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The influence of digitalisation on the role of quality professionals and their practices

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Abstract: Studies suggest that quality management professionals need a range of skills to simultaneously exploit current operational models and explore digital transformation. However, there is limited research on the impact of digitalisation on improvement work, associated practices and the skills and competencies of quality management professionals. To contribute to this gap, this study draws on a framework based on a conceptual combination of the principles of quality management and the field of occupational competence. The study aims to understand how digitalisation influences the role of quality management professionals, by assessing its influence on the professionals' improvement practices. The study employs a multiple cross-case research design with data from interviews with nine interviewees, and two focus groups. The results show a so far nascent and limited influence of digitalisation on improvement practices, a need for explorative and team-based practices. Moreover, nine needed skills areas to enhance the professionals' potential to benefit from digitalisation in improvement work are suggested. These are Integrator, Pragmatic approach based on a good understanding of possibilities, Change management, Process management, General project management, Improvement analysis, Predictive and proactive approach in QM, General IT and Big data proficiency.

Subjects: Quality Control & Reliability; Operations Management; Human Resource Development

Keywords: Quality Management; Digitalisation; Digitisation; Improvement Work; Competence; Quality Professionals

1. Introduction

Digitalisation has been argued to transform society and businesses at multiple levels—the societal level (e.g., the type of jobs), the business level (e.g., new value chains), the organisational level (e.g., new services offered) and the process level (e.g., the use of new digital tools; Parviainen et al.,

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2017). A digital transformation, such as Industry 4.0 (e.g., Kagermann, 2015), can be defined as a "restructuring of the system level (form organisation, firm, industry, etc.) as a result of digital diffusion for improving the business processes (operations)" (Nhelekwa et al., 2022, p. 3) In addition to affecting society and business at all levels, the transformation also cuts across both public (Lindgren et al., 2019) and private (Zangiacomi et al., 2017) sectors. While there are foundational discussions on the meaning of digitalisation, this paper adheres to a view that the term digitalisation has been coined to describe the manifold sociotechnical phenomena and processes of adopting and using these [digital] technologies in broader individual, organizational and societal contexts" (Legner et al., 2017, p. 301).

Digitalisation is compared with digitisation, which is "the action or process of digitizing; the conversion of analogue data [. . .] into digital form" (Parviainen et al., 2017, p. 64). In other words, digitisation refers to the process of converting existing non-digital practices into digital form, whereas digitalisation is the use of digital technologies to provide innovative and improved services, products, processes, or practices. Regardless of whether an organisation undergoes digitalisation or digitisation, the use of digital technologies influences quality management [QM], a management approach focusing on continuous quality improvements of organisations, products and services based on three core principles—customer focus, continuous improvement and teamwork (Dean & Bowen, 1994). In this context, it is argued that digital technologies influence all three core principles of QM. First, in relation to customer focus, customers can drive digitalisation by wanting to co-create value through digital technologies (e.g., Agrifoglio et al., 2017). Second, digitalisation changes how continuous improvements are implemented; this is exemplified through the use of big data for improvements (e.g., Gölzer & Fritzsche, 2017). Finally, digital technologies affect teamwork e.g., as co-workers are used to digital technologies and assume it to be exploited in their workplace (Henriette et al., 2016).

Many organisations have well-established quality departments (Sousa & Voss, 2002). This department is staffed by quality professionals, here defined as employees who have a portion of their time formally dedicated to QM. The roles of quality professionals have been researched from various angles, including their main tasks (Elg et al., 2011), future roles (Waddell & Mallen, 2001) and required competencies (Martin et al., 2019, 2021). Studies have also focussed on how quality professionals are influenced by digital technologies; for example, Ponsignon et al. (2019) outlines a framework that captures competencies that quality professionals must possess to support digitalisation. The framework highlights changes required in both structural (e.g., using customer interface to understand customer needs related to digital technologies) and contextual competencies (e.g., develop partnerships with IT functions; Ponsignon et al., 2019). This need for acquiring the right competencies underlines the role of digitalisation in creating new and transforming existing jobs (Henriette et al., 2016), calling for more studies on how digitalisation impacts the jobs of quality professionals (Ponsignon et al., 2019).

Hence, calls are being made for the identification as well as the development of new and ambidextrous competencies so that quality professionals both enhance current practices (see e.g., Hellsten & Klefsjö, 2000; Zu, 2009) to be up to date in the digital era and acquire new practices to support further digitalisation (Ponsignon et al., 2019). So far, studies detailing quality professionals' daily practices in relation to digitalisation are scarce. Hence, this study aims to understand how digitalisation influences the role of quality professionals, by assessing its influence on the professionals' improvement practices. To address this purpose, two research questions are advanced:

RQ1: In what ways are improvement practices influenced by digitalisation?

RQ2: What competencies should QM professionals possess to deal with the changes in improvement practices made possible by digitalisation?

The layout of the paper is as follows. The next section provides an overview of previous research and focuses both on specific quality practices as well as broader competencies needed for contemporary quality professionals to contribute to a holistic understanding of how digitalisation affects quality professionals. This is followed by a description of the research methods and analysis, with findings presented in the subsequent section emanating from the two research questions. The paper ends with a discussion of the findings and conclusions.

2. Literature review

2.1. Quality management and improvement practices

This study adopts a broad view on the concept of quality captured through the following definition by the Swedish Standards Institute (2015): "The quality of an organisation's products and service is determined by the ability to satisfy customers and the intended and unintended impact on relevant interested parties". Further, the paper adheres to Dean and Bowen's (1994) conceptualisation of QM based on the principles of *customer focus, continuous improvement* and *teamwork*. Subsequently, these principles are systematically realised by employing a set of QM practices and methods or techniques (Dean & Bowen, 1994; Gremyr et al., 2020) together with a stakeholder perspective, which can be perceived as a more inclusive and sustainable foundation for QM than the traditional and rather narrow QM focus on customers only (Foley, 2005). The QM practices are further adapted according to the organisational context and contingencies (Sousa & Voss, 2001, 2002). Table 1 presents an outline of the principles, and examples of practices, and methods, or techniques.

Numerous studies have addressed the need to understand QM practices, the roles of professionals and the improvement work in organisations (e.g., Ahire et al., 1995; Ingason et al., 2017; Sousa & Voss, 2001, 2002). In this paper, we base our perception on Zu's (2009) extensive empirical examination of QM practices and how they affect quality. Zu (2009) describes QM practices as being both "hard" and "soft" and develops a conceptual model with QM practices in two groups: *Core QM practices* (i.e., quality information, product & service design and process management) and *Infrastructure QM practices* (i.e., top management support, customer relationship, supplier relationship and workforce management). With the advent of Industry 4.0 (e.g., Kagermann, 2015; Kagermann et al., 2013; Nhelekwa et al., 2022; Sony & Naik, 2019) and the concept of Quality 4.0 (e.g., Johnson, 2019; Sony et al., 2020), new and changing QM practices are also emerging (e.g., Gunasekaran et al., 2019; Maganga & Taifa, 2022a, 2022b). Technological gains within the realm of Industry 4.0, such as big data, artificial intelligence (AI) applications,

Table 1. ***The concept of QM: Relationships between principles, practices and methods/techniques (adapted from* Dean & Bowen, 1994; Foley, 2005; Gremyr et al., 2020)**

Principles	**Customer and stakeholder focus**	**Continuous improvements**	**Teamwork**
Practices	Customer relationships Identifyingcustomer roles Collecting information on customer needs Using customer and stakeholder data in design and delivery Qualityfunction deployment	Problem-solving Plan-Do-Check-Act (PDCA) Process management Six Sigma (define, measure, analyse, improveand control (DMAIC))	Formation of teams Quality circles Formationof organisational units (i.e. "Quality departments")
Methods/ techniques	Kano model and survey Direct and indirect methodsfordata collection House of quality	Affinity diagrams Matrix diagrams Histogram Control charts	Competence profiling Breakthrough improvements

Internet of Things (IoT), Internet of Services (IoS), automation, robotics and connectivity certainly increases firm performance (e.g., Khalifa et al., 2021) but equally important are the human skills and competencies needed to harness all these technology effective practices. Perhaps not so surprising, few empirical studies have emerged specifically targeting QM practices in relation to such digitalisation efforts. This paper is an empirically based effort to propose a framework where both existing and emerging digital initiatives are considered through the elaboration of current and emerging QM practices in relation to digitalisation

2.2. The influence of digitalisation on quality management

It can be argued that Industry 4.0 in general and Quality 4.0 in particular are the most important drivers and influencers on how digitalisation currently affects QM in practice. Quality 4.0 has been described by Radziwill (2018) as implementing the Industry 4.0 concepts of *connectedness, intelligence, automation* and *performance innovation* into the established concept of QM and its methods and systems. This article also adheres to Chiarini (2020) and Sony et al. (2020) in the view that Quality 4.0 is a model that forms and shapes emerging QM and its practices that requires certain key elements (or "ingredients" as Sony et al. (2020) describes them). By utilising Zu's (2009) two overarching QM practice areas of *Core* and *Infrastructure QM practices*, this paper thus categorizes the core QM practice elements influenced by digitalisation primarily as: big data management, data analytics (in particular prescriptive analytics) and the facilitation of vertical, horizontal and end-to-end integration. Infrastructure QM practices influenced by digitalisation are primarily categorized as: creating strategic advantage, leadership, training, organizational culture and top management support.

In this paper, Quality 4.0 is therefore not perceived as a concept that outright replaces "traditional" QM but rather as a concept that benefits from digital elements in improving, reinforcing and enhancing its existing principles, practices and techniques. One of the few empirical studies so far focusing on the particular influence digitalisation initiatives have on QM practices shows that digitalisation influences professionals' improvement practices both in terms of scope and depth (Elg et al., 2020). The authors argue for the necessity to widen the scope of quality to be more explorative and, especially, to allow digitalisation to influence the way organisations interact with their customers. Elg et al. (2020) also show that digitalisation leads to the creation of new forms and magnitudes of data, influencing the depth of already existing practices such as reliability analyses.

The influence of digitalisation on QM can be analysed based on the aforementioned key principles of QM (Dean & Bowen, 1994). Concerning customer focus, digitalisation opens new possibilities for customization and personalization. Given that customer focus is a key QM principle, these possibilities impact the work of quality professionals. Customers' requirements for individual solutions can also drive digitalisation. As stated by Henriette et al. (2016, p. 3), "The digital transformation places users at the heart of corporate strategy. Customers are more and more demanding regarding the quality of products and services. They expect companies to be able to adapt quickly and customized to their changing needs". The implementation of customised solutions leads to the emergence of new organisational needs to manage these customised solutions. The management of customized solutions may, for example, require the development of applications that facilitate horizontal and end-to-end integration (Sony et al., 2020) and will allow the customer to better interact during the product design process (Mourtzis et al., 2014). In order to offer digitally based customised solutions, organisations may also be required to collaborate with different actors and stakeholders on the fragmented and dynamic markets (Zangiacomi et al., 2017).

Second, continuous improvements are key to QM. Research has demonstrated the need for quality practices to support both incremental and radical improvements (often referred to as exploitative and explorative practices; Fundin et al., 2018). Focusing on digitalisation, Elg et al. (2020) show that quality professionals have mainly focussed on the incremental improvements of

existing practices by digitisation rather than on more radical improvements based on digitalisations, such as new customer offerings. In addition, Birch-Jensen et al. (2020) show that quality professionals fail to use customer feedback on new digital offerings to drive improvements, for example, owing to the lack of channels between customer-facing employees and QM professionals. A critical component in achieving both incremental and radical improvements is the ability for predictive analytics. Gul et al. (2021) show that when properly used, the increased access and availability of information technology solutions, including big data and internet of things induced customer feedback, bring a significant increase in firm performance.

Third, teamwork is often linked to cross-functional collaborations (Dean & Bowen, 1994) facilitated by vertical integration (Sony et al., 2020). However, as argued by Henriette et al. (2016), digitalisation also leads to the creation of new roles or functions that require people with expertise in digital technologies. Elg et al. (2020) point towards these new roles and the need for quality professionals to establish well-functioning collaborations with key actors and stakeholders who develop and maintain relevant IT structures (e.g., the IT function in organisations). Such collaborations can be challenging as IT competence often becomes key to internal QM practices, such as process mapping, which is traditionally conducted by quality professionals. To overcome these possible tensions and better support digitalisation, Ponsignon et al. (2019) propose that professionals must both acquire new competencies and collaborate with the IT function. Competencies and practices supporting the digital transformation of QM for Digitalised Quality Management

Within the QM context, the general momentum of Industry 4.0 is driving a general shift from centralized and rather static production set-ups towards much more flexible and self-controlled production set-ups where most process steps will be digitalised, interconnected and both vertically and horizontally integrated (Ejsmont et al., 2020). This ongoing development has a fundamental impact in a new and emerging understanding of how the skill sets forming the competencies of quality professionals are and will be influenced by such digitalisation driven change. A further understanding of these changes not only serves to influence to change QM practices itself but may even extend knowledge on how the QM function could also, reciprocally, contribute towards digital transformation in organisations (Ponsignon et al., 2019).

The ability to perform digitalised QM practices in relevant contexts and situations (Martin et al., 2019) requires certain competencies, each including a range of practice-guided skill sets, knowledge, and attitudes (Delamare Le Deist & Winterton, 2005; Mulder, 2014) and as well as individual competencies-in-use (Ellström, 1997). The conceptual framework in Martin et al. (2021) proposes four main dimensions for describing competencies in QM: *Human, Methods and process, Conceptual*, and *Contextual competence dimensions*. The competence dimensions are formed by different sets of skills together with subjectively dependent variables, such as affective factors and personality traits (Ellström, 1997) needed to perform the practices and techniques. It should be noted that this paper is restricted to the more objectively defined skills in the competence dimensions, i.e.,, the *cognitive, perceptual motor* and *social skills*, as outlined by Ellström (1997).

The human competence dimension, in QM refers to the set of “soft”, social skills needed, such as relational, motivational and communicative skills also called “relation-making skills” of QM. The methods and process competence dimension in QM refers to the “hard”, action-oriented skills needed, such as being able to exploit and utilize QM-tools, methods, concepts and standards and can be called the “action-making skills” of QM. The conceptual competence dimension in QM refers to problem solving, lateral thinking, explorative and innovative skills or the “change-making skills” of QM. Finally, the contextual competence dimension in QM refers to the sensemaking and understanding of structural, organisational and power dimensions in one’s own organisational environment, including both internal and external perspectives, and can be described as the “sensemaking skills” of QM.

Table 2. *A framework for the anticipated influence of digitalisation on QM competencies* (Dean & Bowen, 1994; Gremyr et al., 2020; Martin et al., 2019)

	Customer and Stakeholder Focus	Continuous Improvement	Teamwork
Human competence	Need to manage customised solutions (Mourtzis et al., 2014; Zangiacomi et al., 2017)	Calls for more research on skill development in digitalized improvement practices (Santos et al., 2021)	New organisational roles relatedtodigital technologies (Henriette et al., 2016)
Methods and process competence	Development of digitalized QM tools and processestoimprove customer satisfaction (Cobelli & Chiarini, 2020)	Digitalisation provides new types and forms of feedback data (Elg et al., 2020).Effortsin implementing digital quality process improvement tools (Dutta et al., 2021)	Sharing and developing knowledge on digitalized QM tools through processes of organisational learning (Kuusisto, 2017) and quality circles (Romero et al., 2019
Conceptual competence	Customersdem and highlycustomised solutions (Henriette et al., 2016)	Need for exploitative and explorative practices—exploiting digitisation as well as digitalisation (Elg et al., 2020)	Need for new competencies in order to exploit new possibilities (Ponsignon et al., 2019; Elg et al., 2020)
Contextual competence	Sense making and better understanding of digital channels and customer interactionto increase customer satisfaction (e.g., Sun et al., 2020; Holmlund et al., 2017)	The need for a solid understandingof he many aspects and context of digitalized production environments to support improvement efforts (Santos et al., 2021)	Teaming up with critical stakeholders and expertise (e.g., IT) to better understand the contextofdigital functions, processes and capabilities (Ponsignon et al., 2019)

By amalgamating an adaptation of the key principles of QM (Dean & Bowen, 1994; Gremyr et al., 2020) together with the QM competence framework (Martin et al., 2021), this paper offers a further take on QM competencies by proposing a framework for articulating the digitalisation skills forming the main competence dimensions in QM work. The proposed framework further reflects what Wen et al. (2020) describes as "the next stage of QM", wherein the concept of quality is open for interpretations, functional integration, customer integration and where the overall performance of the business ecosystem emerges as crucial factors for successful QM. In Table 2 the proposed framework is outlined by including examples of changes resulting from digitalisation.

3. Method

3.1. Study design

This study is based on a qualitative, multiple cross-case study design (Miles & Huberman, 1994). The choice of case study approach is primarily motivated by the study's purpose to understand how the role of the QM professionals is influenced by digitalisation. According to Voss et al. (2002), case study designs are particularly well suited for studies aimed at exploring complex phenomena, such as digitalisation. In this study, the empirical case categories (Dumez, 2015) include the QM practice and, in particular, the daily improvement work performed across different organisations. The theoretical case category (Dumez, 2015) includes digitalisation and how it affects practices. The case is viewed as an instrumental case study (Stake, 1995). Given this, the primary interest was not aimed to explore the intrinsic qualities of the empirical case, but rather in how it enables an understanding and development of theoretical ideas through analytical generalisation (Firestone, 1993).

3.2. Sampling

Due to the rather novel area of the influence of digitalisation on QM practices, the sampling strategy followed what Patton (2015) describes as a *group characteristics sampling strategy*. A group characteristics sampling strategy facilitates a wide variation in the sampling of both organisations and participants together with a potential to identify key informants from relevant case contexts (Patton, 2015). The study therefore draws on data from interviews and focus groups with QM professionals sampled through the *Svenska Förbundet för Kvalitet* (SFK), a professional Swedish QM association committed to help members advance their skills in the field. The participants represented a variety different sector and business areas—four large and also four small and medium-sized enterprises (SMEs), i.e., companies with ≤ 250 employees and a turnover ≤ € 50 m (European Commission, 2003). The unit of analysis for this study is the role of experienced quality professionals. Deep, informed experience about the phenomena was sought. It was therefore ensured that every participant had experience from dedicated professional QM roles with formalised tasks and designated time for carrying out QM work. The selection criteria required each participant to have had at least 5 years of experience in a senior QM position; thus, the participants possessed extensive practical knowledge and expertise. In total, 10 quality professionals participated in the study (see, Table 3).

3.3. Data collection

Data were collected in a two-step process using both interviews and focus groups. Such multiple method approaches not only carry the possibility to strengthen validity in order to maintain the accuracy of descriptions and support for assertions and interpretations (Stake, 1995; Taylor, 1979), it also produces better and richer evidence (Yin, 2014). In the first data collection step, interview data was collected using a thematic and semi-structured interview guide (Arksey & Knight, 1999), based on a predefined interview guide. Each interview lasted approximately 45–60 minutes and was recorded and transcribed verbatim. Before the interviews and focus groups, all participants were informed about ethical considerations. Particular attention was paid to ensure that participation was voluntary, that informed consent was obtained and that the data collected were kept anonymous and confidential. Every participant was also informed about the possibility to withdraw from the study at any stage during the research process. The analysed results from the interviews were then used to prepare the second data collection step, which consisted of two focus groups. In total the focus groups consisted of six experienced QM professionals from SFK who participated in a two-stage session. In the first focus group stage, preliminary results from the interview data were presented. In the second stage, a workshop was conducted to interpret, assess and add to the preliminary results. Here the participants were divided into two sub-groups, and each group was headed by a workshop facilitator (one of the authors). The results were documented jointly by the participants using an online document (see, Figure 1 and 2).

3.4. Data analysis

First, the interview data (transcriptions and survey) were imported into the QSR NVivo 12 software program. The iterative data analysis followed a general five-step process—reading and re-reading the transcripts; data reduction by coding; comparing, relating and integrating codes; thematic analysis and drawing conclusions. Following multiple readings of the transcripts, coding was conducted iteratively in an abductive approach (e.g., Saetre & Van de Ven, 2021). The abductive approach can be described as an iterative, two-step analysis approach combining both deductive and inductive analysis steps (Miles & Huberman, 1994). The deductive part of the analysis (i.e., coding) was based on concepts featured in the previous research presented; it was then complemented by inductive coding, whereby new variables were also identified from the gathered data in order to generate new knowledge and understanding (Miles & Huberman, 1994). Pre-defined codes were amended, and new codes were added to the inductive part of the coding. Thus, the analysis as a whole is abductive enabled by this iterative processing (Eisenhardt, 1989). The coding also included code clustering, pattern clarification and the identification of thematic patterns and categories shared across the codes and available data. The identified themes were subsequently

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Table 3. Overview of the interview and focus group participants

Participant code	Organisational code	Organisational size	Quality Management position and role	Experience	Organisational sector
IP1 & IP2	A	Large	Quality Manager and Quality Business Office	18 years & 10 years	Car manufacturing
IP3	B	SME	Quality director	15 years	Logistics
IP4/FG1	C	SME	Consultant	20 years	Consulting
IP5/FG5	D	SME	Consultant	12 years	Consulting
IP6/FG2	E	Large	Sales director	20 years	Telecommunications
IP7/FG3	F	Large	Quality manager	23 years	Manufacturing
IP8	G	Large	Quality manager	20 years	Telecommunications
IP9/FG6	H	SME	Operations Development Manager	5 years	Construction
FG4	I	SME	Owner	25 years	Consulting

analysed by adopting the theoretical framework; and as a final step of the data analysis, conclusions were drawn.

Second, the focus group data was jointly analysed by the participants using an affinity method, i.e., a brainstorming tool where grouping is based on natural affinity (Shahin et al., 2010). In the first step, the skills and knowledge identified in the interview study were provided in the form of digital post-it notes to the participants. Thus, participants in the focus group were involved in providing feedback, confirmation and cross-validation of preliminary findings (e.g., Miles & Huberman, 1994). The second step involved a discussion of the preliminary findings (skills and knowledge needs), and also an opportunity for the participants to add other skills they regarded as essential. In this way, the interaction with professionals yielded additional input, which helped in developing the findings and enhancing face validity (Bryman & Bell, 2015). As a third step, the digital post-it notes were dragged and dropped into clusters (based on the perceived affinity), and lastly the clusters were labelled with headings.

Besides the use of the focus group to enhance research quality, other measures included discussions of the sampling strategy and regular meetings to discuss, evaluate and validate interpretations and individual perceptions at all stages of the research. Moreover, rigour was achieved through measures, such as e.g., a standardised interview guide.

4. Findings

4.1. Improvement practices

The changes in improvement practices are elaborated on in relation to the principles of customer focus, continuous improvements and teamwork. Concerning customer focus, interviewees expected that they would get a better understanding of their customers resulting from digitalisation, e.g., with sensor technologies that will allow continuous data transfer from the customers' own processes. In addition, that digitalisation facilitating customised solutions as digital components could be altered in response to a specific customer's needs. In this regard, interviewee IP6 provided the following example from the automotive industry:

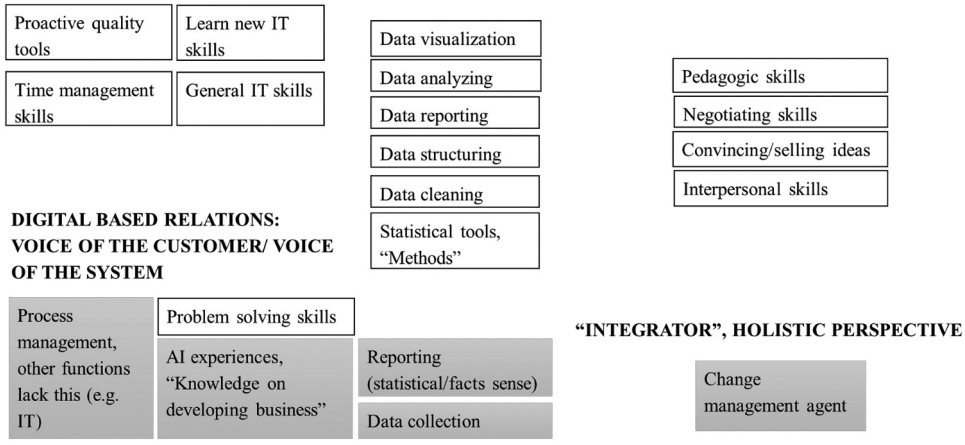

Figure 1. First focus group's clustering.

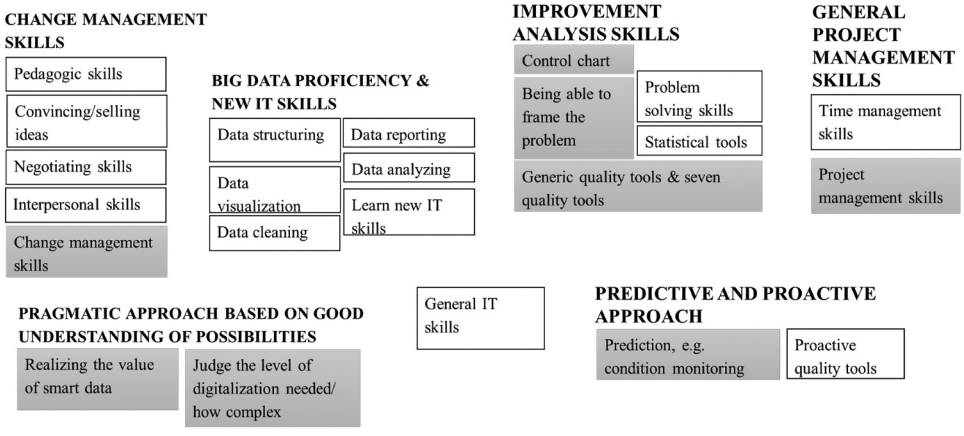

Figure 2. Second focus group's clustering.

> *We developed a product based on customer needs, which we showed to the customers when they contacted us with their requirement. Although they appreciated the product, they required additional functionalities. Based on their feedback, these [digital] functionalities were added by our developers.* (IP6)

Such a customized solution could only be delivered via digitalisation, which allowed the firm to turn an existing standardised product into a new, customized offering. However, this approach will require the organisations to closely interact with their customers (directly, or through digital aids like sensors) to foresee customer needs and develop solutions accordingly. Concerning internal customers, digitalisation has been reported to support automation and self-service of certain tasks in quality departments. The use of digital tools has facilitated the establishment of new practices for both broad audiences and specialists in the organisation.

> *We have developed [. . .] better tools for all the teams to be self-supporting when it comes to quality data. So they can create their own perspective of the data. [. . .] we have quite good tools today, where you can search for patterns, see things that . . . I would say . . . impossible previously to do.* (IP1)

Concerning the principle of continuous improvements, the interviewees reported about the sustained relevance of traditional improvement practices and statistical tools; however, they highlighted that the data flows became more intensive and real-time. In company E, for example, customer data were collected instantly through a cloud-based platform.

> *… data is being uploaded to the cloud that we offer […] All cars that are being sold, they are connected to a cloud and in that cloud, they can communicate with each other. So the car, if it breaks down it gives data to the cloud. We can analyse the data and we can send data back.* (IP6)

In addition to continuously receiving data, there has been a change in data flows in terms of volume and complexity, leading to new challenges for improvement practices. It is also reported that these challenges and needs for changes are simultaneously enhanced as it occurs alongside an agile transformation; for example, organisations receive improvement requests from customers continuously through digital interfaces and are expected to respond accordingly. While sources of data are intense and real-time, the use of it is still unclear to some organisations. Some interviewees felt a need to improve their competencies to deal with big data and acknowledged that there was no plan to exploit data from already implemented digital initiatives.

> *It's the same IT system that we are using for deviations and stuff. And when we get this rolling, the point is to get deviations from different projects or hardships or learning from different projects into the same systems. And of course, that is something for example, I should look closer on later. But that's maybe the next step …* (IP9)

Third, customer focus and continuous improvement both influence and are influenced by teamwork and the collaboration between various stakeholders. Digitalisation facilitates collaboration between teams by providing access to data that could be used as a basis for joint decision-making. In such a setting, quality professionals have the potential to support other functions in developing their own skills:

> *Our role is changing a little bit […] when we provide the data, or make the data available for everyone, we also need to some extent train them, so they know how to use it. So, we're moving more into a teacher role in that sense.* (IP1)

5. Requirements of new competencies

Overall, quality professionals are expected to equip themselves with new skills to make their competence relevant in the context of digitalisation. First, they need to interact with organisational members from various departments using the context-dependent language prevalent in that department. For example, they must talk to engineers in the development team in technical language, while, in order to gain management support for an improvement project, they must translate quality issues into financial language. Second, in the context of digitalisation, quality professionals are expected to handle more tactical and strategic tasks. Regarding cooperation between functions, it is important both to understand other functions' operation in general and also the technologies they use to form teams that can engage in problem solving initiated by the access to new types of data (e.g., deviations identified by analysing sensor data):

> *And we are working to change the structure of the organization and create teams that consist of industrial engineering, quality, maintenance engineering, supply chain, etcetera. So that when there is a problem, when there is a task, they are already a team. […] You solve this together.* (IP7)

In general, the interviewees suggested a wide range of skills needed in QM competencies (see, Table 4 for descriptions of the skills areas) that professionals must possess to exploit the potentials arising from digitalisation, emphasising that the role of quality professionals will be broadened owing to the influence of digitalisation. In the Appendix, illustrative quotes for each of the nine areas are presented.

Building on the competencies identified in the interviews, the focus group participants were asked to structure and cluster skills and if needed add new skills they regarded as critical for the

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Table 4. Types of skills needed in quality practitioners' competence

Types of skills	Description
"Integrator"—holistic perspective	Multiple skills in "translating" and reconfiguring information content that needs to be understood in cross-functional settings.
Pragmatic approach based on a good understanding of possibilities	The ability to understand the situation and assess the level of digitalisation needed for the organizations. These may include, but not limited to, the ability to realise the value of smart data and understand what is needed to develop the business.
Change management skills	Skillsets required for change management—negotiation skills, pedagogical skills and interpersonal skills.
Process management skills	Skillsets required to understand operations and processes and an ability to integrate them with the digital solutions
General project management skills	General project management skills for digitalisation initiatives, especially in the context of agile transformation
Improvement analysis skills	Core skillsets, including problem-solving skills and the ability to use quality- and statistical tools in a sustainable way.
Predictive and proactive approach in Quality Management	Skills and knowledge to use proactive and predictive quality tools, such as condition monitoring
IT skills	Ability to learn and apply IT skills, i.e. generic proficiency in using IT tools that are not specific to quality management work.
Big data proficiency	Skills related to big data handling, such as, data collection, data cleaning, data analysing and visualisation

competencies of QM professionals in a digitalised context. The focus group was divided into two sub-groups generating one affinity diagram for each group. Figures 1 and 2 below illustrate the two diagrams resulting from the focus groups. White notes are skills identified from interview data, and grey notes contain skills added in the focus group. Finally, the participants clustered the notes and added headings to some of these clusters; these headings are displayed in capital letters. Starting with Figure 1, the added skills ranged from aspects like AI experience to aspects more often associated with QM, e.g., process management and reporting of statistical results.

In Figure 1, two clusters were assigned headings; these were the ones under which the participants had added new skills in addition to the ones derived from the interviews. In the discussions on "Digital-based relationships: voice of the customer/voice of the system", the focus was on big data that "requires a QM that can integrate digital solutions throughout the whole business process". However, this new requirement focused on traditional QM practices, such as process management, and how these could be digitised if the quality professionals possessed the needed digital competence. Finally, the second heading—"Integrator, holistic perspective"—points towards the increased need of possessing soft skills related to change management, e.g., to facilitate needed collaborations between the quality and the IT function. This need was also acknowledged by the other sub-group by adding change management in their diagram (Figure 2).

In Figure 2, change management has been assigned as the heading for a cluster of soft skills, but there are also three clusters (big data proficiency, improvement analysis skills, and predictive and proactive approach) focusing on hard, technical skills. This relates to the use of quantitative tools like control charts, data reporting and the proactive use of predictive quality tools (e.g., condition monitoring with sensors). The broader area of big data proficiency refers to skills related to big data handling, such as data collection, data cleaning, data analysing and visualisation.

Looking at the added skills, it can be noted that the two clusters ”Digital based relations: voice of the customer/voice of the system” (Figure 1) and ”Pragmatic Approach based on good understanding of possibilities” (Figure 2) highlight a need to look beyond the skills related to handling large amounts of data and focus on how to digitalise in a way that in a specific context adds most value, for example, by knowing what creates valued in the business' as well as its customers' processes. Following this, the participants were asked to discuss if they thought that the role of quality professionals will be broadened or narrowed owing to digitalisation. The discussions could be summarised by the following quote: ”Management skills of quality professionals must be broadened, and they must understand organisations' goals, objectives and visions. Otherwise, they will just be experts collecting data” (FG2). However, in relation to this, the participants also acknowledged a challenge in acquiring competence based on general management skills as well as highly specialised skills in quantitative methods. A challenge that could lead to ”different roles that might be handled by different persons” (FG1).

6. Discussion

Digitalisation in general requires the development of new organisational roles related to digital technology and digital applications (Elg et al., 2020; Henriette et al., 2016; Ponsignon et al., 2019). In particular, the emergence of Quality 4.0 with its emphasis on connectedness, intelligence, automation and performance innovation (Radziwill, 2018), shapes how existing QM practices (e.g., Zu, 2009) are reinterpreted and changed. This study identifies a varied set of such new practices and skills, including skill components that allow the performance of both “hard” and “soft” QM practices (Zu, 2009).

The “soft” skills identified in the data pertain to the human competence dimension and can be exemplified by project management skills and change management skills; the “hard” skills of the methods and process competence dimension can, in turn, be exemplified by tools and application skills, such as big data proficiency and analytical applications for quality improvement analysis. Such “hard” QM skills are not restricted only to IT-skills but also emphasise digitalised or digitised QM tools and applications that are commonly used within QM. Such a wide and diverse array of different digital QM skills may constitute a potential challenge for QM-professionals in order to master such a combination of skill variety and might lead to ”different roles that might be handled by different persons” (FG1). On the other hand, such challenges can also be seen as opportunities to exploit and enhance the “hard” skills many QM professionals already possess by adding “soft” human competence dimension skills (e.g., in change management) and become equipped to take on a more strategic role of QM, based on an increased understanding of the context-specific values that can be developed by adopting digital solutions.

6.1. QM competencies for digitalised customer and stakeholder focus

First, operationalising the principle of customer and stakeholder focus in a digital world means to develop skills to support e.g., digital-based relations to customers and condition-monitoring of customers' processes and products. Such competencies revolve around infrastructure practices and strategic advantage (Zu, 2009). For example, the dual need of both developing and managing customised solutions (Henriette et al., 2016; Mourtzis et al., 2014; Zangiacomi et al., 2017), tools and processes (Cobelli & Chiarini, 2020) requires innovative thinking (Henriette et al., 2016) and clear conceptual notions of what creates customer satisfaction (Holmlund et al., 2017; Sun et al., 2020). Adopting strategically aligned change management skills are thus critical for QM professionals to create, develop and maintain necessary stakeholder and customer relations as well as communicating needs and requirements across the customer and provider sphere.

The method- and process competence dimension in relation to the conceptual competence dimension primarily revolves around what Zu (2009) describes as core QM practice elements. In our study, the findings concerning the methods and process dimension are somewhat contradictory. For example, one set of skills identified both in the interviews and the focus groups present two possibly contradictory directions: first, a need to be more focused on specific tools and methods, and second,

a need to better understand how to realise the value of smart data. This illustrates the challenge of ambidexterity facing contemporary QM professionals and the need to balance both adaptive, production-oriented QM practices with innovative and developmental QM practices (Martin et al., 2019, 2021). From a pure method and process competence perspective, digitalisation requires improvement analysis skills for adopting, implementing, and utilising the necessary digital tools and concepts. The conceptual competence dimension includes skills pertaining to the exploration of possibilities, change management skills and general improvement analysis skills. In combination, these skill sets necessitate lateral, innovative and explorative thinking as important cognitive skills for any QM professional in a digitalised environment. In relation to customer and stakeholder focus, QM professionals also need to have a set of skills aimed at understanding and exploring the potential possibilities set within a customer and stakeholder context. This also necessitates much more focus on horizontal integration (Zu, 2009) facilitating better intercommunication between the provider and customer spheres. By increased horizontal integration of logic and rationality, as well as the organisational dynamics of the customer sphere, how customers may drive digitalisation as part of their own value creation process (e.g., Agrifoglio et al., 2017), may be better understood and realised by QM professionals in order to grasp how customer satisfaction can be further increased.

6.2. QM competencies for digitalised continuous improvement

Second, when focusing on the principle of continuous improvement it has been argued that digitalisation provides more scope for explorative QM practices (Elg et al., 2020; Fundin et al., 2018). This emphasises skills within the conceptual competence dimension and improved skills in data analytics. However, exploitative practices based on *digitisation* of traditional QM practices seem to be most prevalent in organisations. The data indicates that larger organisations often command enough resources to develop appropriate strategies and policies embracing digitalisation initiatives. For smaller organizations, the findings indicate that digitisation appears to dominate even more, indicating that size might matter when it comes to digitalisation efforts. A caveat for further research is that the difference between digitisation and digitalisation can be somewhat fuzzy, making clear distinctions difficult. To determine whether an organisation is more focused on digitisation over digitalisation in its QM practices, one may analyse the use of feedback data (Birch-Jensen et al., 2020; Gremyr et al., 2022) in the organisation. It can thus be argued that new forms of data and new ways of analysing data are drivers of explorative practice and skills development in QM. Continuous improvement in practices linked to digitalisation and/or digitisation within the human competence dimension emphasises general project management skills to develop necessary improvement practices, as indicated by Santos et al., 2021). The development of new digital improvement tools (Dutta et al., 2021) and new forms of data (Elg et al., 2020) requires the development of methods and process competences, such as process management skills, improvement analysis skills, predictive skills and proficiency in big data practices (e.g., Gölzer & Fritzsche, 2017). Not only does digitalisation require new forms of "hard" skills, but also conceptual competence that includes analytical skills for practice improvement and a conceptual understanding to explore and exploit possibilities in developing new digital improvement practices (e.g., Elg et al., 2020). Continuous improvement also necessitates process and project management skills to understand both internal and external context aspects, especially in production contexts (Santos et al., 2021).

6.3. QM competencies for digitalised teamwork

Third, in line with both Ponsignon et al. (2019) and Elg et al. (2020), this study shows that digitalisation requires an increased focus on teamwork. New organisational roles related to digital technologies (Henriette et al., 2016; Radziwill, 2018; Sony et al., 2020) as well as the task of facilitating learning and knowledge sharing processes (Kuusisto, 2017; Romero et al., 2019) and also stakeholder collaboration (Ponsignon et al., 2019) through increased horizontal integration (Zu, 2009) emphasises QM skills pertaining that facilitates teamwork. It is thus argued that teamwork may be a critical QM principle in digitalised QM contexts since teamwork can be viewed as a fundamental facilitator for practices and techniques of both customer and stakeholder focus and also continuous improvement.

From a human competence perspective, the practice of facilitating cross-functional collaboration using the skillset of holistic, "Integrator" change management and project management skills should therefore be considered as critically important for QM professionals. To take on this role, there is a need to not only focus on "hard" skills related to core QM practice elements, such as methods and process competence, with digitalised process management tools and IT-skills, but to also focus more on "soft" skills, related to leading and motivating change and valuing new forms of data in digital improvement contexts. This was emphasised by the focus group participants along with expressing the need to continuously team up with critical stakeholders, functions (e.g., the IT department), and expertise to better understand the digitalised customer context, as underlined by Ponsignon et al. (2019). In other words, in order to act as a QM professional in the cross-functional and cross-customer and stakeholder sphere role of an "Integrator", the QM professionals must have a good understanding and situational awareness of the overall business and integration efforts needed to add most value; as also advocated by Wen et al. (2020).

6.4. Implications for research and practice

The research implications from this study are that its practices supporting all three underlying principles of QM are influenced by digitalisation, and this also affects the competences needed for QM professionals to carry out improvement work (as outlined in Table 2). Further, digitalisation is argued to reinforce QM as a key strategic concern in organisations (e.g., Elg et al., 2020; Sony et al., 2020). However, by drawing on the framework offered in this paper (see, Table 2), this study also demonstrates a continued need to develop more explorative and team-oriented QM-practices to better realise the potential in digitalisation in all organisations represented (despite differences in sizes, etc.).

The practical implications concern the need for QM professionals to reconsider the practices supporting all three underlying QM principles (customer focus, continuous improvement and teamwork) and acquire skills that support digitisation of existing practices as well as digitalisation that enables new practices. Table 4 outlines and describes nine skills areas to consider. However, the practical implications naturally differ in relation to e.g., size of the organisation. For example, in a large organisation, the need for ambidexterity in both being focused on specific tools and methods and having general knowledge and understanding of the value of smart data can be solved by a team with individuals with different competence profiles. In a smaller organisation, this is more challenging as there might only be one or a couple of QM professionals to manage a majority of improvement work irrespective of what competence, or expertise is needed.

7. Conclusions

This study contributes to a better understanding of the challenges and possibilities that QM professionals face, in the context of digitalisation. As the impact of Quality 4.0 increases, equipping the QM professionals, with skills enabling exploitation of digital opportunities becomes increasingly important. Although it can be argued that much of the traditional QM practices are influenced by *digitisation*, this study highlights skills area where *digitalisation* has the potential to even further position QM as a strategic approach to continuously improve performance. The findings further point to a wide variety of needed skills and a possible challenge or opportunity, for professionals to possess both "hard" and "soft" skills to take on a more strategic role in identifying and creating value from digitalisation. In specific, nine skills areas related to digitalisation initiatives were identified: Integrator, Pragmatic approach based on a good understanding of possibilities, Change management, Process management, General project management, Improvement analysis, Predictive and proactive approach in QM, General IT and Big data proficiency.

By using a framework that integrates established QM principles and competencies, the study argues that the QM principle of teamwork may be critical in digital QM work and therefore needs be much more strongly emphasised. As to QM competencies, methods and process skills in a digital context naturally form an important part of a QM professional in a digital world, however

contextual competence is highlighted as imperative to discern and properly make practical and useful sense of the critical factors for successful QM practice in a digitalised environment.

In summary, the conclusions lead to recommendations for QM professionals to first evaluate the skills areas described in Table 4 and ensure that the focus when digitalising improvement work is not solely on "hard skills" related to skills areas, such as e.g., Improvement analysis, Predictive and proactive approach in QM and Big data proficiency. Rather, to be able to fully exploit the potential in digitalisation, there is a need to also focus on "soft" skills, such as change and process management. Moreover, as some skill areas suggested are strongly linked to the competencies of other professional groups, such as e.g., IT professionals, it is critical to establish integrated improvement teams with members from various professional groups. The latter is likely especially important in smaller organisations where the number of QM professionals is limited and the responsibilities for improvement work tend to fall on one or a few individuals.

As with all studies, there are limitations also in this study. This study is limited owing to its small sample size, which influences the generalisability of the results. The sampling has focussed on QM professionals carrying out improvement work, and naturally the findings could be different if the sampling focused on other professional groups that in some ways are involved in improvement work. Thus, future research could benefit from single-case studies to gain more in-depth data on the impact of digitalisation on improvement work across various professional groups. Moreover, it would be interesting to conduct research that specifically studies how the impact of digitalisation on daily improvement work differs depending on characteristics of the QM professionals in terms of e.g., age, IT experience, education, etc., as attitudes towards digitalisation and proficiency in using digital aids might differ. Another dimension that could be of interest is to study digitalisation of QM work in various sectors with a focus on contrasting, e.g., service vs manufacturing firms and public vs private organisations.

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