QUALITY 4.0

DEFINING QUALITY 4.0

Quality 4.0 has the potential to be a significant driver of change for the quality profession, yet it has no universal definition. The CQI embarked on a significant three-month research project to clearly define Quality 4.0 in order to help address the quality challenges of the future. Professor John Oakland from The Oakland Group, and Mike Turner, CQI Head of Profession, explain the journey

ILLUSTRATION: ALBERTO ANTONIAZZI

QUALITY 4.0 AND THE QUALITY PROFESSION

Businesses and organisations are continuing to evolve out of necessity, responding to an onslaught of disruption, new business models and technology. This continuous change, including that precipitated by Covid-19, is affecting business operations at all levels, with customers demanding real-time interactions, regulators applying increasing levels of scrutiny and governance, and stakeholders requiring continued assurance in this complex and dynamic risk environment. The technology revolution has been referred to as Industry 4.0 (I-4.0) and digital transformation, and includes some increasingly well-known technologies, such as artificial intelligence (AI), machine learning and robotics. It is challenging traditional approaches to quality management and their relevance, effectiveness and efficiency.

Digitalisation and the highly connected nature of global systems means that organisations now operate in a complex and tightly coupled environment. A single flaw in one part of the system can rapidly cause catastrophic systemic failures, such as ones that then lead to the need for product recalls. (In 2020, the Organisation for Economic Co-operation and Development reported 3,759 product recall cases. These spanned all industries including aviation, automotive, clothing, electronics, food and medicines.)

In contrast, the impact of the same significant flaws could perhaps more easily have been contained in previously complex but loosely coupled systems. Tight coupling is being increased by I-4.0 related technologies, something which quality professionals need to be aware of and prepared for.

What is clear is that business models will continue to change dramatically over the coming years. As well as responding to the longer-term implications of short-term changes, business leaders will need to be focused on aggressively seeking out opportunities to innovate within rapidly changing environments and increasing risk. As the risk landscape becomes more complex and fast-moving, it will be crucial for organisations to identify and respond quickly and effectively to emerging events and threats. If Quality 4.0 (Q-4.0) is to be part of the solution, it needs to be properly understood, defined and developed to play a key role in helping organisations manage during this evolution. Moreover, there should be a role for Q-4.0 in helping organisations maximise the opportunities that such an evolution will present.

When contemplating I-4.0 and Q-4.0, there are innumerable possibilities for the quality professional to collaborate with other professions and functions, such as chief designers, chief information officers and IT directors. The quality professional has the opportunity to develop roadmaps that help optimise governance and assurance across organisations, and to lead improvement around new and emerging technologies. This also presents an opportunity for the quality profession to redefine itself and cement its position; not only as a provider of assurance, but also as a function that advises and anticipates. Q-4.0, when properly defined and understood, will help the profession fulfil its governance and assurance responsibilities. This is combined with the opportunity to advise organisations on their anticipation and measurement of risk, particularly around Big Data, using data governance, data engineering and analytics. These are likely to be the critical elements of Q-4.0 in the future, and will help develop the profession to focus on the most relevant and impactful risks to, and opportunities for, their organisations.

Figure 1: Overview of proposed methodology for the research.

> "Q-4.0, when properly defined and understood, will help the profession fulfil its governance and assurance responsibilities"

WHY THE CQI RESEARCHED QUALITY 4.0

The traditional principles, practices and tools of quality management that have proven to be of value over hundreds of years are undergoing huge transformations. The CQI believes that professional institutions, leading thinkers, academics, quality professionals and other managerial-level people expect many of these principles, practices and tools are going to be significantly challenged by digital transformation.

The CQI is committed to preparing its professionals to respond to the ongoing emergence of the digital age, helping them to identify, acquire, and demonstrate the value of the new skills and knowledge required to deliver enhanced benefit to their stakeholders and thrive in the future. It has invested in a research programme comprising a series of projects to ▶

THE RESEARCH APPROACH AND OBJECTIVE

Our approach: A three phase, iterative approach was central to this research project

Phase 1

LITERATURE REVIEW CONDUCTED BY A TEAM FROM THE OAKLAND INSTITUTE AND LEEDS UNIVERSITY TO ESTABLISH CURRENT VIEWS OF WHAT QUALITY 4.0 IS.

Phase 2

SURVEY AND INTERVIEWS WHICH EXPLORED THE DEFINITION AND HOW IT MIGHT BE CHANGED.

TAKING IN CONTRIBUTIONS AND INSIGHTS FROM ADVISORS AND PRACTITIONERS FROM ACROSS THE GLOBE

27 INTERVIEWS

71% OF 41 RESPONDENTS EITHER 'STRONGLY AGREED' OR 'AGREED' WITH THE EMERGING PRINCIPLES DEFINITIONS

Phase 3

VALIDATION AND SHARING OF A POTENTIAL NEW DEFINITION WITH CQI MEMBERS AND PEER ORGANISATIONS

OUR OBJECTIVE

To develop a working definition of Quality 4.0

address some of the fundamental questions concerning the future of quality professionals in the digitally enabled age.

As part of this project, the CQI is developing individual and corporate assets that its members and Corporate Partners can use to develop the necessary competences, such as a revision of the CQI's Competency Framework.

Initial explorations into published literature and conference proceedings on the subjects of Quality 4.0, Industry 4.0 and Supply Chain 4.0, together with discussions with thought leaders around the world concluded that there was no single accepted definition of Q-4.0. Professionals have been contemplating the proposed definition from several different perspectives, causing some confusion for practitioners. For this reason, the CQI decided to start a research project to develop a working definition of Q-4.0, which in turn will help CQI members to better understand what it is, how it is developing and the implications Q-4.0 could have for quality management. The intention was that the definition should not be limited to specific sectors, ie, be universally applicable, and be accompanied by identified core principles.

THE SCOPE OF THE RESEARCH

The CQI commissioned a consortium comprising Leeds University Business School and The Oakland Institute for Business Research and Education, led by Professor John Oakland and supported by Professor Chee Yew Wong, to work with Mike Turner, CQI Head of Profession, to carry out this work.

The main parts of the initial research (shown in Figure 1) were to review published literature and gather the experiences of leading stakeholders in the field of Q-4.0 to develop a working definition. The research sought to delve beneath the surface of the digital transformation of quality by using a systematic approach to investigate, clarify, validate and build a working definition of Q-4.0. Having diverse participation from individuals with a range of knowledge bases and approaches helped uncover assumptions that were not explicit or obvious to others, and helped to promote an understanding of Q-4.0 and develop a common working definition.

PHASE 1: SYSTEMATIC LITERATURE REVIEW

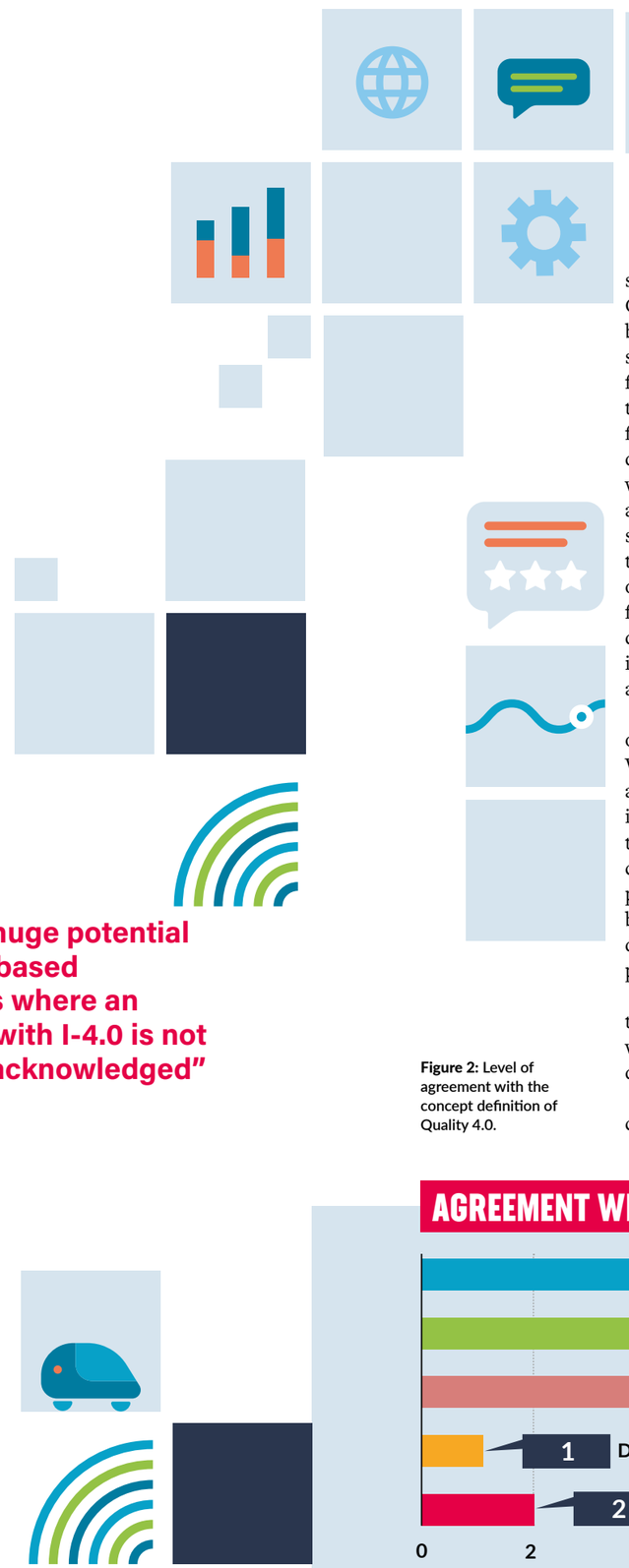
The systematic literature search sought to establish any pre-existing definitions of Q-4.0. It was structured to locate literature from three overlapping disciplines: general industry (I-4.0), quality (Q-4.0) and supply chain (SC-4.0). Less academic and more commercial sources were also selected if they formed conclusions that were based on data acquired through reasonably sound survey techniques. An initial pool of 75,000 references drawn from the ProQuest academic library search engine was filtered and reduced to the most relevant (nearly 300 in total) across the three disciplines. To increase its veracity, the literature search also encompassed other "fourth generations", such as Customer 4.0, Education 4.0, Finance 4.0, Food 4.0, Agriculture 4.0, Healthcare 4.0 and Made in China 2025, which had relevance to Q-40, I-4.0 or SC-4.0. A number of important conclusions have emerged from this review.

Definitions of I-4.0 have developed as part of an emerging narrative involving consultants and practitioner associations. These definitions highlight enhanced customer focus, increased connectivity, transformation of value chains, the merging of real and virtual worlds, and the emergence of cyber-physical systems. It has been said that I-4.0 is a new model in which cyber-physical systems are interconnected with each other over the Internet of Things, developing what is termed a "smart network". The literature recognised that I-4.0 is a transformation of a live and complex system, not a steady state. I-4.0 is also not simply about a narrowly focused adoption of technology within a function or an organisation.

"Q-4.0 has huge potential in service-based businesses where an alignment with I-4.0 is not so readily acknowledged"

It is important to recognise that there are three forms of integration within I-4.0. They are described as: **horizontal integration** along the entire value creation chain, **vertical integration** alongside the production or operational systems within a single organisation, and **end-to-end integration** along the entire product or service life cycle. Applying quality management within these axes of integration requires technology to be optimised to support clear workflows, interoperability of systems and value-driven collaboration. This presents a key opportunity for a discipline that has historically developed an end-to-end value chain influence and perspective.

Previous attempts to define Q-4.0 have tended to focus on the possible structural relationship between I-4.0 and the digital world of Big Data, AI, machine learning, robotics, etc, and the



supply chains needed for the future. However, Q-4.0 has huge potential in service-based businesses where an alignment with I-4.0 is not so readily acknowledged. It could be argued from the literature that this aspect has stalled the progress of Q-4.0. The literature review found definitions of Q-4.0 that focused on the digitalisation of Total Quality Management, with its impact on quality technology, processes and people. It has also been argued that Q-4.0 should be considered as a development of traditional quality tools, with more emphasis on connectedness, intelligence and automation for improving performance and making timely, data-driven decisions in an end-to-end scenario, involving all stakeholders and providing visibility and transparency.

People and processes are important to all areas of business, but are particularly key to quality. While Q-4.0 makes critical new technologies affordable and accessible to the broad market, its story is really about people applying new technologies to solve long-standing quality challenges and re-optimising processes to provide novel solutions. More simply, Q-4.0 has been described as the digitalisation of quality of design, quality of conformance and the quality of performance, using modern technologies.

This review, therefore, concluded that, although there is a range of Q-4.0 definitions, many of which are associated with I-4.0, no one single definition has been commonly adopted.

The work then set out to formulate a working concept definition from the researched literature. The initial attempt sought to encompass all of the essential content of existing definitions. The definition initially used in the survey was:

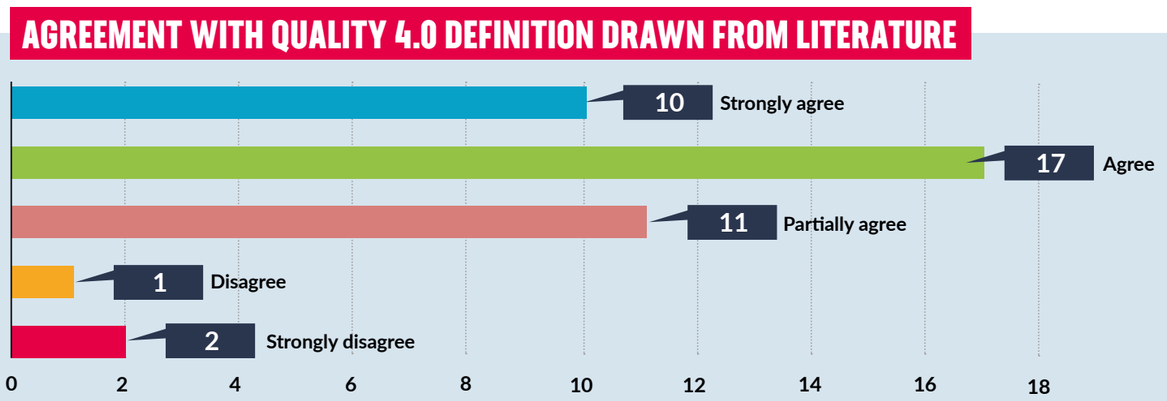
- Quality 4.0 refers to the future of quality and organisational excellence, through digitalisation and its impact on organisations' processes, people and technology.
- It builds upon traditional approaches and tools by considering connectedness, automation and intelligence for improving performance and reducing risk. It leads to better, more timely data-driven decisions in an end-to-end scenario, involving all stakeholders across supply chains to provide visibility and transparency.
- Quality 4.0 includes the digitalisation of quality of design, quality of conformance and quality of performance using modern technologies, and data-rich approaches to managing transactions and meeting customer expectations.

The team also carried out a detailed analysis of the findings of the most relevant sources and discovered a set of 10 core emerging principles in Q-4.0. This is considered vitally important to the understanding of Q-4.0 and its application within any context. With reference to approaches such as Six Sigma and Lean, our profession knows the value of understanding the core principles behind these approaches, as they are necessary to guide thinking. This ensures that the adoption of any improvement approach will suit the context and not be reduced to blindly following a playbook that has been learned from elsewhere.

PHASES 2 AND 3: SURVEYING AND SOCIALISING

The working concept definition and emerging core principles were then cross-examined using an online survey and interviews with practitioners and experts/advisers, together ▶

Figure 2: Level of agreement with the concept definition of Quality 4.0.



with a focus group discussion with members of the European Organisation for Quality. Please note that we are very grateful to all respondents for their contributions. These lines of enquiry were focused on addressing:

- the extent to which organisations have a clear vision and strategy, which includes Q-4.0;
- levels of agreement to the proposed working definition;
- opinions on the level of importance and usefulness of each of the 10 emerging core principles;
- whether each of the 10 emerging core principles are necessary, and together are sufficient;
- the extent to which knowledge of Q-4.0 is developed throughout organisations.

The analysis also captured the qualitative comments made by participants about the proposed definition and 10 emerging core principles.

The overwhelming feedback from the online survey was one of positive agreement with the draft definition. Of the 41 responses to the question, "Does the definition reflect the concept of Quality 4.0?", 66 per cent agreed or strongly agreed, 27 per cent partially agreed and only three respondents disagreed or strongly disagreed (see Figure 2).

However, the length of the definition was considered to detract from its purpose. Through successive iterations, the research team developed a simpler working definition:

"Quality 4.0 is the leveraging of technology with people to improve the quality of an organisation, its products, its services and the outcomes it creates."

Nine out of the 10 emerging core principles were regarded by over 80 per cent of respondents as "important" or "very important". One of the principles was deemed "unimportant" by two of the 41 respondents, and three other principles were each regarded as "unimportant" by just one respondent. Figure 3 shows the extent of importance afforded to each of the 10 emerging core principles.

As a consequence, the team developed a revised set of eight emerging core principles (see p32).

Other key findings from the online survey are as follows:

- The adoption of Q-4.0 is still in its infancy in respondents' organisations (only 20 per cent of respondents strongly agreed their organisation had a clear vision and strategy which includes Q-4.0, while nearly 53 per cent disagreed or strongly disagreed – see Figure 4).
- Where organisations are not adopting Q-4.0 principles and practices, there is an intent to do so.
- There is the need for quality professionals to collaborate with fellow "driving forces" (collaboration is a core leadership role in the CQI's Competency Framework). However, some quality professionals are not being consulted, highlighting the threat that the Q-4.0 agenda could be driven by other disciplines.
- Cost reduction is not a primary pressure for these changes.
- There is a need for a new vocabulary in order to enable quality professionals to collaborate with other disciplines that are involved in Q-4.0.
- It is important to align a Q-4.0 intent with the overall corporate strategic plan – this is a key element of Q-4.0.

"Quality 4.0 is the leveraging of technology with people to improve the quality of an organisation, its products, its services and the outcomes it creates"

SURVEY RANKING OF DRAFT PRINCIPLES DRAWN FROM THE LITERATURE

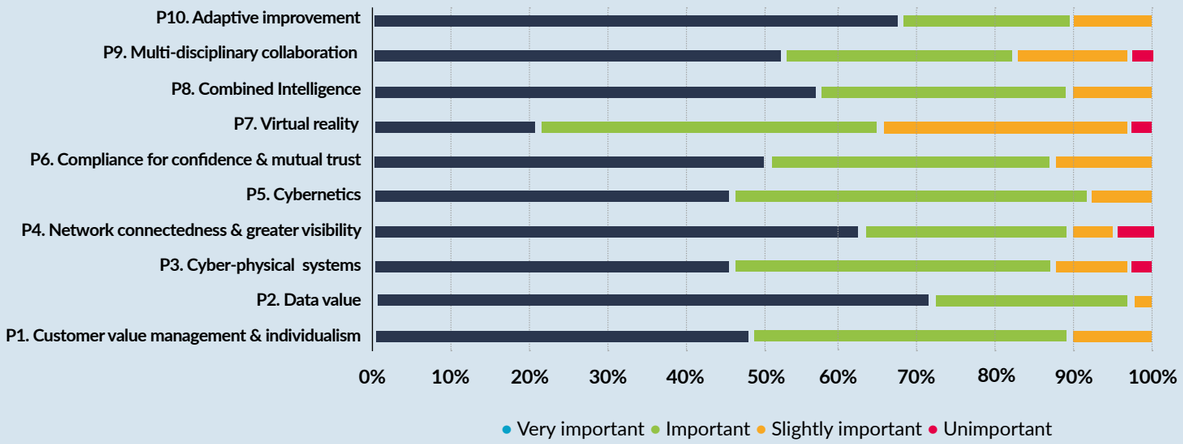


Figure 3: Summary of responses on the 10 emerging core principles of Quality 4.0.

OUR ORGANISATION HAS A CLEAR VISION AND STRATEGY THAT INCLUDES QUALITY 4.0

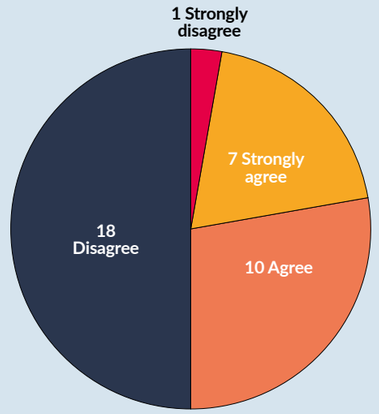


Figure 4: Level of agreement from respondents on whether their organisation includes Quality 4.0.

OUTCOMES OF THE RESEARCH

As a consequence of this project, the team have developed a Quality 4.0 infographic (see p32) that shows a short concept definition, and the supporting eight emerging core principles. It also contains some examples of the principles in practice.

The objective of this infographic is to expand the profession's understanding of Q-4.0 and provide the basis for discussions with colleagues and clients concerning where these principles apply within each organisational setting. This should, in turn, lead to a discussion about the impact these core principles will have on the quality management practice. For example, a principle of cyber-physical systems is designed to lead the professional to think about how best to continually combine technology and people to improve the outputs of any process. This could lead to a redesign of end-to-end assurance approaches that completely transforms what is done and achieved.

This contrasts with blindly accepting and implementing remote audit as a new Q-4.0 practice, out of necessity or pressure from stakeholders; it should be more about intelligent and agile design.

WHAT'S NEXT?

The eventual aim of this programme of research is to identify the competences that a quality professional will need to thrive in the digitally enabled age. Given the momentum, the CQI is moving on to an exploration of Q-4.0 practices, technologies, tools and competences. A project will soon be launched to address the following research questions:

- To what extent do the current principles of quality management map to the eight emerging core principles that have emerged and what does this mean for the future of the discipline?
- What are the most relevant Q-4.0 technologies and tools that quality professionals will need to know about, engage with, participate with, adopt, and lead the use/development of?
- What are the skills, experience, knowledge, and behaviours required to define the competence of a quality professional who can thrive in the digitally enabled age?
- What constitutes the Q-4.0 version of the Competency Framework for a quality professional that is fit for the digitally transforming age?
- What could be the value to an organisation of a quality professional whose competence is fit for the digitally enabled age?

The CQI recognises that Q-4.0 is a gamechanger for the profession and this properly structured, wide-ranging and systematic research creates the need for quality professionals to engage with the outcomes to build a personal development plan. The CQI believes that it is vitally important for quality professionals to embrace Q-4.0 in their work. Some commentators even go as far as suggesting that, unless the quality profession understands and acts upon the impact of this digital age on what they do, the future of the profession could be at risk. The opposite of this is that the future holds huge opportunity for the quality professional to play an even more valuable role at organisational and societal levels. ■

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QUALITY 4.0

a working definition

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Co-creation of value

Customers and society are constantly redefining the value they require, and how and where they want to consume it. Customer value co-creation is increasingly through digital servitisation.

Uber applies this principle – firstly by transforming the traditional taxi service into one which offers on-demand transport and effortless payment from a smartphone; and secondly in the way it collects real-time feedback on driver performance and engages with customers to solve problems and introduce new services and features. Many customers are no longer excited by just owning a product or using a service. Instead their interest lies in how it can serve their needs and outcomes.

Cybernetics

Data is captured from multiple sources across vertical, horizontal and end-to-end supply chains. Interconnected and smart networks in ecosystems are increasingly used to dynamically regulate and improve total system performance, including behaviours, inputs and outputs.

The Smart Home is an example of first and second order cybernetics in action. For example, by using systems such as Amazon Alexa, Hive or Nest, a person with a goal can act to set that goal for a self-regulating device, such as a thermostat in their home.

Transparency and collaboration

The value chain is increasingly an integrated 'smart' network of interrelated and interconnected cyber-physical systems. The ecosystems transcend traditional legacy boundaries and increasingly create whole-life circular economies. The customer, an active part of this network, requires both effective risk management and greater transparency and collaboration across multiple disciplines as technology networks expand.

Fitness trackers are an example of transparency and collaboration in action. They can guide you on your run, tell you how far you've run, where you ran and how fast. However, this highly connected network can also present a potential risk. In 2018, an interactive map of tracked fitness activities of people who use the Strava app inadvertently revealed the location of military bases overseas. This caused the US military to review its employees' use of personal fitness tracking devices.

Cyber physical systems

The balance and integration of human effort and machine effort, in the broadest sense, continually changes over time, automating some previously human roles and creating new ones around the co-design of cyber-physical quality systems.

The Auto Pilot is a trusted and proven example of the cyber physical system used by avionics today. The move towards self-driving cars is another example of such a system. Take Tesla cars which all now feature, as standard, advanced hardware capable of providing autopilot, and full self-driving capabilities.

OUR OBJECTIVE

To develop a working definition of Quality 4.0

OUR WORKING DEFINITION

Quality 4.0 is the leveraging of technology with people to improve the quality of an organisation, its products, its services and the outcomes it creates.

THE EIGHT SUPPORTING PRINCIPLES

These principles underpin our working definition of Quality 4.0. They enhance the established quality principles, which provide a focus on customer needs, expectations and satisfaction.

Mutual trust

Mutual trust is vital to drive out fear of surveillance and fraud, and digital tools enable transparency in partnering and contract executions. Inter-system compliance is authenticated and immutable to give assurance and confidence leading to greater resilience.

Effective data systems should engender trust in:

- **the infrastructure for collecting and storing data;**
- **the people, systems and machines using data;**
- **how organisations use data.**

Rapid adaptive learning

Continuous and rapid adaptive learning from data characterises innovation and improvement in value creation. Changing customer expectations are met based on new predictive capabilities rather than being reactive. Quality of design, conformance and performance is increasingly managed and communicated virtually, together with agile development and integration of systems leading to greater connectedness.

Airbnb has more than 100 machine learning models running on its website. It uses the data it collects to help improve and personalise every aspect of a customer's experience. When applied correctly, this principle sees organisations elegantly using data to better identify and recommend the most appropriate content or products, inspiring customers to buy.

Data value

Data is increasingly a contextually dependent strategic asset, requiring quality professionals to be knowledgeable in data governance, data architecture, data engineering and data analytics.

For the data to have value, it must satisfy some basic premises. It must be identifiable and definable, promise probable future economic benefits and be under the organisation's control. (*Putting a value on data*, PwC, 2019.)

Technology and combined intelligence

The vast array of enabling technology, machine learning and artificial intelligence augment human intelligence. The symbiotic human and machine relationship, in which virtual and real worlds co-exist, enables them to react, learn, make decisions and optimise quality processes.

The BMW Group's use of AI to evaluate component images from its production line is an example of this principle in action. This use of technology is allowing it to spot, in real time, deviations from quality standards.