance; (3) Technology: data, analytics, connectivity, scalability. The first two dimensions (people and processes) build capabilities (called 4.0 capabilities), which include: real-time data management, interoperability, visualization, decentralization, agility, service orientation, integrated business process and sustainability. Technology-driven business models based on I4.0 technologies and 4.0 capabilities create the ability to cater to customer and societal requirements.

Despite the emergence of Q4.0 models that aim to integrate new digital technologies and enhance quality management, these models fail to consider the organization's environment and the societal demands prevalent in the current context of the climate crisis and planetary emergency. Q4.0, as defined by various researchers, primarily focuses on the application of digital technologies to improve processes, products, and the organization, without distinguishing it from I4.0. While some models emphasize the integration of quality management principles with new technologies, they neglect the urgent need to address deep social tensions and environmental concerns. The models fail to encompass the broader societal and environmental aspects necessary for a holistic approach to quality management in the face of the current challenges.

2.2. Society 5.0: Towards the Fifth Industrial Revolution

Society 5.0 (S5.0) is an evolutionary concept that builds upon the foundations of information societies (Societies 3.0) and knowledge societies (Societies 4.0). It envisions a society where digital technology, artificial intelligence, and automation are harnessed to promote social well-being and sustainable development (Deguchi et al., 2020, 4). In S5.0, advanced I4.0 information technologies are actively utilized not only in the industrial sector (production processes) but also in everyday life, healthcare, and various other domains. The primary focus is no longer solely on economic gains but on enhancing the benefits and convenience for every individual citizen. This concept emphasizes leveraging technology to create a society that prioritizes the welfare and needs of its members (EC, 2021, 9).

The concept of S5.0 emerged in Japan as a response to the country's challenges, including energy shortages, reliance on foreign imports, limited natural

resources, and an aging population. Recognizing the need for strategic changes, Japan sought to develop a new societal model. In 2016, the Fifth Science and Technology Base Plan was implemented, envisioning a transition from I4.0 to S5.0. Unlike I4.0, S5.0 places emphasis on people, society, and human relationships, prioritizing a human-centric approach. It is also known by names such as creative, imaginative, or super-intelligent society (Salgues, 2018, 1–3).

The transition to S5.0 brings about a shift in paradigms and beliefs. This new society moves away from economies of scale and a focus on efficiency in industries, towards value creation and problem-solving for the society as a whole. The detrimental environmental impacts of mass production and resource consumption are being replaced by a commitment to sustainability and environmental harmony. Values like diversity, decentralization, and resilience are gaining prominence. The concept of S5.0 is closely aligned with the United Nations' SDGs and the Triple Bottom Line framework (prosperity, people, planet) (Keidanren Policy and Action, 2018, 15–20).

In Europe, the concept of S5.0 has been adapted into a new industrial development strategy known as Industry 5.0 (EC, 2020, 7; EC, 2021, 9). The transformative model of Industry 5.0 (I5.0) reflects the societal and economic changes brought about by the COVID-19 pandemic. I5.0 was formulated to create an industrial system that possesses inherent resilience against future shocks and pressures, while fully embracing the social and environmental principles of the European Green Deal (EC, 2022, 7–11). The concept of I5.0 transcends the narrow focus on technological and economic growth inherent in the existing economic model, which revolves around extraction, production, and consumption. Instead, it presents a fresh perspective on growth, prioritizing human progress and well-being. This entails reducing and transitioning consumption patterns towards sustainable, circular, and regenerative forms of economic value creation, aiming for equitable prosperity. I5.0 is not simply a technological advancement; rather, it contextualizes the principles of I4.0 within the broader challenges of the modern world, aligning with the SDGs and S5.0 (EC, 2022, 6).

3. Research methodology

The research utilized a critical literature review as described by Snyder (2019). This approach is particularly useful when addressing new and emerging issues. Unlike a systematic literature review, it allows for the assessment, criticism, and synthesis of areas and theories that are not yet firmly established. Its main objective is to develop initial conceptualizations and theoretical models. Given that the concept of Q5.0 is in the early stages of being incorporated into the field, grounded theory was employed to construct the conceptual model (Glaser and Strauss, 2017).

An exploratory analysis of scientific publications in the Scopus database revealed a scarcity of articles focusing on the concept of Q5.0. Table 1 presents the

number of publications retrieved from searches using the terms “Quality 4.0”, “Society 5.0”, “Industry 5.0”, and “Quality 5.0” within the TITLE-ABSTRACT-KEYWORDS field between 2017 and 2022. In comparison, a search using the same method for the term “Industry 4.0” yielded 26,292 scientific publications. Considering the paradigm shift, as mentioned in the theoretical section, a corresponding increase in the number of publications is also expected within the realm of Industry 5.0.

Table 1. Number of searches for the indicated terms in the Scopus database

	Quality 4.0	Society 5.0	Industry 5.0	Quality 5.0
2017	3	7	–	–
2018	3	16	2	–
2019	6	42	22	1
2020	16	100	41	3
2021	32	168	102	1
2022	67	181	404	–
Total	127	514	771	5

Source: own research as of July 4, 2023.

For the analysis, a Scopus database was utilized, acknowledging that some of the publications may address topics outside the field of management and quality. Specifically, the publications that delve into the subject of Q5.0 in the domain of management include Arsovski (2019), Deleryd and Fundin (2020), and Fundin et al. (2020). In addition, employing the snowball approach, the article by Frick and Grudowski (2023) found on Google Scholar was added. Publications that explore the evolution and future of concepts associated with quality management were also considered, such as Garvare and Johansson (2010), Dahlgaard-Park (2011), Weckenmann et. al. (2015), Siva et al. (2016), Carnerud and Bäckström (2021), and Wen et al. (2022). Additionally, publications referenced in the theoretical framework were consulted as a foundation for inference.

4. Results

4.1. Quality 5.0 as a new paradigm in the quality management evolution

The evolution of quality management in organizations has transitioned from traditional quality control-based approaches to the concept of Q5.0, reflecting a shift in the understanding of quality. Traditionally, quality was primarily focused on process control and eliminating defects. However, with the advent of I5.0, the integration of advanced technologies, resource limitations, and changing societal

expectations have prompted a change in the approach to quality management. In the present context, quality management extends beyond the confines of the organization and its immediate surroundings, encompassing broader social and environmental aspects.

Q5.0 represents a novel paradigm for enhancing quality, emphasizing the harmonious collaboration between technology and human resources to foster social value and sustainability. This entails leveraging advanced technologies like artificial intelligence, robotics, and data analytics to enhance processes, while actively involving employees, customers, and stakeholders in co-creating superior solutions. Unlike earlier stages of quality management, Q5.0 extends the scope of pro-quality endeavors to encompass the Triple Bottom Line, encompassing stakeholders' well-being, societal considerations, and environmental impact. Figure 1 illustrates the placement of the concept of Q5.0 within the overall evolution of quality management.

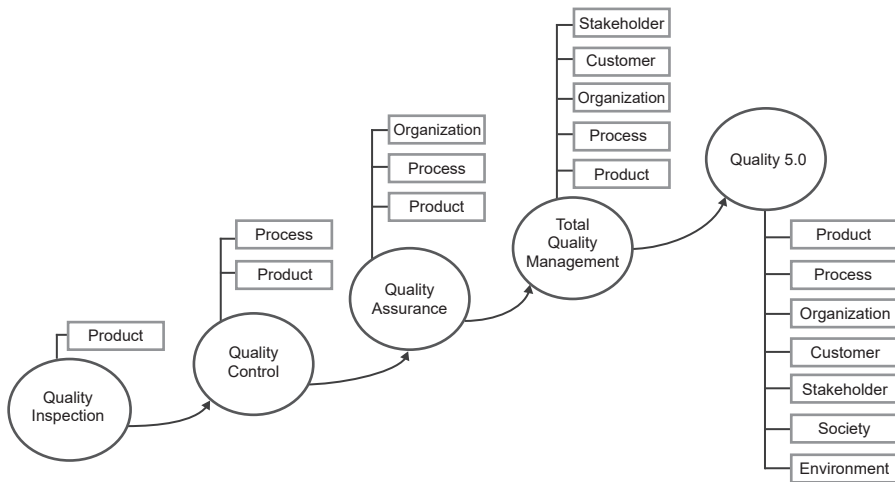


Figure 1. Quality 5.0 as a new paradigm in the quality management evolution

Source: own research.

Q5.0 is experiencing a broadening of its impact beyond the traditional domains of product, process, organization, and customer. In this new approach, organizations strive to establish connections and collaborations with all stakeholders. This includes actively engaging with the local community and the environment, considering their needs and expectations when conducting their operations. The essence of Q5.0 lies in promoting the creation of social value and sustainability. Consequently, organizations are expected to embrace social responsibility and demonstrate a commitment to environmental well-being. This entails incorporating SDGs, addressing environmental considerations, and fulfilling the responsibil-

ities associated with corporate social responsibility. By adopting these practices, organizations can contribute to the greater good and enhance their overall quality performance.

4.2. Quality 5.0 origins

Q5.0 emerged as an evolution of Q4.0, resulting from the integration of modern ideas related to I5.0 and S5.0, alongside the established principles of TQM as depicted in Figure 2. By blending the concepts of I5.0 and TQM, the Q5.0 framework harnesses advanced technologies like artificial intelligence, robotics, and data analytics to enhance the quality of products and services. Simultaneously, similar to TQM, it places significant emphasis on involving the entire organization, managing processes effectively, and considering diverse needs and requirements.

In this new paradigm, the notion of the customer expands beyond its traditional boundaries and encompasses all stakeholders with society at large and the environment. Q5.0 acknowledges the broader scope of impact and extends its focus to meet the needs and expectations of these diverse entities. By adopting the holistic approach, organizations can align their efforts with the interests of various stakeholders, as well as contribute to societal well-being and environmental sustainability.

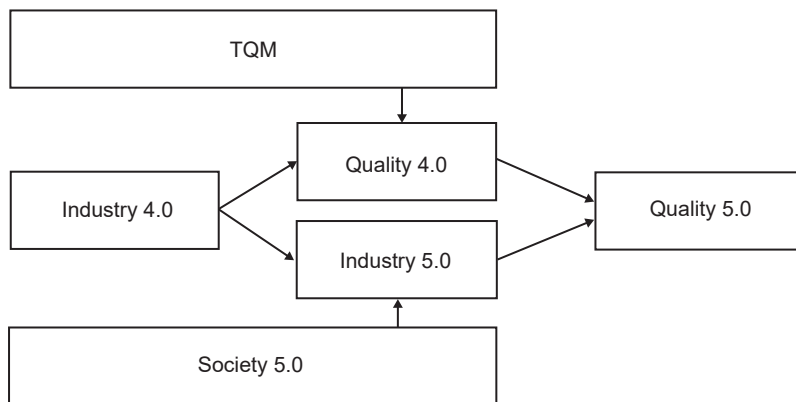


Figure 2. The origins of Quality 5.0

Source: own research.

Q5.0 embraces a Triple Bottom Line of SDGs that encompasses economic, social, and environmental dimensions. Unlike the technology-centric focus of I4.0, Q5.0 broadens its perspective to include human and social considerations. It recognizes the significance of human collaboration, creativity, and well-being along-

side the utilization of advanced technologies. The objective of Q5.0 is to generate value not only in economic terms but also in social and environmental realms.

4.3. Quality 5.0 conceptual model

The development of the Q5.0 conceptual model (Figure 3) was the outcome of a critical literature review, examining various sources in depth. The model illustrates the key attributes of Q5.0, focusing on four fundamental organizational components: the management system, people, technology, and processes. These components are interconnected and work in tandem within an organization's Quality Management System (QMS). Traditionally, the QMS responds to the demands and expectations of customers. However, in the context of Q5.0, the QMS extends its scope to encompass the requirements, expectations, and needs of not only customers and stakeholders but also local communities and the environment, embracing the Triple Bottom Line framework.

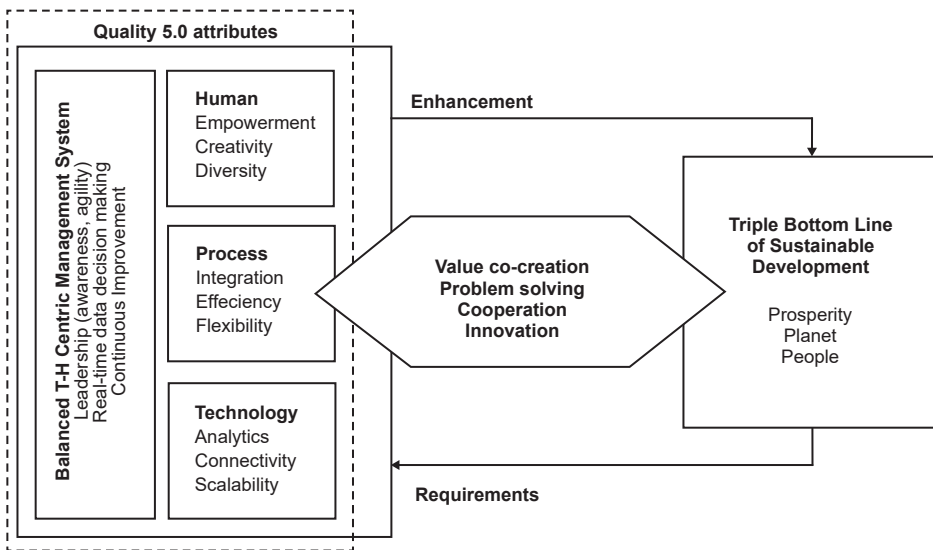


Figure 3. Quality 5.0 conceptual model

Source: own research.

The management system in Q5.0 is centered around maintaining a balance between technology and human aspects. It includes attributes such as leadership awareness and agility, enabling leaders to understand the impact of technological advancements and respond effectively. Real-time data decision-making ensures that decisions are based on up-to-date information. Continuous improvement is emphasized to drive organizational growth and enhance overall performance. The

human component of Q5.0 focuses on empowering individuals within the organization. It promotes creativity and diversity by providing an environment that encourages employees to contribute their unique perspectives and ideas. Empowerment initiatives enable individuals to take ownership of their work and contribute meaningfully to organizational goals. By prioritizing the well-being and development of people, Q5.0 aims to foster a positive and inclusive organizational culture. The process component of Q5.0 emphasizes integration, efficiency, and flexibility. Processes are designed to be seamlessly integrated, ensuring smooth flow and collaboration across different departments, functions, people, and technology. Efficiency allows organizations to minimize waste and optimize resource utilization. Flexibility is prioritized to adapt quickly to changing organizational environment conditions and stakeholder requirements, enhancing agility and responsiveness. Technology still plays a crucial role, supporting the organization's goals and objectives. Analytics enables data-driven decision-making, leveraging insights from large volumes of information. Connectivity ensures seamless communication and collaboration across various systems and stakeholders. Scalability allows organizations to grow and adapt their technological infrastructure as needed to meet changing demands.

The relationship between the Q5.0 components and Triple Bottom Line of SD is characterized by mutual enhancement. The results of QMS in the context of Q5.0 contribute to the achievement of SDGs, promoting prosperity, people's well-being, partnerships, a healthy planet, and peace. At the same time, SD goals set requirements for the Q5.0 components, serving as guiding principles for organizational practices. To strengthen this relationship, value creation is emphasized. Q5.0 encourages organizations to generate value for all stakeholders, but not only in terms of financial prosperity, but also in terms of societal welfare. Problem-solving is crucial to address the challenges and complexities associated with SDGs, fostering innovative approaches. Cooperation and collaboration across organizations, industries, and sectors are essential to create synergies and achieve sustainable outcomes.

5. Conclusions

The rapidly changing organizational landscape, driven by advancements in technology and a growing awareness of social and environmental values, has brought about a significant impact on organizational activities. Today, organizations are increasingly focused on achieving sustainable development goals and recognizing the consequences of their actions beyond economic benefits for shareholders. This shift has been represented in the field of quality management science in the concept of Q5.0.

Q5.0 recognizes the importance of harmonious collaboration between technology and human resources in achieving social value and sustainability. It leverages advanced technologies to improve processes while actively involving employees, customers, and stakeholders in the co-creation of solutions. Unlike previous stages of quality management, Q5.0 extends the scope of pro-quality activities to encompass the Triple Bottom Line, considering the well-being of stakeholders, societal considerations, and environmental impact. By adopting this holistic approach, organizations can contribute to the greater good, align with sustainable development goals, and enhance their overall quality performance. The proposed by authors conceptual model of Q5.0 outlines 12 quality attributes in four key organizational components: (1) Balanced Techno-Human Centric Management System: agile and aware leadership, real-time data decision making, continuous improvement; (2) Human: empowerment, creativity, diversity; (3) Process: integration, efficiency, flexibility; (4) Technology: analytics, connectivity, and scalability.

In conclusion, Q5.0 represents a paradigm shift in quality management, integrating advanced technologies with human-centric approaches and sustainable development goals. It expands the scope of quality to include social and environmental dimensions, fostering collaboration, innovation, and value creation. The conceptual model of Q5.0 provides a foundation for organizations to embrace this new paradigm and strive towards sustainable quality improvement. Further research and empirical studies are needed to fully explore and implement the principles and attributes of Q5.0 in various organizational contexts.

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