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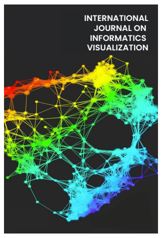

Industry 4.0: The New Quality Management Paradigm in Era of the Industrial Internet of Things

Benjamin Duraković [a,*], Maida Halilovic [a]

[a] *International University of Sarajevo, Hrasnička cesta 15, 71000 Sarajevo, Bosnia*

Corresponding author: [*]bdurakovic@ius.edu.ba

***Abstract*— Advanced technologies such as Big Data, the Internet of Things, artificial intelligence, robotics, cloud computing, and additive manufacturing are enablers of the industry 4.0 revolution and signify intense transformations in socio-economic systems. This work investigates the enabling nature of certain technologies in the emergence and development of different quality paradigms. Each enabling technology is related to a certain industrial revolution; consequently, a certain quality paradigm has been developed. Where is quality management now, in which direction its development is going, and what can be expected in the future is discussed in this paper. The research focuses on the most important factors discussed in the literature that influenced quality development throughout history. Results are presented in written and graphical form and include newly established theories based on recent innovations. Since this is a cumulative overview of different quality methods, it only briefly discusses the most important theories. It was observed that with Industry 4.0 enabling technologies, we are currently experiencing a transformation in this discipline, reaching a higher level in the competition for market positioning. Particularly, meeting explicit customer needs is upgraded with latent customer needs - linked to the customer's emotional responses (delight) to products/services. This paper contributes to a new field of research that is becoming increasingly popular.**

***Keywords*—Quality evolution; IoT; industry 4.0; latent customer needs.**

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I. Introduction

The current state of quality management is a product of the long-term development process, influenced by major historical events, accomplishments of the individuals, and broadened over different continents. However, the historical traces of the development of quality date back to the Industrial Revolution and continue to modern phases as Total Quality Management (TQM) and Customer Experience Management (CEM). This research paper focuses on the historical evolution of quality and reflects quality inspections as a part of craftsmanship production, the introduction of mass production, standardization, assembly line, and recent quality concepts. Quality can be defined in many ways; however, most people relate it to one or more desirable aspects a product provides [1], usually in terms of performance, reliability, and durability. Although quality can be perceived as one of the most important decision-making aspects for the customers that differentiates a certain product from its competitors, it has a long-term development process. Quality was always an 'integral part' of the products and services. However, its official introduction to improving products has been prolonged and evolved gradually throughout centuries [1]. This research paper examines quality development and its reflection on quality methods while addressing this broad evolution from today's perspective. In this context, it reviews the current situation in quality development.

II. Materials and Method

For this review paper, we used various literature sources to understand the evolution of quality management practices in the context of the Industrial Revolution. The literature sources included peer-reviewed journal articles, books, reports, and conference proceedings. A comprehensive search of relevant databases such as Scopus, Web of Science, and Google Scholar was conducted. The inclusion criteria for the literature search were publications in English from 1990 to 2022.

The literature search was conducted in three stages. In the first stage, we used the search terms to identify potentially relevant articles from the databases. We screened the titles and abstracts of the articles to determine their relevance to quality management evolution. In the second stage, we read the full text of the articles that met the inclusion criteria and extracted relevant information on the evolution of quality management in the context of the Industrial Revolution. In the third stage, we analyzed the information and organized it into a chronological framework to describe the evolution of quality.

A qualitative approach analyzes literature and identifies patterns and themes. The information is coded into categories such as historical developments, key concepts, methodologies, industry applications, and complexity. The literature is critically evaluated to assess the quality of the evidence and the validity of the claims made about the evolution of quality. The literature is critically evaluated to provide a balanced and objective assessment of changes and continuities over time.

III. Results and Discussion

The traditional craftsmanship production model, which traces back to the Middle Ages, marked the quality in the pre-industrial era. Similarly, inspection to assure satisfaction of certain requirements dates to the Middle Ages. This process initially included a group of skilled workers inspecting and performing remedies during production. This process remained during the period of low-volume manufacturing by informal inspection and arbitrary review of the production process. Therefore, the traditional craftsmanship model was based on the personal point of the 'master' [2]. Since many craftsmen were selling the goods, they manufactured in small and closed communities, there was a high possibility of losing customers if their needs were unmet. So, the masters maintained quality control through inspections before the sale.

This process continued until the early 19th century. The system of factories that started in Great Britain in the 1750s, was also established upon product inspection and grew into the Industrial Revolution at the beginning of 1800s. Since the production systems became larger and oriented towards enlarged trade markets, the traditional craftsmen inspections needed to be replaced by more effective and efficient systems. The need for 'quality control' and organized operations was more expressed during the Industrial Revolution. Although industrial development was very low in the medieval period, manufacturing processes were sometimes mechanized and based not only on the use of muscles but on the power of wind and water. Windmills and water wheels were used in manufacturing the forge hammer and grinding mill for cereals even in the 10th century [3]. Until the beginning of the 14th century, windmills and water wheels were widely used to supplement or replace the human workforce in basic industries. These were used for leather processing, washing fabrics, wood cutting, firing blacksmiths and abrasives for grinding weapons, making paper, and similar. Even though the industrial revolution did not mark the medieval period still stands as a period of changes that influenced technological developments through constant improvements and many innovations [3]. Mechanical innovations such as the development of steam power and coal-powered external combustion engines inspired the first industrial revolution. Mechanization enabled it in the 18th century in the textile industry and factories establishments.

The second industrial revolution started in 1870 and came up with innovations such as the oil-powered internal combustion engine and the development of electrical communications. This was followed by standardization, mass production, and the establishment of an assembly line in 1913. The third industrial revolution in 1969 brought computerization, the internet, and the information and communication technology (ICT) available today [4]. The fourth industrial revolution, which arrived at the beginning of the 21st century, is known for developing cyber-physical systems. It is followed by the development of technologies across the biological, physical, and digital worlds [4]. The visual representation of the developments regarding the Industrial Revolution is visible in Figure 1.

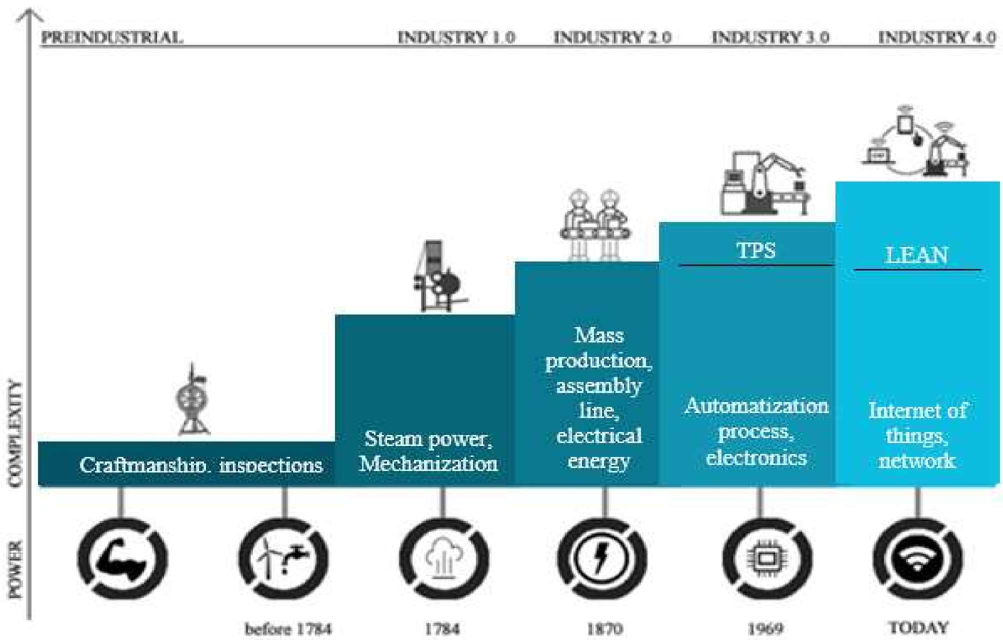

Fig. 1 Development of manufacturing processes reflected by industrial revolutions

A. Importance of Standardization of Quality Development

After the production of the steam engine by James Watt in 1782, the Industrial Revolution started. Following this, the steam engine became part of the manufacturing process, and the mode of low-level production started to be shifted to mechanized production. This development in the means of production was possible due to technological innovations that allowed production to become standardized [5]. Standardization is an age-old process preconditioning transcultural and transnational exchange [6]. However, it was not until the 18th century that standardization took a crucial role in the systematization of the industry. The growing need to establish a bigger market and provide services to the masses included developing many units that customers will be satisfied with.

Furthermore, this process was strengthened by the need to establish large-scale norms that will be followed as standards. One of the earliest examples of implementing standardization procedures is developed upon the need for high-precision machine tools and interchangeable parts. Other than manufacturing weapons' parts, standardization was also included in developing everyday products. In 1800, Henry Maudslay developed the first screw-cutting later. This further influenced the standardization of screw thread sizes due to the need for the interchangeability of parts [5]. The introduction of standardization automatically contributed to many large-scale changes: production did not include the need for skilled masters who would inspect the manual work of others, rather it was developed on cheap labor where men, due to standardization of parts, just needed to pass simple instructions to be able to fill in for jobs in factories.

The implementation of standardization was enforced onto manufacturing devices, raw materials, workplaces, operating actions, etc. At the end of 1790s, soon after the USA was founded, Vice President Thomas Jefferson signed an agreement with Eli Whitney to deliver the country's needed ammunition. A mechanical engineer, Eli Whitney, agreed to deliver 10 000 rifles within two years. Due to the war and lack of resources, the government required that all rifles be interchangeable. The first undertaken by Whitney was the prototype rifle. This process was inspired by the invention of the Charleville in France in 1763. Furthermore, this process, among several others, provided the foundations for standardized production and manufacturing for mass production, which was to be developed in the following decades.

B. The Concept of Quality and the Inspection Sector

In the first thirty years of the 20th century, quality was described as *'conforming to the standards and specifications of a product'* [7]. Therefore, quality practices in the industry included standardization and constant inspections, as Deming argued that the definition of quality is based on providing and following customers' requirements and needs [8]. Simultaneously, quality started to be understood as a *'customer-focused'* concept. Following this, the industry's goal was to satisfy customers' needs and use their loyalty [9], [10]. To learn customers' expectations, enterprises conducted many surveys and market research [2]. However, before the twentieth century [11], manufacturing companies focused on productivity levels and manufacturing costs. This meant that the concept of quality and control was focused on a product. Standardization was an enabler for the invention of the assembly line. The Ford Company 1913 designed an assembly that had 84 discrete steps and was maintained by highly skilled workers. Reduction of the manufacturing time and further assembly line improvements decreased the costs. As a result, the price of the car decreased from $850 to $300. The shorter manufacturing process produced the car every 24 seconds and sold more than 15 million T model cars worldwide until 1927.

Furthermore, in 1914, Ford changed the working hours from 9 to 8 hours and increased wages from $2.34 to $5 (around $110 in 2022). These changes increased the productivity and satisfaction of the employees. The assembly line development happened under the influence of Frederick W. Taylor, whereas the first concepts of work in factories were based on his book. *Taylorism*, named after him, became widely popular during the progress of the industrial inventions that brought about the revolution. It became the mode of production, and the best production representative became the Ford Company. Assembly lines were considered a milestone that made a remarkable influence on the establishment of mass production, established upon standardization [12].

Both standardization and the assembly line became reasons for Ford's increasing manufacturing volume [13]. Since, in that period, manufacturers were still "product-focused", the concept of quality was targeting the *"conformation to the standard and product specification"* [7]. Simultaneously, engineers started to implement inspections to maintain control over the quality. As the manufacturing process started to grow, companies were focused on the production and manufacturing costs related to this. Furthermore, they were relying on the standard of operations (SOPs). The inspection sector members checked the characteristics of all manufactured products and manually searched for failures and errors. If these were found, the inspection sector performed the necessary steps to improve the quality of the manufactured product [2].

1) The Control Charts: The control charts by Walter Shewhart represented statistical quality control (SPC, SQC). Shewhart invented it when he worked for a factory called *Bell Labs* in the 1920s. It was based on his idea to establish sampling inspection quality control to decrease the inspection [14]. The control chart, one of the seven basic quality control tools, is a tool companies use to determine whether manufacturing is in a state of control. In this chart, the characteristics of a manufactured good 'were identified as a means of sampling methods [15], while the chart follows tools such as the theory of probability, random sampling, mean, deviations, etc. One of the characteristics of sampling inspection was its ability to send a lower number of defective produced goods to customers [16]; as Shewhart claimed that the missed number of errors was lower in the end, the savings in the inspection control process made it worthwhile [17]. The Shewhart cycle, developed in 1924, became a model of guidelines for improvement [1]. Its four steps: Plan, Do, Check, and Act, represent a way in which a process to performing a change, checking and analyzing the results of the change, and acting to decide whether it is better to adopt or abandon a change, was developed.

2) The Quality Management System in the Middle of 20th Century: As product quality and cost represent the most important aspects for the companies and influence the customers to make a purchase, these are considered the hot points of companies' interest [18]. The development of the 'quality costs' started with Juran in his book *Quality Control Handbook* in 1951 [2]. His philosophy of quality is based on three components: planning, control, and improvement, together forming Juran Trilogy [1]. Since SPS could not influence the quality costs decrease, and the losses due to the production of defective goods proved to be higher than the costs of quality control, a new quality control method needed to be developed. Quality was further enhanced by one of its gurus, Genichi Taguchi, who contributed to industrial statistics. His quality philosophy is based on the following key elements: Taguchi Loss function, the philosophy of *off-line* quality that implements designing robust products and processes, and innovation in the statistical design of experiments. Robustness is one of the Taguchi methods that improve engineering productivity. It can be defined as reducing variation in a product without eliminating the causes of the variation. It is also the most successful method for reducing product costs, improving quality, and reducing development intervals. Design is focused on improvements in the function of the product or process by systematically arriving at solutions that make designs less sensitive to various cases of variation, whereas the strategy can be used for optimizing product design and manufacturing process design [19]. The Taguchi loss function was considered a breakthrough in describing the quality and helped fuel the continuous improvement movement that has since become manufacturing [20].

The concept of Taguchi's quality loss function was in contrast with the American concept of quality, known as the goal post philosophy, designed by Phil Crosby. The post-philosophy goal emphasizes that if the product dimension goes out of the *tolerance* limit, the product quality drops suddenly. In this manner, if a product feature does not meet the designed specifications, it is termed a product of low quality that is rejected. Following this, Taguchi explained that from the customer's point of view, the quality drop is not sudden. Customers' experiences are based on a loss of quality the moment product specification goes further from the 'target value'. Taguchi argued that variations in the performance of customers are used to become customer dissatisfaction. In this case, the quality not sudden and represents a gradual decrease [21].

Furthermore, quality development was strongly influenced by Phil Crosby, who largely contributed to management theory and quality management practices. Crosby initiated the Zero Defects program at the Martin Company [22]. Zero Defects present a concept for the elimination of errors and defects that was popular from 1964 to the early 1970s [23]. Philip Crosby, who designed it, made it part of his theories of absolutes, and it became one of the most important aspects of the automobile industry. A method based on eliminating defects was developed to decrease costs by reducing inspections and improving the supply [22]. The zero defects concept ensures that no waste exists in a project. Waste can be defined as all unproductive processes, tools, employees, etc. Once defined, all waste components are further eliminated, whereas improvements and lower costs follow this. Common with the zero defects theory is the method of "doing it right the first time", also coined by Phil Crosby, to avoid costly and time-consuming fixes in the project management process.

3) The "Quality Assurance" Quality Control, TQC and TQM: The quality assurance concept was introduced at the time when quality cost and Juran's concepts were accepted in the industry. *Gurus* in the quality field, such as Feigenbaum, argued that SPC could not control quality costs [24]. The quality assurance concept was 'user-oriented', and the product is based on the purpose that follows functions. Hence quality must be presented as zero defects that meet the requirements 100% [25]. Based on the improved Company Wide Quality Control (CWQC) product performances of the quality developed in Japan, American and Western industries established total quality management (TQM). This philosophy is focused on a fundamental principle, which is customer-based management. This is further strengthened by "continuous improvement" with well-established leadership, long-term supplier chains, top management, etc. [2].

Furthermore, TQM establishment was influenced by quality *Gurus* such as Deming, Juran, and Crosby [2]. As a result, TQM was established as a model integrating Deming's 14 points of improvement and Juran quality trilogy. However, according to Yang [2], successful implementation of TQM defines combining the "hard tools" with the "soft tools". "Soft tools" incorporate satisfying customers' requirements, training of employees, team building, the commitment of top management, involvement, etc. "Hard tools" are based on long-term improvement, process control, standardization, testing, quality management, and certification for conformity assessment [26]. "Soft tools" are focused on providing employee training, teamwork, cooperation among employees, the commitment of top management, involvement of employees etc. The Six Sigma foundations incorporate the comprehensive plan and integrate the appropriate statistical tools and other techniques for process improvement [27]. Six Sigma is based on DMAIC (Define, Measure, Analyze, Improve, and Control) methodology to establish an effective processes quality improvement system [28], and stands for an advanced quality system that became part of the management in companies aiming for business excellence [29]. Although there is no definition of Six Sigma, it is very well known for utilizing hardware and software of information technology regarding problem-solving [30].

Furthermore, it represents an opportunity at the organizational level to increase product/process quality, increase profit, and reduce costs [31], [32], [33]. The Toyota Production System (TPS) was originally developed between 1948 and 1975. Today's TPS and its core methods, which were improved over the years, stand as the 'global benchmark' over the world [34]. It is focused on the practices of conserving resources by eliminating waste. The main objectives of the TPS are based on designing out overburden (muri) and inconsistency (mura) and eliminating waste (muda) [35]. The eight types of muda that are addressed in the TPS are defects, transportation, motion, waiting, inventory, overproduction, overprocessing, and underutilized workers. Lean production, lean manufacturing, or simply "lean", were introduced to the West in 1990, but developed under TPS creators Sakichi Toyoda, Kiichiro Toyoda, Eiji Toyoda, and Taiichi Ohno [36]. As Sakichi Toyoda was working in the textile industry, he invented a loom that was motor driven with an integrated utensil that would make a mechanism stop if a thread was broken. Later, it was this mechanism that pioneered Jidoka, automatization with human intelligence [36]. Lean became a systematic method for minimizing waste within a manufacturing system without sacrificing productivity, which can cause problems. As a follow-up to the TPS, the lean is addressing the waste caused by *overburden* (muri) and *unevenness* in workloads (mura), to improve customer value [9].

The main goals of implementing lean manufacturing are improving quality and staying competitive, eliminating waste, reducing time in finishing activities from start to finish, and reducing total costs. A Lean Six Sigma is widely used and often combined into Lean Six Sigma [37]. Furthermore, hybrid Lean and Six Sigma principles are used to enhance sustainability studies, whereas it is being implemented in research and practice. The most used method in implementing Six Sigma starts with acknowledging a sustainable project, preparing a sustainability performance assessment, and then improving sustainability using Lean Six Sigma tools [38]. Furthermore, due to the increase in demand for the implementation of sustainability practices in architecture, construction, and engineering, lean practices are also implemented in all these fields to increase the sustainability rate [39].

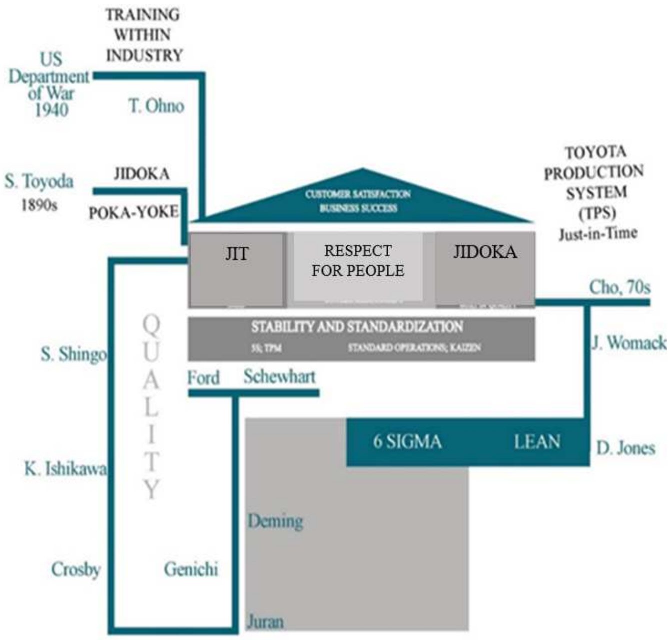

Fig. 2 Individuals that contributed to the development of lean

Nevertheless, the scope of applying lean manufacturing concepts is reaching to communication and information sectors [40], environmental practices, finance etc. The Toyota Motor Corporation started implementing the Lean process in the late 1940s. Lean was connected to customers' demand in real-time and supplemented the required materials so that the exact number of needed products was produced at any given moment. Similarly, the Just-In-Time production paradigm changed the traditional "delivery-and-demand" model for a more efficient, faster model of "demand-then-delivery".

shows the most important individuals who have contributed to developing the Lean concept in all production and service provision spheres.

Lean production is based on creating value for customers with as little funds as possible. Among lean tools that companies adopt to increase productivity and eliminate waste are just-in-time (JIT) delivery, quality, and cost. Toyota's management has recognized that the effective Lean flow must be directed from inside to eliminate waste by dealing with a reduction in inventory, downtime, transport, costs, etc., but externally focused on meeting customer demand. This helped to achieve the flexibility that Ford did not have.

C. Trends of Quality Control in the Recent Period

During the last three decades of 20th century, quality reflected different quality control philosophies, including quality practices that changed the flow in quality control development, such as standardization and inspection that further influenced the establishment of TQM and satisfaction of explicit customer needs. Explicit customer needs are articulated and present what customers want or expect from a product or service. Recently these needs have been upgraded with latent customer needs. Latent needs are those that customers are unaware of, not requested by customers, or not served by the market. However, satisfying these needs provides a huge benefit to the business. Unlike explicit customer needs, latent needs are not easy to articulate because they are not obvious and because customers are unaware of them [41]. To identify them, qualitative and quantitative research must be done to identify unsolved or emergent customer needs based on macroeconomics, rapidly shifting lifestyles, and socio-demographics. Latent customer needs can lead to major innovations. There are different methods for latent customer needs elicitation based on customer observation methodology [42] or analogical case reasoning [41].

The best example of satisfaction of latent customer needs in the recent period are numbers of well-accepted innovative Apple products. When Apple increased sales, it became understandable that satisfying the explicit customer needs was insufficient. Therefore, the explicit customer needs were upgraded by the process of identifying and fulfilling customers' needs that are unsatisfied and latent. These needs are further connected with the emotional responses of the customers [43], [42]. The philosophy that Apple is applying is further supported by different studies, that also argue that satisfaction of customer cannot provide loyalty, whereas the new focus should be switched to customer's emotional response and attractive design able to provide customer's delight [44], [45], [46] Customers delight was provided by Apple by establishing strong customer support and service department [47]. With the production of new, innovative designs: iPod, iPad, and iPhone, the quality concepts have changed as well. Nowadays, quality is strongly justified by the 'customer delight', 'attractive design' and 'innovative design'. 'Delight' is often described as the emotion of 'joy' or 'surprise', and satisfaction of the latent needs of customers. All these recent processes influenced the quality development beyond the TQM, established on the concepts of 'innovation' that has become the key force for achieving quality and increasing sales.

The main tool for obtaining quality control nowadays lies in the relationship between a customer and a product, whereas satisfaction is rooted deeply in the unconsciousness of the customer. To be declared a product of quality, a brand must be able to fulfill internal emotional needs and evoke a strong positive reaction. This is further enhanced by an innovative and attractive design. Consumers have more choices today than ever before [44]. Customer satisfaction can be defined as a product of a series of experiences that a customer has. Nowadays, closing the gap between what customers expect and the experiences following this must be closed. Companies need to know much about the emotions and thoughts that occur via interaction with different products to control quality. Since dissatisfaction that customers may experience is widespread, it becomes dangerous. Schwager and Meyer conclude that companies possess information on habits, incomes, and other characteristics for classification, and they need to satisfy customers' latent needs and evoke sentiments [44]. Cumulative information of quality control methods is represented in TABLE I, whereas quality concept evolution is represented graphically in Fig. 3.

TABLE I.
THE QUALITY CONTROL METHODS TIMELINE

Epoch	Year	Key features	Quality enablers	Quality concept	Quality focus	Focus
Pre-industrial revolution	Before 1784	Muscles / water as power source Craftsmanship	Skills	Inspection	Defined by skilled masters	Product focused
INDUSTRY 1.0	1784	Steam Steam engine Mechanization	Standardization	Inspection		
	1870	Electricity		Inspection		
	1870-1924			Inspection		
INDUSTRY 2.0	1924	Assembly line Mass production Electrical motor	Standardization. SPC; PDCA; Seven Basic Quality Tools	Shewhart's Control chart - Sampling inspection - to have fewer defective products	Statistical process control (SPC) Conforming to the standards and specifications of a product	
	1957			Juran's Quality Assurance	Quality is zero defects	Process focused
	1959			TQC - Total Quality Control - Product quality needs to be implemented at all stages of the product life cycle	Quality concepts pursuing the zero-defect culture and executing the task right first time	
	1969	Automatization PLC		TQC - Total Quality Control	Wide quality control	
INDUSTRY 3.0	1980s	Automotive production Computers & Electronics Robotics	Soft TQM tools & Hard TQM tools	TQM - Total Quality Management; Six Sigma; Lean	Work culture, customer focus, integration of the quality system with business goals Hard tools, soft tools	Customer focused
INDUSTRY 4.0	Today	Cyber IoT Big Data	Creative research: Qualitative Quantitative	The identification and fulfilment customers' unmet **latent needs**	Customer's emotional response. 'Customer's delight'; Innovative product/service	

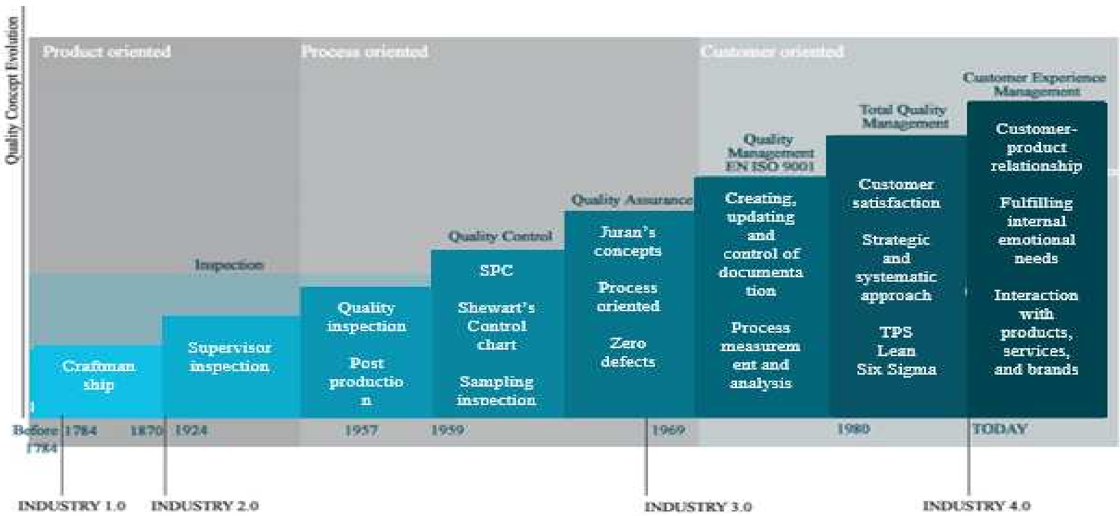

Fig. 3 Timetable Quality Concept Evolution

IV. Conclusion

This research paper examined the development of quality and provided a comprehensive summary of the complex and long-term process of the evolution of quality. It is based upon research analysis and literature review and follows the most important steps in enhancing quality, from the initial phases when quality started to be established and all further steps following milestones such as the industrial revolution, standardization, establishment of the assembly line, etc. Furthermore, this research paper reflects the evolution of quality methods in written form and diagrams. While there is a need for further development in the field regarding the grading and analysis of the TQM, which is still a mostly implemented paradigm, this paper also presents the data introducing more recent quality management philosophies and proposes.

This research showed that quality management moved to meet explicit and latent customer needs, connected with the emotional response (delight) to the product or service. The innovations in design by Apple Inc became the paradigm in quality management that reflects a different need in the domain of customer-oriented services in the era of Industry 4.0. Particularly, they introduce means to investigate the latent needs of their customers, with the main goal of creating a design that is capable of evoking sentiments and emotional reactions. As this philosophy is currently being followed by a limited number of companies but with huge success, the following period will represent a switch from current ad-hock transitions to a new paradigm of Customer Experience Management (CEM). All processes of implementation and grading their success will demand a new wave of research in the field.

References

[1] D. C. Montgomery, *Introduction to Statistical Quality Control*, 8th ed. John Wiley & Sons, Inc, 2019. Accessed: Nov. 08, 2021. [Online]. Available: https://www.wiley.com/en-us/Introduction+to+Statistical+Quality+Control%2C+8th+Edition-p-9781119399308

[2] C.-C. Yang, "The Evolution of Quality Concepts and the Related Quality Management," in *Quality Control and Assurance - An Ancient Greek Term Re-Mastered*, IntechOpen, 2017. doi: 10.5772/67211.

[3] L. White, "Medieval technology and social change," in *The Pre-Industrial Cities and Technology Reader in Colin Chant*, London: Routledge, 1998, pp. 99–103.

[4] J. K.-J. of I. E. Management and undefined 2008, "Industrial revolutions and the evolution of the firm's organization: an historical perspective," *cairn.info*, Accessed: Nov. 08, 2021. [Online]. Available: https://www.cairn.info/revue-journal-of-innovation-economics-2008-2-page-15.htm?ref=doi

[5] W. Ping, "A brief history of Standards and Standardization organizations: A Chinese perspective," 2011, Accessed: Nov. 08, 2021. [Online]. Available: https://scholarspace.manoa.hawaii.edu/handle/10125/21412

[6] R. Wenzlhuemer, "The history of standardisation in Europe," in *European History Online*, 2010.

[7] G. F. Smith, "The meaning of quality," *Total Quality Management,* vol. 4, no. 3, pp. 235–244, Jan. 2006, doi: 10.1080/09544129300000038.

[8] W. E. Deming, "Out of Crisis - Deming's 14 Points for Management," *MIT Press*, pp. 23–24, 2000, Accessed: Nov. 11, 2021. [Online]. Available: https://mitpress.mit.edu/books/out-crisis

[9] J. Gorst, G. Kanji, and W. Wallace, "Providing customer satisfaction," *Total Quality Management*, vol. 9, no. 4–5, pp. 100–103, 2010, doi: 10.1080/0954412988659.

[10] N. Sirohi, E. W. McLaughlin, and D. R. Wittink, "A model of consumer perceptions and store loyalty intentions for a supermarket retailer," *Journal of Retailing*, vol. 74, no. 2, pp. 223–245, Jun. 1998, doi: 10.1016/S0022-4359(99)80094-3.

[11] Ashok. Rao, "Total quality management: a cross functional perspective," p. 630, 1996.

[12] J. M. Wilson, "Henry Ford vs. assembly line balancing," *Int J Prod Res*, vol. 52, no. 3, pp. 757–765, Feb. 2014, doi: 10.1080/00207543.2013.836616.

[13] K. Zokaei and D. Simons, "Performance Improvements through Implementation of Lean Practices: A Study of the U.K. Red Meat Industry," *International Food and Agribusiness Management Review*, vol. 9, no. 2, 2006, Accessed: Nov. 11, 2021. [Online]. Available: www.defra.gov.uk/farm.

[14] Amitava. Mitra, "Fundamentals of quality control and improvement," p. 723, 1998.

[15] M. Xie, T. N. Goh, and P. Ranjan, "Some effective control chart procedures for reliability monitoring," *Reliab Eng Syst Saf*, vol. 77, no. 2, pp. 143–150, Aug. 2002, doi: 10.1016/S0951-8320(02)00041-8.

[16] M. Lavin, "Inspection Efficiency and Sampling Inspection Plans," *J Am Stat Assoc*, vol. 41, no. 236, pp. 432–438, 1946, doi: 10.1080/01621459.1946.10501889.

[17] G. Giakatis, T. Enkawa, and K. Washitani, "Hidden quality costs and the distinction between quality cost and quality loss," *Total Quality Management,* vol. 12, no. 2, pp. 179–190, 2010, doi: 10.1080/09544120120011406.

[18] J. S. Oakland, "Total quality management - Text with cases," *Butterworth-Heinemann*, p. 495, 2003, Accessed: Nov. 11, 2021. [Online]. Available: https://books.google.com/books/about/Total_Quality_Management.html?id=eo2y8mgEFHAC

[19] R. Kumar, R. Chandrakar, A. Kumar, and Haldhar Ram Chandrakar, "Taguchi loss function as optimised model for supplier selection and evaluation," *International Journal of Advanced Engineering Technology*, vol. 3, no. 1, pp. 268–270, 2012.

[20] K. Ueno, "Company-wide implementations of robust-technology development," p. 174, 1997, Accessed: Nov. 11, 2021. [Online]. Available: https://books.google.com/books/about/Company_wide_Implementations_of_Robust_t.html?id=Otp6QgAACAAJ

[21] W. E. (William E. Deming, "The new economics: for industry, government, education," p. 247, 2000.

[22] Feigenbaum Armand V., "Total Quality Control," *Harv Bus Rev*, vol. 34, no. 6, pp. 93–101, 1956, Accessed: Apr. 27, 2023. [Online]. Available: https://www.scribd.com/doc/86118750/TQC-Total-Quality-Control-1956-Harvard-Business-Review-9p-Feigenbaum-Armand-V

[23] P. B. Crosby, "Quality is free: the art of making quality certain," 1980.

[24] B. H. B. and H. M. Duraković, "The Interrelationships between Quality Management Practices and Their Effects on Innovation Performances," in *Trends in The Development of Machinery and Associated Technology*, Budapest, 2014., 2014, pp. 181–184.

[25] H. Bašić, B. Duraković, and A. Softić, "Six Sigma Model Testing in Optimizing Medium-Sized Company Production Process," in *16th International Research/Expert Conference" Trends in the Development of Machinery and Associated Technology" (TMT)*, 2012.

[26] B. Durakovic and H. Basic, "Continuous Quality Improvement in Textile Processing by Statistical Process Control Tools: A Case Study of Medium-Sized Company," *Periodicals of Engineering and Natural Sciences (PEN)*, 2013.

[27] B. Duraković and A. Cosic, "Impact of quality and innovation strategies on business performance of Bosnian B2B and B2C companies," *Sustainable Engineering and Innovation, ISSN 2712-0562*, vol. 1, no. 1, pp. 24–42, Jun. 2019.

[28] "Leading Six Sigma – A Step-by-Step Guide Based on Experience with GE and Other Six Sigma Companies," *International Journal of Quality & Reliability Management*, vol. 21, no. 4, pp. 467–468, May 2004, doi: 10.1108/02656710410530136.

[29] B. Durakovic and H. Basic, "Textile Cutting Process Optimization Model Based on Six Sigma Methodology in A Medium-Sized Company," *Journal of Trends in the Development of Machinery and Associated Technology*, 2012.

[30] J. Antony, M. Kumar, and C. N. Madu, "Six sigma in small- and medium-sized UK manufacturing enterprises: Some empirical observations," *International Journal of Quality and Reliability Management*, vol. 22, no. 8, pp. 860–874, 2005, doi: 10.1108/02656710510617265/FULL/XML.

[31] "The vote for lean six sigma." https://www.researchgate.net/publication/294274688_The_vote_for_lean_six_sigma (accessed Apr. 27, 2023).
[32] G. Ringena, S. Aschehouga, H. Holtskogb, and J. Ingvaldsena, "Integrating Quality and Lean into a Holistic Production System," *Procedia CIRP*, vol. 17, pp. 242–247, Jan. 2014, doi: 10.1016/J.PROCIR.2014.01.139.
[33] M. Holweg, "The genealogy of lean production," *Journal of Operations Management*, vol. 25, no. 2, pp. 420–437, Mar. 2007, doi: 10.1016/J.JOM.2006.04.001.
[34] B. Durakovic, R. Demir, K. Abat, and C. Emek, "Lean manufacturing: Trends and implementation issues," *Periodicals of Engineering and Natural Sciences*, vol. 6, no. 1, pp. 130–139, 2018, doi: 10.21533/pen.v6i1.45.
[35] L. B. M. Costa, M. Godinho Filho, L. D. Fredendall, and F. J. Gómez Paredes, "Lean, six sigma and lean six sigma in the food industry: A systematic literature review," *Trends Food Sci Technol*, vol. 82, pp. 122–133, Dec. 2018, doi: 10.1016/J.TIFS.2018.10.002.
[36] N. O. Erdil, C. B. Aktas, and O. M. Arani, "Embedding sustainability in lean six sigma efforts," *J Clean Prod*, vol. 198, pp. 520–529, Oct. 2018, doi: 10.1016/J.JCLEPRO.2018.07.048.
[37] H. I. Altintas, "Investigation of zero energy house design: Principles concepts opportunities and challenges," *Heritage and Sustainable Development*, vol. 1, no. 1, pp. 21–32, Jun. 2019, doi: 10.37868/HSD.V1I1.8.
[38] A. Krdžalić, A. Brgulja, and B. Duraković, "Implementation of lean practices in a higher education institution's student affairs office: A case study from a Bosnian University," *Int J Adv Sci Eng Inf Technol*, vol. 10, no. 2, pp. 567–577, 2020, doi: 10.18517/ijaseit.10.2.10822.
[39] Shashi, P. Centobelli, R. Cerchione, and R. Singh, "The impact of leanness and innovativeness on environmental and financial performance: Insights from Indian SMEs," *Int J Prod Econ*, vol. 212, pp. 111–124, Jun. 2019, doi: 10.1016/J.IJPE.2019.02.011.
[40] K. N. Otto and K. L. Wood, "Product design: techniques in reverse engineering and new product development," 2001.
[41] F. Zhou, R. J. Jiao, and J. S. Linsey, "Latent customer needs elicitation by use case analogical reasoning from sentiment analysis of online product reviews," *Journal of Mechanical Design, Transactions of the ASME*, vol. 137, no. 7, Jul. 2015, doi: 10.1115/1.4030159.
[42] J. Hanski, M. Reunanen, S. Kunttu, E. Karppi, M. Lintala, and H. Nieminen, "Customer observation as a source of latent customer needs and radical new ideas for product-service systems," *Lecture Notes in Mechanical Engineering*, vol. 9, pp. 395–407, 2014, doi: 10.1007/978-1-4471-4993-4_35/COVER.
[43] Carmine. Gallo, "The Apple experience: the secrets of delivering insanely great customer service," p. 234, 2012, Accessed: Apr. 27, 2023. [Online]. Available: http://93.174.95.29/_ads/E69B2C82BC8678CFEC900C3548B2B128
[44] A. Kumar, R. W. Olshavsky, and M. F. King, "Exploring Alternative Antecedents of Customer Delight," *Journal of Consumer Satisfaction, Dissatisfaction and Complaining Behavior*, vol. 14, pp. 14–26, 2001, Accessed: Apr. 27, 2023. [Online]. Available: https://jcsdcb.com/index.php/JCSDCB/article/view/102
[45] V. P. Rindova and A. P. Petkova, "When is a new thing a good thing? Technological change, product form design, and perceptions of value for product innovations," *Organization Science*, vol. 18, no. 2, pp. 217–232, Mar. 2007, doi: 10.1287/ORSC.1060.0233.
[46] D. J. Teece, "Business Models, Business Strategy and Innovation," *Long Range Plann*, vol. 43, no. 2–3, pp. 172–194, Apr. 2010, doi: 10.1016/J.LRP.2009.07.003.
[47] B. Schneider and D. E. Bowen, "Understanding Customer Delight and Outrage," *MIT Sloan Manag Rev*, Oct. 1999, Accessed: Apr. 27, 2023. [Online]. Available: https://sloanreview.mit.edu/article/understanding-customer-delight-and-outrage/.