CHAPTER 13

Becoming Digital: The Need to Redesign Competences and Skills in the Fashion Industry

Lucia Varra

Introduction

Technology, which has always been an important driver of change, has in recent years become the most disruptive factor in manufacturing and service industries, as well as in consumer lifestyles. The pervasiveness of technologies in manufacturing industries has given rise to a new approach to business activities which interconnects all the components of the value chain, both mechanical and human; this interconnection results in more efficient, flexible, fast and reliable business processes.

In smart factories, which are based on intelligent technologies combined with new values and new or renewed competences and skills, accurate and fast decisions can be made based on extensive information (big data) derived from the interactions between workers, objects, and machines. This information allows factories to use resources more intelligently, drastically reduce waste, and increase general efficiency, including

L. Varra (✉)
University of Florence, Florence, Italy

W. Ozuem and S. Ranfagni (eds.), *The Art of Digital Marketing for Fashion and Luxury Brands*,
https://doi.org/10.1007/978-3-030-70324-0_13

energy efficiency (Guercini & Ranfagni, 2013; Majeed & Rupasinghe, 2017; Ozuem et al., 2008; Tao et al., 2018; Zhong et al., 2017).

The fashion sector, particularly the luxury fashion sector, is an interesting field of study for the transformations underway: it constitutes a laboratory of solutions that reconcile artisanry, authenticity, and product exclusivity with the most innovative industrial technologies. However, it is also a sector that, even more than others, must take advantage of the opportunity to exploit digital technology to create symbiotic relationships with customers and translate new requests into products and processes, including emotional experiences and sustainability. The absence of a rigid separation inside a smart factory between physical and digital components deeply affects both operational and managerial processes and both organisational and interorganisational processes, with strong implications for professional skills, both technical and soft skills.

The problem of skills and competences is at the core of an effective transformation towards the factory of the future. In this factory, smart machines and "augmented operators" are paradigms that exist simultaneously (Longo et al., 2017; Weyer et al., 2015); however, these developments also present challenges that must be overcome, and the ability and vision of managers are fundamental to this process (Longo et al., 2017). At the same time, the need for specialists and newly conceived engineering roles increases (Magone & Mazali, 2016). Therefore, all types of performed tasks – operational, specialist, and managerial – are affected by the required changes to activities and skills. These changes also raise questions about the acquisition, development, and enhancement of skills both within organisations and through the education and university training system. Yet the issue of competences in Industry 4.0 has only recently been addressed, and few previous studies have linked it to the processes and roles that are involved.

This work, beginning with an analysis of the most recent literature on the topic of Industry 4.0, examines the implications of changing required competences within this industry, linking them to the processes of the fashion sector and some key roles within the sector. It also identifies several new roles entering the sector, considering roles and competences in the context of both manufacturing processes and managing processes supporting technology.

Finally, the work investigates the impact the required new skills have on employee management processes in human resource management (HRM)

and reflects on the challenges of adapting to these skills at both an organisational level and at a level of education and training.

Literature Overview

Digital Factory and Digital Fashion: Characteristics and Processes

The transformations in the production and services sector can be traced back to the 4.0 revolution (Hofmann & Rusch, 2017; Zhang et al., 2019; Zhong et al., 2017) which fundamentally changed the technological matrix, including integrated systems, applications of information and communications technology (ICT), and industrial technology; the result was the creation of a digital and intelligent factory that allows faster production driven by information, including information from users, (Zhong et al., 2017; Zhou et al., 2015). The so-called fourth industrial revolution arose from a plan developed by the German government in 2011 that exploited the potential of digital technologies to renew the country's production system (BMBF, 2014; Kagermann et al., 2013). This revolution was based on the concept of cyberphysical systems or (Wu et al., 2017; Zhong et al., 2017), which centre on real-time interaction between people, products, and devices during the production process (Zhou et al., 2015).

In particular, three groups of technologies support the new factory: (1) the internet of things (IoT) (Liu et al., 2017; Kong et al., 2019; Majeed & Rupasinghe, 2017); (2) cloud computing technology (Chen & Lin, 2015; Wan et al., 2013); and (3) big data analytics (Obitko et al., 2013; Silva et al., 2020; Tao et al., 2018).

The IoT allows you to integrate IT with operations technology and is characterised by the pervasive presence of a variety of exchanges that not only put people in perpetual communication with each other but also put people in communication with machines and, crucially, put machines in communication with each other (Wan et al., 2013; Zhou et al., 2015). These exchanges make it easier and more effective to control and monitor processes in companies. The IoT includes radio frequency identification devices, infrared sensors, global positioning systems, laser scanners, and other information sensing devices and objects which communicate and exchange information relating to intelligent identification, location, and tracking (Beltrametti et al., 2017; Zhou et al., 2015).

Cloud computing technology (Hashem et al., 2015; Tao et al., 2014, 2018) refers to the set of technologies aimed at storing, processing, and transmitting data and the set of applications and software that allow users access to the resources they need (applications, programs, and services). Cloud computing technology uses a "software as a service" mode, avoiding companies' investments in IT infrastructures, system maintenance, and upgrades in favour of a dynamic allocation of services, more flexible access and consumption, and the ability to share resources with other subjects (Zhou et al., 2015).

Big data and advanced analysis techniques allow users to quickly obtain valuable information from a variety of sources at various levels to acquire, process, and understand in-depth data and information, as well as to make queries necessary to make complex decisions. In addition to the aforementioned enabling technologies, others exist in Industry 4.0 (Tao et al., 2018; Zhou et al., 2015): advanced manufacturing solutions, such as interconnected and rapidly programmable collaborative robots; augmented reality; cyber security, and so on; and complementary technologies, such as e-commerce systems, geolocation systems, and technologies supporting the in-store customer experience.

The smart factory model affects the fashion industry by ushering in a gradual transformation (Bertola & Teunissen, 2018; Gilchrist, 2016; Hermann et al., 2016; Sun & Zhao, 2017, 2018). This transformation particularly affects the luxury sector as technology provides major contributions to the main critical success factors in the field (Brun, 2017; Brun et al., 2008), including premium quality, exclusivity and brand development, expertise, and timeliness (Brun, 2017; Brun et al., 2008; Freire, 2014; Kapferer & Bastien, 2009, 2012).

This sector has always been susceptible to change due to the volatility of fashion and the companies' ongoing search for positive performance, which has historically been elusive because of the high complexity of the reference environment (De Felice & Petrillo, 2013).

The transformations that fashion companies have undergone in recent decades concern both the supply chain and relations with the market. The fashion supply chain had already undergone an upheaval in the 1980s and 1990s after new low-cost competitors and the need to reduce production costs and increase efficiency led to the strategies of outsourcing and delocalising of some phases of the production processes (Bertola & Teunissen, 2018). The crumbling of the value chain has led to a company's transformation from a pyramidal organisation to a horizontal one, dictated by the

lean production of the 1990s, and ultimately to a network organisation with new coordination mechanisms (Cavaliere & Varra, 2020; Mintzberg, 1983; Thompson, 1967) and new leadership styles (Kleefstra, 2019).

In the wake of this transformation, as the emphasis on market relations has increased, knowledge and communication systems have become focused on the search for complicity with consumers. The ability to understand the customer is an asset (Som & Blanckaert, 2015) which is supported by continuously balancing between exploitation and exploration or innovation (Jensen, 2017) to safeguard the mix between identity and renewal, both are valued aspects to consumers of fashion.

Therefore, from the competitive perspective of organisations in advanced sectors, knowledge has become a productive factor, a feature of material processes that is directly integrated with information and its systems of creation and development (Tao et al., 2018). This is a massive difference compared to previous processes where information, although it was always the basis of manufacturing decisions, remained on a separate distinct level from production (Tao et al., 2018). In the artisan era, information was transferred to paper artefacts that incorporated the operators' tacit knowledge (Polanji, 1966), while the limited amount of production data the system generated was transferred to scheduling tools or verbally handed down. In the industrial era, especially the second industrial era, a high amount of data existed, but it was handled on a managerial level where analyses were increasingly accurate and special systems facilitated the creation and development of knowledge, which was then shared within the system. It is only in the information age and with the exponential growth of data that companies can collect, process, and use data to facilitate production and meet customer expectations more economically and effectively (Tao et al., 2018).

All this has contributed to the development in fashion companies of a structured set of activities that exploit digital channels to build lasting, trusting, and two-way relationships with customers and to promote products and services in a personalised way. These activities fall under the name of digital marketing (Kannan & Li, 2017; Ozuem et al., 2017). Digital marketing uses a variety of technologies and devices in both online and mobile contexts to overcome information asymmetry between the consumer and the company (relating to the product search process, expectations, price and quality preferences, judgements, etc.) by creating a high number and variety of contact points with the customer and generating extensive information. Information coming from online platforms,

in which customers interact with each other or other companies, as well as platforms in which companies interact with each other, is added to information generated or acquired from direct contacts between company and consumer. Innovative, open platforms are increasingly being developed that allow customers to directly provide requests for products and services, as well as crowdsourcing platforms (Bayus, 2013; Kannan & Li, 2017; Luo & Toubia, 2015) where volunteers and freelance professionals willing to offer their services meet with companies that intend to outsource parts of internal processes, including online communication activities. Therefore, various one-to-one relationships also develop between the company and "the crowd". Recent research has questioned how platforms can keep the crowd engaged in e-commerce interactions or in the process of new product development (Kannan & Li, 2017). Search engines also provide high-quality information on the behaviours of actual and potential customers (Chan et al., 2011; Dinner et al., 2014) that companies increasingly buy, because of the fact that company actions based on lists provided by search engines have been found effective.

Digital marketing activities have an almost immediate impact on the organisation and products of a digital fashion factory. Competitive advantage in digital enterprises comes from the ability to transfer external information into internal products and processes in almost real time. Therefore, digital marketing is a fundamental and transversal support process for the entire value chain of the digital factory. Furthermore, the trend towards product digitalisation, and therefore the transformation of products into services, invites the question of the creation of special virtual products; for example, a virtual outfit for a selfie to be published on social networks requires the creation of a new product or service that agrees with the design policies of real products and services. More generally, product digitisation introduces the problem of freemium products, that is, the definition of choice models to strategically offer a product to the consumer in the free online version and the paid material version (Li et al., 2019). This customer interaction poses the problem of defining the price in real time based on product demand and customer purchasing alternatives, which involves creating pricing models that have yet to be defined and communicating with production and company policies to facilitate the service.

Product design in the digital age requires new design and pricing options and introduces concerning questions about privacy (Kannan & Li,

2017) from both the consumer and company point of view, as well as the possible barriers that can be erected to prevent the sharing of knowledge.

Digital Fashion Processes

Intelligent production compresses the typical processes of a fashion company (such as design, planning, manufacturing, distribution, maintenance, and quality control) to increase effectiveness and efficiency. The variable of time, which significantly impacts both of these elements, refers to: time-to-market or the time between the recognition of a market opportunity and the translation into a product or service on the market; time-to-serve or the time between the acquisition of an order and its delivery; and reaction time or the time it takes a company to adapt its output in response to volatile demand (Christopher et al., 2004).

It is a complex task to examine the literature on the classification of processes in the fashion sector because their level of aggregation and articulation varies (depending on the field of activity and size of the company), and the names studios and companies assign to these processes vary as well. The literature on processes in the fashion industry has largely revolved around two themes: the supply chain and the process of new product development. While the first theme was guided by the need for rationality and efficiency, the second focused on the need for creativity and responsiveness to consumers' changing expectations. Parallel to the development of ICT and, subsequently, intelligent factories, researchers focused attention on knowledge processes, the operational and communication networks that are generated on the market, and the construction of intercompany and intercommunity processes.

Researchers frequently measured processes against the critical success factors for each stage of the supply chain. Brun et al. (2008) considered three macro processes (sourcing, manufacturing and retail) and indicated a company's attention points (e.g., co-design, co-branding, suppliers and localisation) for each. Lin and Piercy (2013) analysed the development process of a new product, distinguishing between conception, creation, commercialisation, and production, drawing from various authors and research on the subject. Their description of the development process covered the following topics: market and trend research, the creation of sources and fabrics, design patterns and samples, review and finalisation of collections, commercialisation and marketing, fashion show and fashion week, sales and marketing, production of fabric, collation

of orders, delivery of fabrics, and pre-production samples, patterns and production (Lin & Piercy, 2013).

As already mentioned, the timelines of these processes are increasingly compressed, even when they are spatially distant from each other. The implementation of a new process system in a smart factory is based on six design principles: interoperability, virtualisation, decentralisation, modularity, service orientation, and real-time capability (Hermann et al., 2016; Ozuem et al., 2016).

Due to the characteristics of the product, the fashion industry can benefit from an extensive interpretation of the concept of Industry 4.0 that goes beyond smart manufacturing (Bertola & Teunissen, 2018; Gilchrist, 2016) to include supply networks, sales networks, and consumer networks. This digitised open process can create unprecedented advantages in efficiency, leanness, and speed (Bertola & Teunissen, 2018; Schwab, 2017; Ustundag & Cevikcan, 2017) and overcome the issues of environmental impact and social exclusion (Ashby, 2016; Fratocchi et al., 2014) that the mass production model produced. The rise of modularity and decentralisation (Hermann et al., 2016) virtually recreated new glocal manufacturing districts, which is an ideal system to foster the development of the fashion industry (Becattini, 1998; Bertola & Teunissen, 2018; Buciuni & Finotto, 2016).

Two major challenges arise in the creation of a 4.0 system in the fashion sector: (1) how to preserve artisanal and high-quality "professional" content in a digitised company; and (2) how to update skill adaptation and learning processes which have received less attention than operational processes.

The creation of an integrated digital infrastructure in which objects, machines, and people can communicate is complex, and even a manufacturing model that is "artisanal and advanced" requires organisational reflections (Tao et al., 2018; Vacca, 2015). However, many examples exist of fashion companies that have embarked on digital transformation, although they now appear to have shifted towards downstream processes in contact with the customer or with customer communities, and are more focused on internal automation (Bertola & Teubussen, 2018).

Researchers investigating required skills within a sector must pay attention not only to the creation of the product but also to the entire production system (Piccarozzi et al., 2018; Trstenjak, 2018). This system involves designing a multidisciplinary complex and reimagining new workforce concepts and roles in the process (Mabkhot et al.,

2018); however, the human element of these processes is still frequently overlooked (Jerman et al., 2019).

Skills and Competences in the Digital Fashion Industry

The theme of skills and competences linked to a smart factory is very recent (Imran & Kantola, 2018; Jerman et al., 2018; Pecina & Sladek, 2017). A review on the subject (Jerman et al., 2018), conducted on articles and proceedings in the Web of Science and Scopus databases, counted 43 works specifically concerning the skills of employees. The earliest articles were written in 2012, with an increase in number starting from 2015. In the literature, these articles often focused on sectors other than fashion; therefore, analyses and reflections may be affected by the specific characteristics of specific sectors.

An explanation of the terminology appears necessary. In the literature, the concept of skills does not have a unique meaning (Roberts, 1997; Spencer & Spencer, 1993; Torres et al., 2003) and numerous overlaps exist between concepts. The relationship between skill and competence is not always clear. By skill, we mean a capacity or personal characteristic that, in adequate motivational and contextual conditions, manifests as competence or effective, successful behaviours and performances (Boyatzis, 1982). According to this interpretation, competence is a proven ability to use and finalise knowledge, skills, and abilities; it includes a result (Rowe, 1995) and can be developed (McClelland, 1973), while skill is a more stable element. Therefore, a competence is a skill that has been activated by personal motivations in a job or an organisational context.

Extensive variety exists in the classification of skills and competences (skills vs competences, technical skills vs soft skills, generic skills vs specialist skills, transversal skills vs job-related skills, etc.). An initial macro distinction separates technical skills and soft skills, or technical competences and behavioural competences: technical competences concern knowledge and skills related to the performance of work, while behavioural competences concern relational, cognitive, social, and personal skills, such as motivation, attitudes, abilities, emotional intelligence, and relational intelligence (Hecklau et al., 2017; Grzybowska & Łupicka, 2017; Prifti et al., 2017; Fitsilis et al., 2018).

The existing articles on skills associated with the digital industry are framed against the broader theme of the correlation between technologies

and the labour market (Piwowar-Sulej, 2020), which suggests two alternative situations: a negative correlation, which suggests technology destroys traditional workplaces and replaces workers with automation; and a positive correlation, which suggests technology is a lever that can increase skills and therefore offer more job opportunities (Ugur et al., 2018; Piwowar-Sulej, 2018; Whysall et al., 2019). The World Economic Forum (2020) presented the opinions expressed by companies on the technological changes expected in work by 2025: 43% of the companies interviewed planned to reduce the current workforce as a result of automation, 34% planned to expand it as a result of deeper technology integration and new potential for exploiting the value chain, and 41% planned to expand the use of contractors for specialised tasks. Most companies interviewed expected an increase in skills related to critical thinking and analysis, problem solving, and technology use and development.

No comprehensive overview exists of anticipated future competencies for manufacturing processes in smart factory systems (Antosz, 2018; Jerman et al., 2019; Kinkel et al., 2017; Nyikes, 2018), and existing literature presents several methodologies and focuses on different aspects and sectors (Grzybowska & Łupicka, 2017; Hecklau et al., 2017; Prifti et al., 2017). Although some skills can be considered interdisciplinary (Prifti et al., 2017), research has shown that the importance attributed to one factor can change across sectors (Grzybowska & Łupicka, 2017), especially for technical skills, which can vary significantly in their perceived importance (Gehrke et al., 2015). Moreover, it is precisely the technical aspect of competences that has been mostly discussed in the works on digital companies (Sinsel et al., 2017), while fewer articles focused on the areas of soft skills and management skills, which have instead been the subjects of analysis by consulting companies such as Boston Consulting Group (Lorenz et al., 2015), Ares2.0—Confindustria (Bettarini & Tartaglione, 2018), and others (Jerman et al., 2019; Vacek, 2016). Some studies on the skills associated with Industry 4.0 involved keyword analyses of literature contributions (Benešová & Tupa, 2017; Hartmann & Bovenschulte, 2013; Hecklau et al., 2017; Jerman et al., 2018, 2019; Lorenz et al., 2015). Using this methodology, Hecklau et al. (2017) analysed skills in various areas by searching for the keywords “Industry 4.0” or “Digital transformation” combined with “job”, “skills”, and so on. Their search included all studies that were published before July 2017 and spanned various roles and sectors. The research was based on a database of 2709 enterprise

interviews and 90 expert interviews. The competences found covered four areas: methodological competences, or knowledge and skills related to problem solving and successful decision making (analytical competence, complex problem solving, decision making, creativity); social competences, including knowledge, skills, and abilities to communicate and cooperate with other individuals and groups (cooperation and communication, leadership competences); personal competences, or individual values, motivation, and attitudes (willingness to learn, flexibility, and adaptability); and domain-related or specialist competences (digital networks, digital security, coding competence, process understating, interdisciplinary competence). Their research indicated that the most important and necessary competence was social competence (communication and cooperation), followed by coding, complex problem solving, interdisciplinary competence, and other competences.

Following a methodology similar to Hecklau et al.'s (2017), an analysis by Jerman et al. (2018) focused on paper content and four clusters of themes. This analysis indicated: technical competences, including the ability to understand IT security, processes, and analogies of the operations of new technologies; methodological competences, including creativity, research skills, and problem solving; social competences, such as networking skills and the ability to transfer knowledge; and personal competences, such as social responsibility and personal flexibility (Jerman et al., 2018).

The results of Piwowar-Sulej (2020) similarly identified the following types of skills needed for Industry 4.0: social (communication and cooperation), methodological (analytic competence, complex problem solving, and decision making), personnel (willingness to learn), and domain-related skills (digital networks, digital security, coding competence, and process understanding).

Notably, digital skills are transversal; the literature emphasises the importance of skills related to the ability to work with new materials, manage information, and plan and control IT tasks (Bonekamp & Matthias, 2015; Grzybowska & Łupicka, 2017; Jerman et al., 2019).

Some researchers identified necessary skills that are specific to the fashion industry by examining job postings from LinkedIn (Kalbaska & Cantoni, 2019 Ronchetti et al., 2020). The research by Kalbaska and Cantoni (2019), covering 29 countries, including all 28 in the European Union, examined 1427 available digital fashion jobs to determine which major skills were most in demand in the current digital fashion

job market; in order, the skills most frequently mentioned in job titles were digital marketing, social media, digital design, graphic design, and e-commerce management. The skills most frequently mentioned within the job descriptions of available jobs were social media, digital marketing, e-commerce, and communication skills, followed by customer service care, customer/user experience, web analytic skills, and experience with luxury fashion. The research highlights how digital fashion roles require both analytical and creative skills as well as knowledge of certain tools, such as social media or paid searches, at the operational level. Kalbaska and Cantoni (2019, p. 133) ultimately found that successful candidates should have a strong attitude as well as a passion for the digital world.

With a similar methodology applied in the same countries, the research by Ronchetti et al. (2020) confirmed, albeit in a different order, the presence of similar requirements in terms of skills. The results, arising from 1397 digital fashion jobs examined in 2020, showed that the most frequent combinations of keywords found in digital fashion job titles appeared to be (in order of frequency) e-commerce, digital marketing, visual associate, product manager, and social media. The most frequent keyword combinations found in the job descriptions of digital fashion job postings were (in order of frequency) social media, customer service/care, commerce, communication skills, digital marketing, team player, and customer experience. Considering both of these studies, the top required competence today in the digital fashion domain appears to be "social media", and the demand for skills in "digital marketing" continues to increase over time.

These new skills required in digital fashion companies may modify the traditional roles of typical activities of the industry, such as product development and creation, marketing development and retailing, and communication planning and management (Bertola et al., 2017), while also creating new positions. The development of new skills in traditional profiles leads to an increase in operational roles, creating an "augmented operator" who can conduct traditional activities by interacting with intangible assets and new digital content (Longo et al., 2017, Weyer et al., 2015).

The most typical jobs in fashion, designer and producer, are also affected by the change (Bertola & Teunissen, 2018; Sun & Zhao, 2017, 2018). Sun and Zhao (2018), through the focus groups method, explored the new skills related to these two roles. Designers perceived themselves (and are perceived in research) as workers who must be experts

in many different things, with an increasing need for technical knowledge and a profile between a stylist and an engineer (Sun & Zhao, 2018). They must have the ability to connect in real time with internal and external sources of information and generate emotions in customers connected to the product to satisfy customers' search for an aesthetic experience.

Even the producer, who is typically involved in rational, standardised processes, must adopt a dynamic role, able to quickly make necessary or requested changes. Producers must consider the fact that with the adoption of new technology, their role can be played by anyone, including users who choose their product configurations before testing them out in virtual showcases and dressing rooms. As the fashion industry develops, the producer will be one node of a network (Bertola et al., 2017) with an increasingly communicative role with everyone (Sun & Zhao, 2018). IT designers, programmers, robotics and mechatronics experts, as well as maintenance experts, are new key figures (Jerman et al., 2019) with the ability to collect big data and conduct monitoring activities to detect problems in products or equipment (Lorenz et al., 2015; Nagorny et al., 2017). The role of data analysts, particularly big data analysts, is also fundamental; they possess the ability to use tools to capture, process, and interpret an enormous amount of data (Waterman & Bruening, 2014).

Digital companies will see the development of strategic business units which can grow effectively through the interconnection of strategic plans with operational ones; therefore, intermediate roles with hybrid managerial and creative characteristics will be needed. These roles include brand managers, merchandisers, product managers, and line builders (Bertola et al., 2017; Granger, 2012).

Digitalisation requires the development of skills throughout the system at various levels of job specialisation (Mintzberg, 1983); traditional artisans will coexist in companies and within the same role with hyper-specialised engineers, augmented workers, and advanced craftspeople. These possess different sets of skills that allow unique human attributes, creativity, and manual skills to be in dialogue with technology and digital devices, improving dexterity and productiveness (Bertola & Teunissen, 2018; Bostrom, 2016; Braidotti, 2008).

These changes underscore the importance of continuous learning, which emerges in the form of key skills (Jerman et al., 2019) and benefits from two other skills, teamwork and leadership, which research suggests are also in high demand.

Major changes are needed at all levels, including managerial and entrepreneurial skills. Kruger and Steyn (2020 identified the entrepreneurial skills needed in Industry 4.0. Skills were classified according to several significant dimensions: experience or knowledge of the business, qualification (e.g., branding), strategy, customer focus, and training. They proposed a model that combined business functions with competencies; among these, the main classifications were innovation, creativity, integrated business and technology skills, leadership and communication, and networking and sales. Similar needs exist in small and medium-sized enterprises (SMEs), where 3D printing (3DP) technology is introducing digital content to the following key competences: strategy vision, marketing orientation, operational competence, supply chain management, project management, commercial competence, innovation management, knowledge management, and network competence (Sun & Zhao, 2018).

Managerial skills have also been affected, with the importance of entrepreneurial thinking, decision-making skills, problem solving, profit resolution, and analytical skills emerging in Industry 4.0 (Grzybowska & Łupicka, 2017).

A qualitative survey of 15 managers highlighted the following clusters of skills required for the transition to Industry 4.0 (Díaz et al., 2017): ICT (knowledge of big data, ability to analyse data, and knowledge and management of software and interfaces that support operational management); innovation management (virtual collaboration and openness to change); organisational learning (the ability to develop employee skills and encourage participation in decision making); and environment (ability to develop research with external partners, creativity in designing strategies to introduce new practices). The same research highlighted the shortcomings within organisational leadership in the processes of developing employee skills, capabilities, and improvement: the knowledge and management of software and interfaces that support operations management (resources, people, and production) within ICT; and the ability to adopt new models of work and organisation within innovation management (Díaz Bermúdez & Flores Juárez, 2017, p. 743).

A recent report by Ares2.0 for the fashion sector (Bettarini & Tartaglione, 2018) identified competences in fashion at entrepreneurial, managerial, and workforce levels, offering the following classifications: knowledge (including knowledge of legislation on health and safety, environment, corporate social responsibility, advanced English language,

e-skills, marketing, machinery and device remote control); social skills (including teamwork, communication, and networking skills); technical-productive competences (including data analysis and management of complex machinery); problem-solving skills (including creativity, experimentation, verification, and resourcefulness); self-management skills (including time and stress management skills and the ability to work remotely); management skills (including orientation to change and continuous improvement); and entrepreneurial understanding (including innovation and orientation to the customer) (Bettarini & Tartaglione, 2018, p. 19).

The problem of skills calls into question the management and development of the same, that is the HRM processes. The management of skills in Industry 4.0 is particularly concerned with: the measurement of employee performance, based on data collected from private and public sensors (Grzybowska & Łupicka, 2017) the need to have data on employees in real time and to provide them with immediate feedback on the results achieved (Cascio & Montealegre, 2016) and new forms of compensation in line with the new organisation of work. However, because creative and conceptual work is increasingly autonomous and remote, it is difficult to create tools that help to control this work, meaning feedback on results is essential (Grzybowska & Łupicka, 2017). The traditional money-based remuneration approach will also be a critical element: new forms of compensation will be identified and IT systems will help manage individualised total compensation packages for medium and highly skilled employees.

New opportunities for the implementation of IT tools in human resource (HR) processes are also discussed in the relevant literature (e.g., Cascio & Montealegre, 2016; Onik et al., 2018; Piwowar-Sulej, 2020); new techniques will transform HRM from a straightforward service into "smart HRM" with an increasingly strategic role (Piwowar-Sulej, 2020) and more sustainable systems (Varra & Timolo, 2017).

HRM processes and necessary skills depend on several variables: job characteristics, the contextual conditions determining a department's technology level (i.e., the availability and functioning of connections), and workers' qualification levels (i.e., whether workers are low skilled, medium skilled or in creative jobs, or highly skilled specialists and managers) (Piwowar-Sulej, 2020).

As this review indicates, research has investigated all aspects of the digital revolution, including those related to managerial and HRM skills.

However, findings have not previously been consolidated into a model that could be applied to concrete cases within the fashion sector; such a model could measure knowhow and skills, reflect unfulfilled training needs (Fitsilis et al., 2018), and indicate sources of competitive advantage for companies of the fashion sector.

The Proposed Model

The summary of the literature shows that:

- The changes that have taken place in organisations because of Industry 4.0 have an important impact on competences, which have recently been the subject of study at all sectors and levels (Fitsilis et al., 2018; Hecklau et al., 2017; Jerman et al., 2018, 2019; Grzybowska & Łupicka, 2017; Piwowar-Sulej, 2020; World Economic Forum, 2020).
- Few studies exist that specifically focus on digital fashion skills; they do not show substantial differences compared to studies focusing on the types of skills deemed necessary in other sectors. However, they confirm that the changes affect all roles: managerial, middle management, specialist, and operational (Bettarini & Tartaglione, 2018; Kalbaska & Cantoni, 2019; Ronchetti et al., 2020).
- Previous studies have considered the transversal nature of skills across all sectors of Industry 4.0 as they relate to some professional positions. Studies have also focused on how these skills affect key positions in the fashion sector, such as designers and producers (Bertola & Teunissen, 2018; Bertola et al., 2017; Bettarini & Tartaglione, 2018; Lorenz et al., 2015; Sun & Zhao, 2018).
- There is no organic model that brings together the processes of the digital fashion industry and the new skills profiles related to traditional or new roles that are changing as a result of technology.

Based on the literary evidence, the proposed model (see Fig. 13.1) incorporates both skills and professional roles into the best-known classifications of processes, including Brun et al. (2008) and Lin and Piercy (2013). The model identifies the necessary skills and competences within the macro-processes of sourcing, manufacturing, and retailing and the sub-processes that characterise them, following the model of Hecklau

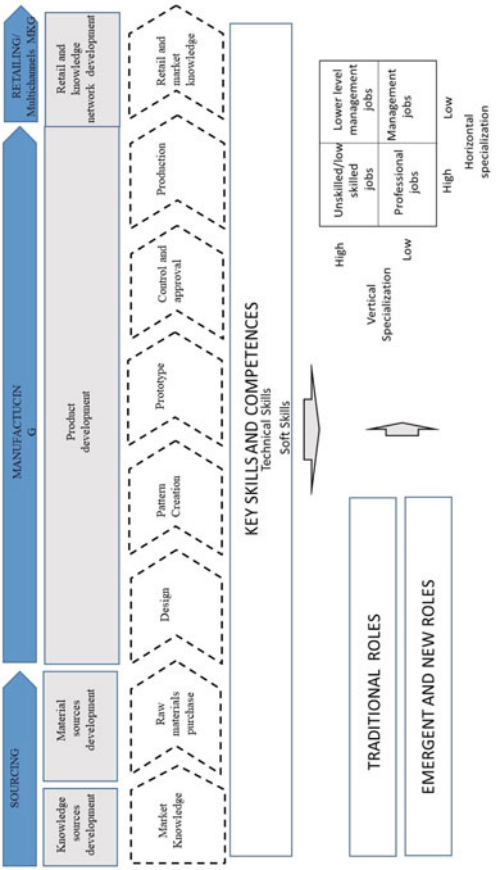

Fig. 13.1 A proposed model of skills and roles in the Industry 4.0 fashion industry

et al. (2017), to create macro-level categories of technical competences and behavioural competences and related sub-divisions. Following the approach of Bettarini and Tartaglione (2018), the skills observations are then related to the content of traditional and new roles in the Industry 4.0 fashion industry. Finally, these transformations are reported in the more general scheme of Mintzberg (1983) on the typology of duties and distinguished according to vertical versus horizontal specialisation.

The future organisation of work will mirror the characteristics of the digital fashion company, that is, an organisation with a high level of knowledge that loosens the boundaries between well-defined activities, functions, and roles in favour of intense but more fluid connections that shorten the traditional value chain (dashed lines in Fig. 13.1). Consequently, work will be characterised by more qualified content at all levels, opportunities for remote work, and hybridisations between work and private life (work porosity) in an organisational system that both incorporates the market and sells assets to the market. Considering these characteristics, it is possible to identify a series of transversal skills for the sector as shown in Table 13.1. These skills will be common to all roles in a fashion company in Industry 4.0. The competences are categorised following the distinctions of Hecklau et al. (2017).

Various specialised technological roles characterise the digital fashion company. Table 13.2 shows several specialists (with related skills) who support the development and application of digital technology in organisations. The roles and skills of digital fashion are described below based on the processes and the innovation level of each role (Tables 13.3, 13.4, 13.5, 13.6, 13.7, and 13.8).

Significant Roles and Related Skills in Digital Fashion Processes

Sourcing: Knowledge Source Development and Material Source Development

The macro process includes activities aimed at the market in search of the sources of raw materials, including knowledge. All understanding of market activities is included in this process, which involves market analysis and acquisition of customer trends and expectations through all channels and customer relationship nodes. Therefore the roles and competences related to the macro process will be examined in the "retailing and multichannel marketing" category in the context of digital marketing activities. Material source development is the process by which raw materials,

Table 13.1 Transversal competences common to all roles in the digital fashion industry

Category of competences	*Transversal competences common in the digital fashion industry*
Technical competences	Knowledge of health, safety, privacy, cyber security, legislation
	Knowledge of environmental issues; corporate social responsibility
	Marketing knowledge
	Interdisciplinary knowledge
	Digital marketing
	Network social platform
	Digital security
	Coding competence
	Process and product understanding
	Machines and devices understanding
Behavioural competences	
Methodological	Analytical thinking
	Problem solving
	Decision making
	Creativity
	Efficient orientation
	Conflict solving
	Client orientation (internal and external client)
Personal	Flexibility and adaptability
	Willingness to learn
	Resistance to stress
	Sustainable mindset
Social	Communication and cooperation
	Intercultural skills
	Teamworking
	Knowledge sharing
	Leadership

Sources Fitsilis et al. (2018), Grzybowska and Łupicka (2017), Hecklau et al. (2017), Kalbaska and Cantoni, 2019, Leinweber (2013), and Piwowar-Sulej (2020)

fabrics, accessory parts, and so on are sought. This phase is traditionally carried out by the buyer or by textile designers. The globalisation of the market and the virtualisation of the purchases of raw materials mean that the traditional positions related to this process are evolving to require a high mastery of technology, which is essential for intercepting innovations and procurement opportunities for international supply. Digital technology makes it possible to: access all possible information on the

Table 13.2 Roles and competences that support the development of digital technology

Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Industrial data scientist	Extract and prepare data, conduct advanced analyses, apply the results to improve products or production	Ability to understand both production processes and IT systems Programming competences, including the ability to use programming languages	Analytical skills Flexibility. Self-organisational capacity Systemic vision
IT solutions architect	Responsible for the overall design of the system Map business needs based on system requirements and technical requirements Produce the technical specifications, integrating different technologies, platforms, and people	Data management competences Skills and knowledge of enabling and complementary technologies Business processes understanding	Design skills Systemic vision Adaptability
Computer engineer/industrial programmer	Develop the technical solutions identified by the IT solutions architect	Use of major general purpose languages, such as Java, C++ or Python Ability to use specific applications for industrial simulations and general programming of data analysis Ability to program robots and digital devices	Problem solving Analytical skills Design ability

Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Industrial UI (user interface)/UX (user experience) designer	Design and optimise interfaces for the user (UI) and for user experience (UX) Design each screen or page with which a user interacts (UI designer), design the product fruition path (UX designer) Guarantee the correct use of interfaces according to the planned path	Ability to design intuitive dashboards on tablets and mobile phones, machine and robot interfaces, augmented reality applications Ability to optimise the usability of devices	Design skills Customer orientation Systemic vision Flexibility

Table 13.3 An emerging role and related skills in the material source development process

Role	*Job description*	*Main technical competences*	*Main behavioural competences*
E-buyer	Study international supply Monitor trends and performance of countries and suppliers, analyse data in real time and make purchase plans Simulate combinations of international purchases from the perspective of global performance Lead the production team towards raw material changes	Knowledge of international supply markets Mastery of digital tools and e-commerce platforms Language skills (English + emerging countries' languages) Legal knowledge of different international contexts Ability to read global changes in supply and demand Ability to use analytics tools Ability to work on performance indicators	Team management Problem and conflict solving Communication with all parts of the organisation Coordination

sources by which trends are created; develop innovation in terms of materials, fabrics, research, and advanced experiments; and purchase materials virtually. The e-buyer, which is considered an emerging, highly innovative role, represents an evolution of traditional roles (Table 13.3).

Manufacturing

Technology transforms production processes not only in large companies but also in SMEs, which increasingly exploit the opportunities offered by 3DP and related digital technologies to facilitate prototyping, production efficiency, and product customisation. Requiring more limited operational involvement from the designer, 3DP allows users to develop virtual models of products based on generative design algorithms, to modify new or previously inserted models using a digitiser, and to optimise "the placement of the pieces" according to predefined criteria using robotics that reduce operating costs in production by automating and optimising standardised tasks (Sun & Zhao, 2017, 2018). In this way, technology redefines the roles of the designer, patternmaker, and manufacturer and

Table 13.4 Several traditional roles and related skills and competences in the digital manufacturing process

Traditional roles enriched			
Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Designer/planner/patternmaker and roles connected with creativity	Design goods that are customisable and in line with the changing demands of the market Improve design processes by making them faster and more actionable throughout the chain Work with digital design machinery Combine new technologies with traditional knowledge	Marketing knowledge and data analysis skills Design skills to develop new collections in line with demand Advanced and constantly updated technical and digital skills Computer competences in the use of computer-aided design and CAM2® programs	Relational skills Teamwork Ability to relate to management and production staff Problem and conflict solving
Repairer and maintenance of industrial machines and plants	Assemble and/or disassemble parts and mechanical components Repair parts or components of machinery or industrial plants by identifying faults and finding effective solutions to solve problems Carry out routine and extraordinary maintenance activities on equipment and systems and carry out checks and revisions on parts and components	Knowledge of mechanics and production techniques Computer and electronic knowledge Technical design skills Knowledge and ability to use machine tools available Ability to interface with various devices Ability to use complex machinery Ability to understand and draw up the technical sheets Ability to evaluate the quality of work	Ability to process and analyse data from a variety of sources Problem solving Systemic vision Adaptability

(continued)

Table 13.4 (continued)

Traditional roles enriched			
Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Researcher (on fibres, fabrics, leather, etc.)	Realise studies and solutions for new materials, new textile applications. and the development of digital technologies Combine the knowledge of materials sciences, chemistry, and physics with new engineering and manufacturing technologies to contribute to future innovations	Knowledge of marketing and market trends Chemical-pharmaceutical and physical knowledge Computer and engineering knowledge Knowledge of statistics Ability to collect and interpret empirical data Ability to develop organisational proposals	Ability to investigate alternative solutions Teamwork ability Ability to draw up technical documentation

Table 13.5 Several emerging and new roles and related skills and competences in the digital manufacturing process

Emerging and new roles			
Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Systems engineer	Implement structured development processes from conception to implementation up to the commissioning of the system Optimise technological and infrastructural solutions by providing support to management and specialists Collect the needs expressed by the various actors (customers, production units, suppliers) and carry out a project risk analysis Manage the system	Project management Knowledge of IT systems Knowledge of programming languages Understanding of corporate processes and procedures Logical-mathematical skills Ability to jointly process several factors Management of the different interfaces Ability to understand and draft technical documentation	Ability to understand the problems Ability to identify alternative solutions Written and oral technical communication skills Interpersonal skills
Customisation manager	Plan to encourage the production of products in line with the needs of end customers Responsible for conducting product, competition, market trend, and consumer panel analysis Support the purchasing department through the creation and structuring of the collection, ensuring that the range meets market demands	Ability to understand market changes Ability to use tools for analysing consumer preferences Innovation Ability to link between research and production	Ability to work in synergy with different departments Communication skills Problem and conflict solving

(continued)

Table 13.5 (continued)

Emerging and new roles			
Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Sustainability manager/risk manager	Ensure that the company operates in conditions of complete legality and ethics, safety, and respect for workers, efficiency and maximum protection of the environment Propose corporate social responsibility policies, exploiting the opportunities of technology Collaborate with designers and managers for the development of sustainable processes and products Ensure contingency plans	Legal-regulatory knowledge of health and safety Business management knowledge Knowledge of environmental sustainability and corporate social responsibility Ability to understand computer, electronic, and production processes. Ability to analyse big data and detect opportunities and problems Ability to prepare reports and projects	Strategic vision, planning, and multitasking control competences Ability to motivate organisational change Relational skills with the whole organisation Ability to communicate with the outside world on social media about sustainability and risk prevention policies

creates new roles. The designer and model maker can increasingly be an independent professional who exists externally rather than being a material part of the company. Table 13.4 presents the new roles according to the level of innovation: traditional roles subject to transformation, emerging roles, and new roles.

Retail and Multichannel Marketing

IT skills are becoming increasingly important in the macro process, as they are necessary to master the new tools of e-commerce and multichannel marketing. The roles that assert themselves in this process are related to digital marketing. They are considered emerging and new roles because they appeared recently and demand for them is growing rapidly. Although these roles are categorised under retail and multichannel marketing processes, in Industry 4.0, they are so frequently associated

Table 13.6 A traditional role and related skills and competences in the retail and multichannel marketing process

Traditional role enriched			
Role	*Job description*	*Main technical competences*	*Main behavioural competences*
Online sales clerk	Putting strategies into practice Selling both B2C and B2B types Maintain online platforms where the company's products are marketed Manage orders and purchases and schedules Conduct deliveries Manage online after-sales and customer care services	Commercial and sales knowledge Ability to use new media and ICT Ability to interact with new media Ability to offer customer service Language skills Understanding of processes Knowledge of how to manage orders Bargaining competences Marketing competences Ability to collect, analyse, and interpret data on customers Ability to use IT tools and databases Knowledge of customer data	Empathic skills Cultural skills Relational skills Data and information analysis skills Problem-solving skills

B2B business-to-business, *B2C* business-to-consumer, *ICT* information and communications technology

with all operations that digital marketing skills have become a transversal competence, as indicated in the research mentioned above.

Digital marketers take on very different responsibilities depending on whether they are working as managers or specialists. Specialists frequently possess skills that can constitute specific specialised roles (social marketing expert, search engine optimisation master, etc.). As experts, they often deal with external professionals who collaborate with the company.

The traditional profile of a remote sales employee (including currently required skills) is presented in Table 13.6, while the positions related to multichannel and digital marketing are shown in Table 13.7.

Table 13.7 Several emerging and new roles and related skills and competences in the retail and digital marketing process

Emerging and new roles			
Role	*Job description*	*Main technical competences*	*Main behavioural competences*
E-business manager	Study the markets to create an electronic strategic plan for the sale of products and services online Improve data integrity, positioning of online tools and brand exposure Lead the marketing and sales management team using ICT tools to achieve sales goals Provide accurate information and offers to business partners	Knowledge of international markets Advanced marketing knowledge Mastery of digital tools and e-commerce platforms Linguistic knowledge (English + emerging countries) Legal knowledge of the various international contexts Ability to read global changes in supply and demand Ability to use analytics tools Ability to plan a sales strategy	Team management Communication Ability to relate with all parts of the organisatio Coordination Motivation for learning and knowledge transfer
Digital marketing expert Transversal to supply chain processes	Define online marketing strategies and propose online and offline initiatives Take care of online customers Monitor the development of material useful for a marketing strategy (engagement, communication, visual and textual content, marketing strategy, customer and potential)	Marketing knowledge Knowledge of multichannel strategy Ability to use IoT technologies Knowledge of the various customer interface devices Some or all of the competences listed in Table 13.8	Communication skills Empathy Interpersonal skills

ICT information and communications technology, *IoT* internet of things

Table 13.8 Set of skills and competences for specialist roles in the retail and digital marketing process

Competence or specialist role (job description) to support digital marketing	
Social marketing	Select the social networks suitable for promoting the business Publish content on social networks using the most suitable expressive techniques for each publication
Search engine optimisation	Occupy and improve the positioning of the company's website pages within the search engine results Direct the work of copywriters and select external sites with which to collaborate
Customer relationship management	Take care of the systems that keep track of all contacts between company and customer (phone calls, complaints, purchases, etc.) and then allow users to profile guests according to economic importance, level of loyalty, purchasing habits, etc
Copy writer	Curate the contents of the site to optimise its position within search engine results and communicate effectively with visitors to the corporate website
Web editing	Create the contents of the company website while keeping the information provided to customers updated

Table 13.8 lists some skills that may be present in the digital marketing expert, or constitute other specific specialist roles.

A Summary of the Changes to Position Characteristics in the Digital Fashion Industry

The proposed roles and skills in the previous tables highlight how the transformation of the digital fashion industry includes both operational roles and specialist and management roles. To examine these impacts on positions, and the skills required to occupy them, it is useful to consider the classification of jobs created by Mintzberg (1983) according to horizontal and vertical specialisation. Horizontal specialisation measures breadth, or the number and extent of duties required in the position, while vertical specialisation measures depth, or the amount

of control employees have over the tasks they perform[1]. Mintzberg identified four types of positions: unskilled/low-skilled jobs, which are characterised by high horizontal and vertical specialisation (few and highly standardised tasks over which workers have no control); specialist or expert/professional positions, which have high horizontal and low vertical specialisation (specific tasks over which workers have a high level of control); middle-management positions, which have low horizontal and high vertical specialisation (many and varied tasks over which workers do not have full control); and other management positions (many varied tasks over which workers have full control).

Unskilled/Low-Skilled Jobs

Operational roles are characterised by gradual position expansion and enrichment with a consequent increase in skills and a strong reduction in their traditionally high levels of horizontal and vertical specialisation. These positions are expanding due to a work organisation that is less and less fragmented and more oriented to the logic of the process; this evolving system asks workers to perform a plurality of operations that are strongly integrated. These operational positions require higher levels of qualification than traditional activities in these roles and, as such, companies are more likely to invest in training to improve operator qualifications. It follows that the nine activities associated with traditionally unskilled jobs require a higher level of decision-making discretion and autonomy (Scheer, 2012); these competences are associated with responsibility and, often, results that must be achieved. Therefore, initially unskilled positions also absorb activities traditionally associated with higher levels of employment, entrusted with not only the programming and control of simple machines but also more advanced coordination roles. A transition from initially or traditionally low-skilled positions to specialist positions or coordination positions (upgrading) is likely. Operators are therefore more educated and digitised, working in teams with engineers, technologists, logisticians, and maintainers (Magone & Mazali, 2016); this collaboration inserts them within knowledge-sharing processes that facilitate further professional development.

Consequently, there is a strong reduction in truly unskilled positions; these positions are increasingly replaced by automation and robotics.

Lower-Level Management Jobs

Lower-level managers are traditionally characterised by a wide range of activities which places them in a position of coordination of processes or at the head of organisational units at an intermediate level. From a quantitative point of view, two scenarios are possible: middle management positions may be reduced following the downward transfer of programming and coordination skills that were traditionally their focus, or these positions may increase as more low-skilled workers become professionalised and must be coordinated (which reduces the extent of control for each middle manager). In any case, these positions will be subject to job enrichment processes, and entrusted with the task of using increasingly sophisticated and innovative tools for programming and controlling activities. Regardless of the scenario, managerial competences will be important for those occupying these positions. These positions are also increasingly likely to require leadership skills or the ability to involve, guide, and support a group.

Professional Jobs

Future digital fashion companies will feature an increasing number of specialist figures. The strong integration between activities means there will be a need for roles capable of in-depth intervention on specific activities and problems, both regarding technology (Table 13.2) and parts of production and managerial processes. Specialists in risks, sustainability, innovative fibres and products, research and development, and HRM processes (online recruiters, etc.), although they may be external, will share business activities and objectives. Therefore, specific technical skills previously associated with middle management (programming and control, marketing, finance, etc.) and soft skills (such as internal and external communication) will be necessary even within increasingly specialised positions.

Management Jobs

Managerial roles will be associated with a rapidly expanding set of skills, particularly skills related to technological principles and tools. New knowledge and skills related to digital techniques will be applied to traditional positions (marketing managers, finance managers, etc.). Necessary

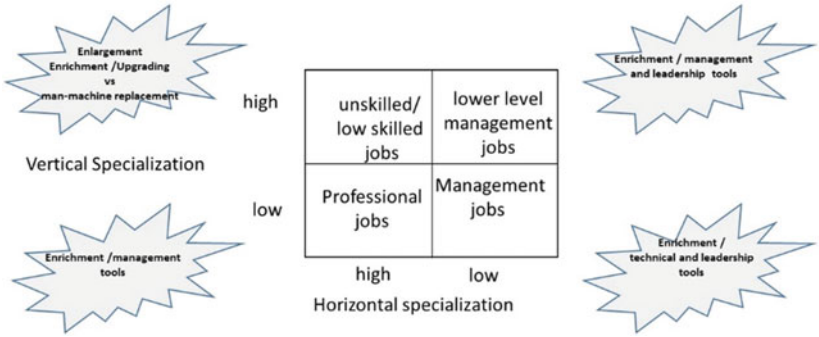

Fig. 13.2 Summary of changes in jobs according to the level of specialisation

competences will include real-time monitoring of information, knowledge related to supervisees and activities, and knowledge decision-making systems that integrate quantitative and qualitative information. HRM tools will also be fundamental due to the widespread and collaborative nature that management will increasingly assume within organisations; rather than only applying to HRM experts, HRM skills and tools will be required of all those who coordinate teams. Figure 13.2 represents a synthesis of these anticipated position changes.

The Impact of the Digital Fashion Industry on HRM

The new professions present in Industry 4.0 raise the question of skills required in HRM processes. Technology will strongly integrate operations, machinery, and other parts of the physical and digital system, and digitalisation will organise workers into collective units (teams, task forces, etc.) in which workers with different skills will manage integrated nuclei of activities together while probably conducting many activities remotely. These two trends will considerably loosen traditional boss–employee bonds in favour of horizontal relationships of support, self-programming, and control. This situation poses challenges for HRM; it will be necessary to consider the changes caused by technology when reimagining the processes of evaluating, training, and managing employees. Through a survey conducted in focus groups, Piwowar-Sulej (2020) noted that the methods of managing human resources change depending on the type of

position, that is, depending on whether employees are low skilled, middle skilled, creative/highly skilled or specialists/managers. The surveyed individuals believed that companies reserve innovative HRM tools and approaches for the most qualified levels. This result, as Piwowar-Sulej hypothesised, is very likely due to access to technology that is not yet widespread in the area under investigation; therefore, it seems likely that context, culture, and level of business skills make a greater difference in the use of HRM techniques and tools than the characteristics of jobs.

Technology impacts HRM in two major ways: how new techniques and tools enter HRM processes and which new skills become required for HR managers.

The sections below explore technology's effect on HRM processes based on recent literature on the subject (Cascio & Montealegre, 2016; Onik et al., 2018; Sivathanu & Pillai, 2018).

Recruitment and Selection

Recruitment and selection could represent an example of how, in contrast to the Piwowar-Sulej (2020) research results, for some activities, technology could apply especially to low-skilled positions. Because less strategic decision making is involved, technology may be most useful in recruiting and selecting unskilled roles (Varra, 2020): predictive techniques can manage the entire process of recruitment, choice, and relative learning (Elfenbein & Sterling, 2018; Varra, 2020). The use of algorithms is important for probing context information, including the data that candidates leave on social media, mobile devices, electronic cards, and so on, and, therefore, for predicting candidates' productivity. Furthermore, the software can adapt information to internal data and incorporate it into their evolution, developing a progressive model of learning that improves prediction (Elfenbein & Sterling, 2018; Varra, 2020). Artificial intelligence can also adequately support the recruitment and selection process of other moderately skilled positions, especially by decreasing the number of candidates when it is too high. For highly qualified figures, automation is limited to the recruitment phase and almost exclusively used to sift through the candidate's previous work experience (Elfenbein & Sterling, 2018). These positions are less compatible with predictive techniques; even in this case, however, ICT techniques (such as expert systems, scenario techniques, and simulations) can facilitate the interpretation of information or the formulation of alternative prefigurations of

the decision-making context. These tasks are fundamental for exploring and rethinking problems, even when they do not automatically arrive at a solution.

Technological changes have affected the actual selection phase by changing the required methods of verifying the skills candidates possess. The soft skills component, required in all positions of the digital fashion factory, means that the interview phase cannot be conducted in a summary "to meet" way; rather, it requires specific techniques (assessment centres, in-depth interviews, personality tests) to verify the wide set of skills the literature phase and job postings indicate are needed. It may be useful to conduct necessary tests on candidates, including fact finding, role playing, leaderless discussions, and so on.

Appraisal

Similar considerations must be made for the employee appraisal process. The assessment of human resources will extend to all levels and include different methodologies and a broad portfolio of skills. Much assessment information will come from digital traces left from work—instant or on-demand—alerts triggered by integrated, context-sensitive technologies that track the work of roaming employees. The software manages performance evaluation. Other factors, however, must take on increased weight in the evaluation, namely skills such as self-organisation, teamwork, and internal communication. Like employee selection, appraisal requires HR managers to possess adequate skills and use appropriate techniques and assessment tools (such as assessment centres). Furthermore, the introduction of autonomy and discretion to tasks performed at all levels raises the issue of performance evaluation, particularly when it comes to defining and verifying objectives which in the digital factory are also a coordination mechanism (Mintzberg, 1983; Thompson, 1967) while loosening the hierarchical links within organisational units. The process of defining objectives must increasingly be conducted by those who are within the system. This situation emphasises the importance of participatory leadership styles with ample autonomy left to collaborators, and of evaluation systems that are not only brought to employees' attention and shared but also, in a move toward self-determination, largely entrusted to individuals.

Remuneration

Technology also affects the remuneration process. Modern software can handle pay survey analyses, complex bonus and commission structures, reports, and analyses. Future remuneration will be based on an articulated system that includes specific work production and individual results linked to objectives, productivity, and company results in terms of efficiency, sustainability, and so on.

Increasing weight may be attributed to the variables of remuneration, which will have to both compensate the individual for their contribution to the organisation and create a very high commitment at the base of low top-level systems. It is essential to combine three types of information: information on context (benchmarking of remuneration systems); information on how work is carried out (appraisal system); and information on the personal and professional needs of workers (which can be used to identify effective compensation and incentive systems).

Career

The career system is based on employee-centred career arrangements in recognition that wishes and needs vary throughout an individual's career. Unattached workers can carry out activities anywhere and at any time (Piwowar-Sulej, 2020). Therefore, personalised paths will be designed outside company boundaries that will be supported by the operational and relationship networks created by Industry 4.0. The mobility of resources across innovative structures can increase the development of knowledge and innovation within structures and the transfer of knowledge across the industry system. Therefore, in addition to traditional vertical career paths, the spiral paths and professional paths of deepening knowledge typical of specialist jobs will be important.

Training

The corporate training process is affected by technological change in both the content of employee training and the tools used to complete the training. The transition to the digital fashion industry requires strong training support and internal adaptation of the technical skills necessary to develop, expand, and enrich the roles we have discussed. Training cannot stop at the content of the new technology; it must also develop

new ways of approaching and organising activities, considering issues of teamwork, cooperation, orientation to change, and adaptability, while simultaneously focusing on the need to develop sustainable orientations and social responsibility. Training in Industry 4.0 is based on access to immediately available knowledge through new techniques and tools; this transformation requires on-demand development of intellectual skills and abilities through the unlimited supply of teaching materials, virtual reality simulations, asynchronous training, educational games, chat rooms, and knowledge management systems (Piwowar-Sulej, 2020).

Conclusions: The Challenges for Businesses and the Education System

The fourth technological era is gradually transforming the world of manufacturing and services, while also creating closely related social and cultural changes. This transformation affects all processes and all professional roles within companies. The fashion sector, by nature exposed to extremely variable demand and a long-standing trade-off between exclusivity and artisan refinement and the need for efficiency and productivity, can grasp, with new technologies, the possibility of incorporating into internal processes, in almost real time, customers' expectations and purchasing and consumption behaviours; they can then combine these behaviours with the demands of environmental sustainability and the needs of internal organisational rationality. Two issues are particularly critical: the difficulty of making innovations in very small contexts, and the difficulty of adapting traditional roles to incorporate new required qualifications, increased hybridity, and the possibility of acquiring the latest professional skills. These changes cannot occur unless managerial positions incorporate greater technical skills and leadership components to integrate the traditional set of skills and competences with modern ones. Management skills and leadership skills must coexist in all managerial roles. A major managerial process subject to change is that of human resources, which faces challenges both in having to manage employees with more qualified skills and in losing its exclusive role of HRM as automation and other departments take on these tasks. All roles coordinating teams or employees will adopt HRM activities, which means specific relationships must be defined between centre and periphery. As a result, those conducting HRM activities will need to prepare to use

technological HRM tools suitable for different contexts and support their effective use by others.

Organisational culture appears to play a fundamental role in all innovation processes (Varra, 2012). Innovation requires a culture of comparison, exchange, and collaboration within and outside the system so that all processes of knowledge development can be activated (Nonaka & Takeuki, 1995) and remain innovative on the market.

A person-centric culture is needed which emphasises the characteristics and contributions of individuals. The enhancement of the person in a high-tech system is mistakenly considered an oxymoron, considering how the technological changes have depersonalised many public and private organisations, yet it is the prerequisite for the creation of digital factories because of the close interconnection between machines, skills, and reasons. Finally, institutions must support organisations in the transition to Industry 4.0 enterprises by creating adequate policies. A system of basic and applied research must be developed and adequately supported to remain competitive at a national level. The systems of education and academic training must adapt to change. Education in technological innovation must be present in all schools. Schools must not only bridge the gaps in the use of technology to support traditional forms of knowledge sharing and delivery, but also create structured and frequent opportunities for experimentation through innovation and applied research laboratories. In particular, management schools must adapt to the updated needs of businesses. It is clear that, especially in countries such as Italy, university programmes are slower to react to the needs of companies in terms of skills: university masters' programs, professional courses, and a wider range of academic offerings must be designed to adequately respond to the rise of digital businesses. It is once again necessary that countries create development plans, following European requests for Innovation 4.0., and implement them with a systemic vision and the involvement of all interested parties.

Note

1. Therefore, the positions in which few and very limited tasks are carried out have high levels of horizontal specialisation, while the positions in which workers operate with low decision-making autonomy have high levels of vertical specialisation. At the opposite extreme are positions in which many major tasks are carried out and workers have significant or complete control over these tasks.

References

Antosz, K. (2018). Maintenance—Identification and analysis of the competency gap. Eksploatacja I Niezawodnos. *Maintenance and Reliability, 20*(3), 484–494.

Ashby, A. (2016). From global to local: Reshoring for sustainability. *Operations Management Research, 9*(3/4), 75–88.

Bayus, B. L. (2013). Crowdsourcing new product ideas over time: An analysis of the Dell IdeaStorm community. *Management Science, 59*(1), 226–244.

Becattini, G. (1998). *Distretti industriali e made in Italy*. Bollati Boringhieri.

Beltrametti L., Guarnacci N., Intini N., & La Forgia C. (2017). *La fabbrica connessa. La manifattura italiana (attra)verso Industria 4.0*. Guerini e Associati.

Benešová, A., & Tupa, J. (2017). Requirements for education and qualification of people in Industry 4.0. *Procedia Manufacturing, 11,* 2195–2202.

Bertola, P., Colombi, C., & Vacca, F. (2017). Managing the creative process. In E. Rigaud-Lacresse & F. M. Pini (Eds.), *New luxury management, Palgrave: Creating and managing sustainable value across the organization* (pp. 159–188). MacMillan.

Bertola, P., & Teunissen, J. (2018). Fashion 4.0. Innovating fashion industry through digital transformation. *Research Journal of Textile and Apparel*, *22*(4), 352–369.

Bettarini, U., & Tartaglione, C. (2018). Le nuove professioni 4.0 nel sistema moda. https://ares20.it/wp-content/uploads/2018/06/ebook_lenuoveprofessioni4.0giugno2018.pdf.

BMBF. (2014). Industrie 4.0-Volks- und betriebswirtschaftliche Faktoren für den Standort Deutschland. https://www.digitaletechnologien.de/DT/Redaktion/DE/Downloads/Publikation/autonomik-40-studie-markttperspektiven-broschuere.html. Accessed 29 November 2020.

Bonekamp, L., & Matthias, S. (2015). Consequences of Industry 4.0 on human labour and work organization. *Journal of Business and Media Psychology*, 6(1), 33–40.

Bostrom, N. (2016). *Superintelligence: Paths, dangers, strategies*. Oxford University Press.

Boyatzis, R. E. (1982). *The competent manager: A model for effective performance*. John Wiley and Sons.

Braidotti, R. (2008). *The posthuman*. Polity Press.

Brun, A. (2017). Luxury as a construct: An evolutionary perspective. In E. Rigaud-Lacresse & F. M. Pini (Eds.), *Palgrave, advances in luxury* (pp. 1–18). MacMillan.

Brun, A., Caniato, F., Caridi, M., Castelli, C., Miragliotta, G., Ronchi, S., et al. (2008). Logistics and supply chain management in luxury fashion retail:

Empirical investigation of Italian firms. *International Journal of Production Economics, 114,* 554–570.

Buciuni, G., & Finotto, V. (2016). Innovation in global value chains: Co-location of production and development in Italian low-tech industries. *Regional Studies, 50*(12), 2010–2023.

Cascio, W. F., & Montealegre, R. (2016). How technology is changing work and organizations. *Annual Review of Organizational Psychology and Organizational Behavior, 3*(1), 349–375.

Cavaliere, V., & Varra, L. (2020). La gestione delle interdipendenze e il coordinamento. In C. Bonti, V. Cavaliere, & E. Cori (Eds.), *Lineamenti di organizzazione* (pp. 203–233). EGEA.

Chan, T. Y., Wu, C., & Xie, Y. (2011). Measuring the lifetime value of customers acquired from google search advertising. *Marketing Science, 30*(5), 837–850.

Chen, T., & Lin, C. W. (2015). Estimating the simulation workload for factory simulation as a cloud service. *Journal of Intelligent Manufacturing, 28,* 1–19.

Christopher, M., Lowson, R., & Peck, H. (2004). Creating agile supply chains in the fashion Industry. *International Journal of Retail & Distribution Management, 32*(8), 367–376.

De Felice, F., & Petrillo, A. (2013). Key success factors for organizational innovation in the fashion industry. *International Journal of Engineering Business Management, 5,* 1–11.

Díaz Bermúdez, M., & Flores Juárez, B. F. (2017). Competencies to adopt Industry 4.0 for operations management personnel at automotive parts suppliers in Nuevo Leon. In *Proceedings of the international conference on industrial engineering and operations management Bogota, Colombia* (pp. 736–747).

Dinner, I. M., Van Heerde, H. J., & Neslin, S. A. (2014). Driving online and offline sales: The cross-channel effects of traditional, online display, and paid search advertising. *Journal of Marketing Research, 51*(5), 527–545.

Elfenbein, D. W., & Sterling, A. D. (2018). (When) is hiring strategic? Human capital acquisition in the age of algorithms. *Strategy Science, 3*(4), 668–682.

Fitsilis, P., Tsoutsa, P., & Gerogiannis, V. (2018). Industry 4.0: Required personnel. *International Scientific Journal "Industry 4.0", 3*(3), 130–133.

Fratocchi, L., Di Mauro, C., Barbieri, P., Nassimbeni, G., & Zanoni, A. (2014). When manufacturing moves back: Concepts and questions. *Journal of Purchasing and Supply Management, 20*(1), 54–59.

Freire, N. A. (2014). When luxury advertising adds the identitary values of luxury: A semiotic analysis. *Journal of Business Research, 67,* 2666–2675.

Gehrke, L., Rule, D., Bellmann, C., & Siemes, S. (2015). A discussion of qualifications and skills in the factory of the future: A German and American

perspective. https://www.academia.edu/26953030/A_Discussion_of_Qualifications_and_Skills_in_the_Factory_of_the_Future_A_German_and_American_Perspective. Accessed 25 November 2020.

Gilchrist, A. (2016). *Industry 4.0: The industrial internet of things*. Apress.

Granger, M. M. (2012). *Fashion: The industry and its careers*. Fairchild Books.

Grzybowska, K., & Łupicka, A. (2017). Key competencies for industry 4.0. *Economics & Management Innovations*, *1*(1), 250–253.

Guercini, S., & Ranfagni, S. (2013). Sustainability and luxury: The Italian case of a supply chain based on native wools. *The Journal of Corporate Citizenship, 52,* 76–89.

Hartmann, E., & Bovenschulte, M. (2013). Skills needs analysis for "industry 4.0" based on roadmaps for smart systems. In: SKOLKOVO Moscow School of Management & International Labour Organization (Ed.), *Using technology foresights for identifying future skills needs* (pp. 24–36). Global Workshop Proceedings.

Hashem, I. A. T., Yaqoob, I., Anuar, N. B., Mokhtar, S., Gani, A., & Khan, S. U. (2015). The rise of big data on cloud computing: Review and open research issues. *Information Systems, 47,* 98–115.

Hecklau, F., Orth, R., Kidschun, R., & Kohl, O. (2017). Human resources management: Meta-study—Analysis of future competences in industry 4.0. file:///C:/Users/lucia/Downloads/Human_Resources_Management_Meta-Study_Analysis_of_Future_Competences_in_Industry_4_0%20(1).pdf.

Hermann, M., Pentek, T., & Otto, B. (2016). Design principles for industrie 4.0 scenarios. In *49th Hawaii international conference on system sciences (HICSS)* (pp. 3928–3937).

Hofmann, E., & Rusch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. *Computers in Industry, 89,* 23–34.

Imran, F., & Kantola, J. (2018, 21–25 July). Review of industry 4.0 in the light of sociotechnical system theory and competence-based view: A future research agenda for the evolute approach. In *Proceedings of the international conference on applied human factors and ergonomics, Orlando, FL, USA*, (pp. 118–128). Springer.

Jensen K. R. (2017). Global organizational leadership for luxury companies (2017). In E. Rigaud-Lacresse, & F. M. Pini (Eds.), *New luxury management: Creating and managing sustainable value across the organization. Palgrave advances in luxury* (pp. 33–46).

Jerman, A., Bach, M. P., & Aleksić, A. (2019). Transformation towards smart factory system: Examining new job profiles and competencies. *Systems Research and Behavioral Science, 37*(2), 388–402.

Jerman, A., Bach, M. P., & Bertoncelj, A. (2018). A bibliometric and topic analysis on future, competences at smart factories. *Machines*, *6*(41), 1–13.

Kagermann, H., Wahlster, W., & Helbig, J. (2013, April). *Recommendations for implementing the strategic initiative industrie 4.0: Final report of the Industrie 4.0 Working Group*. Munich: Academy of Science and Engineering. http://digital.bib-bvb.de/view/bvb_single/single.jsp?dvs=1606649485498~98&locale=it_IT&VIEWER_URL=/view/bvb_single/single.jsp?&DELIVERY_RULE_ID=39&bfe=view/action/singleViewer.do?dvs=&frameId=1&usePid1=true&usePid2=true. Accessed 29 November 2020.

Kalbaska, N., & Cantoni L. (2019). Digital fashion competences: Market practices and needs. In: R. Rinaldo, & R. Bandinelli (Eds.), Business models and ICT technologies for the fashion supply chain. In *Proceedings of IT4Fashion 2017 and IT4Fashion 2018* (pp. 125–135). Springer.

Kannan, P. K., & Li, H. (2017). Digital marketing: A framework, review and research agenda. *International Journal of Research in Marketing, 34,* 22–45.

Kapferer, J. N., & Bastien, V. (2009). The specificity of luxury management: Turning marketing upside down. *Journal of Brand Management*, *16*(5), 311–322.

Kapferer, J. N., & Bastien, V. (2012). *The luxury strategy: Break the rules of marketing to build luxury brands.* Kogan Page.

Kinkel, S., Schemmann, B., & Lichtner, R. (2017). Critical competencies for the innovativeness of value creation champions: Identifying challenges and work-integrated solutions. *Procedia Manufacturing, 9,* 323–330.

Kleefstra, A. (2019). A literature review into leadership styles discussed in the past five years. *Open Journal of Social Sciences, 7,* 180–190.

Kong, X. T. R., Luo, H., Huang, G. Q., & Yang, X. (2019). Industrial wearable system: The human-centric empowering technology in Industry 4.0. *Journal of Intelligent Manufacturing, 30,* 2853–2869.

Kruger, S., & Steyn, A. A. (2020). A conceptual model of entrepreneurial competencies needed to utilise technologies of industry 4.0. *The International Journal of Entrepreneurship and Innovation*, 1–12. https://journals.sagepub.com/doi/pdf/10.1177/1465750320927359. Accessed 29 November 2020.

Leinweber, S. (2013). Etappe 3: Kompetenzmanagement. In M. T. Meifert (Ed.), *Strategische Personalentwicklung - Ein Programm in acht Etappen* (3rd ed., pp. 145–178). Springer Fachmedien.

Li, H., Jain, S., & Kannan, P. K. (2019). Optimal design of free samples for digital products and services. *Journal of Marketing Research, 56*(3), 419–438.

Lin, S., & Piercy, N. (2013). New product development competencies and capabilities: The case of the fashion SME. *Journal of General Management*, *38*(2), 61–77.

Liu, M., Ma, J., Lin, L., Ge, M., Wang, Q., & Liu, C. (2017). Intelligent assembly system for mechanical products and key technology based on internet of things. *Journal of Intelligent Manufacturing, 28*(2), 271–299.

Longo, F., Nicoletti, L., & Padovano, A. (2017). Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. *Computer and Industrial Engineering, 113,* 144–159.

Lorenz, M., Rüßmann, M., Strack, R., Lueth, K. L., & Bolle, M. (2015). Man and machine in industry 4.0: How will technology transform the industrial workforce through 2025. In BCG (Ed.) https://www.bcg.com/it-it/publications/2015/technology-business-transformation-engineered-products-infrastructure-man-machine-industry-4.

Luo, L., & Toubia, O. (2015). Improving online idea generation platforms and customizing the task structure on the basis of consumers' domain-specific knowledge. *Journal of Marketing, 79*(5), 100–114.

Mabkhot, M. M., Al-Ahmari, A. M., Salah, B., & Alkhalefah, H. (2018). Requirements of the smart factory system: A survey and perspective. *Machines, 6*(2), 1–22.

Magone, A., & Mazali, T. (2016). *Industria 4.0: Uomini e macchine nella fabbrica digitale*. Guerini e Associati Edizioni.

Majeed, M. A. A., & Rupasinghe, T. D. (2017). Internet of things (IoT) embedded future supply chains for industry 4.0: An assessment from an ERP-based fashion apparel and footwear industry. *International Journal of Supply Chain Management*, *6*(1), 25–40.

McClelland, D. C. (1973). Testing for competence rather than for intelligence. *American Psychologist, 28*(1), 1–14.

Mintzberg, H. (1983). *La progettazione dell'organizzazione aziendale*. Il Mulino.

Nagorny, K., Lima-Mointeiro, P., Barata, J., & Colombo, A. W. (2017). Big data analysis in smart manufacturing: A review. *International Journal of Communications, Network and System Sciences, 10*(3), 31–58.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford University Press.

Nyikes, Z. (2018). Contemporary digital competency review. *Interdisciplinary Description of Complex Systems: INDECS, 16*(1), 124–131.

Obitko, M., Jirkovský, V., & Bezdíček, J. (2013). Big data challenges in industrial automation. In V. Mařík, J. L. Martinez Lastra, & P. Skobelev (Eds.) *Applications of Holonic and multi-agent systems* (pp. 305–316). Springer.

Onik, M. M. H., Miraz, M. H., & Kim, C. S. (2018). A recruitment and human resource management technique using Blockchain technology for Industry 4.0. In *Proceedings of the smart cities symposium (SCS-2018)* (pp. 11–16).

Ozuem, W., Howell, K. E., & Lancaster, G. (2008). Communicating in the new interactive marketspace. *European Journal of Marketing, 42*(9/10), 1059–1083.

Ozuem, W., Patel, A., Howell, K. E., & Lancaster, G. (2017). An exploration of customers' response to online service recovery initiatives. *International Journal of Market Research, 59*(1), 97–116.

Ozuem, W., Thomas, T., & Lancaster, G. (2016). The influence of customer loyalty on small island economies: An empirical and exploratory study. *Journal of Strategic Marketing, 24*(6), 447–469.

Pecina, P., & Sladek, P. (2017, 6–8 March). Fourth industrial revolution and technical education. In *Proceedings of the 11th international conference on technology, education and development (INTED), Valencia, Spain* (pp. 2089–2093).

Piccarozzi, M., Aquilani, B., & Gatti, C. (2018). Industry 4.0 in management studies: A systematic literature review. *Sustainability*, *10*(10), 3821–3845.

Piwowar-Sulej, K. (2018). Human resources management in the industrial revolution 4.0: General and polish perspective. In *Double-blind peer-reviewed proceedings of the international scientific conference Hradec economic days* (Vol. 8, No. 2, pp. 179–187). https://digilib.uhk.cz/bitstream/handle/20.500.12603/437/Piwowar_HED18_paper_9.pdf?sequence=1&isAllowed=y. Accessed 29 November 2020.

Piwowar-Sulej, K. (2020). Human resource management in the context of industry 4.0. *Scientific Quarterly Organization and Management*, *1*(49), 103–113.

Polanji, M. (1966). *The tacit dimension*. Routledge & Kegan Paul.

Prifti, L., Knigge, M., Kienegger, H., & Krcmar, H. (2017). "A competency model for "Industrie 4.0" employees. In J. M. Leimeister, & W. Brenner (Eds.). *Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik (WI 2017)*, St. Gallen, S. (pp. 46–60). https://wi2017.ch/images/wi2017-0262.pdf. Accessed 29 November 2020.

Roberts, G. (1997). *Recruitment and selection: A competency approach*. Chartered Institute of Personnel and Development.

Ronchetti, M., Nobile, T. H., Oliveira, R. A., Kalbaska, N., & Cantoni, L. (2020). *Digital fashion competences: Market practices and needs during COVID19*. https://www.researchgate.net/publication/343259575.

Rowe, C. (1995). Clarifying the use of competence and competency models in recruitment, assessment and staff development. *Industrial and Commercial Training, 27*(11), 12–17.

Scheer, A.-W. (2012). Industrierevolution 4.0 ist mit weitreichenden organisatorischen Konsequenzen verbunden! *Information Management & Consulting*, *3*, 10–11.

Schwab, K. (2017). *The fourth industrial revolution*. Crown Business.

Silva, E. S., Hassani, H., & Madsen, D. Ø. (2020). Big Data in fashion: Transforming the retail sector. *Journal of Business Strategy, 41*(4), 21–27.

Sinsel, A., Bangert, C., Stoldt, J., & Buttner, T. (2017). Economic evaluation of the smart ffactory—An approach to the assessment of digitalization in production. *Zeitschrift Für Wirtschaftlichen Fabrikbetrieb, 112*(9), 602–606.

Sivathanu, B., & Pillai, R. (2018). Smart HR 4.0—How industry 4.0 is disrupting HR. *Human Resource Management International Digest*, *26*(4), 7–11.

Som, A., & Blanckaert, C. (2015). *The road to luxury: The evolution, markets and strategies of luxury brand management*. John Wiley & Sons.

Spencer, L. M., & Spencer, S. M. (1993). *Competence at work: Models for superior performance*. Wiley.

Sun, L., & Zhao, L. (2017). Envisioning the era of 3D printing: A conceptual model for the fashion industry. *Fashion and Textiles, 4*(25), 2–16.

Sun, L., & Zhao, L. (2018). Technology disruptions: Exploring the changing roles of designers, makers, and users in the fashion industry. *International Journal of Fashion Design, Technology and Education, 11*(3), 362–374.

Tao, F., Cheng, Y., Xu, L. D., Zhang, L., & Li, B. H. (2014). CCIoT-CMfg: Cloud computing and internet of things-based cloud manufacturing service system. *IEEE Transactions on Industrial Informatics, 10*(2), 1435–1442.

Tao, F., Qi, Q., Liu, A., & Kusiak, A. (2018). Data-driven smart manufacturing. *Journal of Manufacturing Systems, 48,* 157–169.

Thompson, J. D. (1967). *Organizations in action*. McGraw-Hill.

Torres, M. V. T., Cardelle-Elawar, M., Mena, M. J. B., & Sanchez, A. M. M. (2003). Social background, gender and self-reported social competence in 11- and 12-year-old Andalusian children. *Electronic Journal of Research in Educational Psychology, 1*(2), 38–56.

Trstenjak, M. (2018). Challenges of human resources management with implementation of industry 4.0. file:///C:/Users/lucia/Downloads/956303.IoTSm_2018_paper_87.pdf. Accessed 29 November 2020.

Ugur, M., Churchill, S. A., & Solomon, E. (2018). Technological innovation and employment in derived labour demand models: A hierarchical meta-regression analysis. *Journal of Economic Surveys, 32*(1), 50–82.

Ustundag, A., & Cevikcan, E. (2017). *Industry 4.0: Managing the digital transformation*. Springer.

Vacca, F. (2015). Artisanal advanced design: Advanced manufacturing processes as a tool to revitalize peculiar Italian (craft)productions. In L. Collina, L. Galluzzo, & A. Meroni (Eds.), *The virtuous circle: Design culture and experimentation* (pp. 703–715). Proceedings of the Cumulus Conference, Milano, McGraw–Hill, Milano.

Vacek, J. (2016). Socio-economic aspects of Industry 4.0. In Proceeding of 4th international conference on innovation management, entrepreneurship and corporate sustainability (IMECS) (pp. 731–741).

Varra, L. (2012). *L'innovazione in azienda: razionalità e creatività nei relativi processi decisionali e organizzativi*. CEDAM.

Varra, L. (2020). Sulla decisione di assunzione: Approcci, contenuti di strategicità e caratteri della scelta. In V. Cavaliere (a cura), *Employability e soft skilldegli studenti universitari. Un modello di analisi del mismatchnella prospettiva manageriale. Implicazioni per l'alta formazionee i career service* (pp. 77–99). Pacini.

Varra, L., & Timolo, M. (2017, 13–15, September). Sustainable human resource management and CSR performance measurement: Sseeking an integration through international standards. In *9th conference on performance measurement and management control- EIASM conference proceedings, Nice, France* (pp. 1–31).

Wan, J., Chen, M., Xia, F., Li, D., & Zhou, K. (2013). From machine-to-machine communications towards cyberphysical systems. *Computer Science and Information Systems, 10*(3), 1105–1128.

Waterman, K. K., & Bruening, P. J. (2014). Big data analytics: Risks and responsibilities. *International Data Privacy Law, 4*(2), 89–95.

Weyer, S., Schmitt, M., Ohmer, M., & Gorecky, D. (2015). Towards industry 4.0—Standardization as the crucial challenge for highly modular, multi-vendor production systems. *IFAC-PapersOnLine, 48*(3), 579–584.

Whysall, Z., Owtram, M., & Brittain, S. (2019). The new talent management challenges of Industry 4.0. *Journal of Management Development*, *38*(2), 118–129.

World Economic Forum. (2020). *The future of the job Report 2020*. http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf. Accessed 29 November 2020.

Wu, D., Liu, X., Hebert, S., Gentzsch, W., & Terpenny, J. (2017). Democratizing digital design and manufacturing using high performance cloud computing: Performance evaluation and benchmarking. *Journal of Manufacturing Systems, 43,* 316–326.

Zhang, J., Ding, G., Zou, Y., Qin, S., & Fu, J. (2019). Review of job shop scheduling research and its new perspectives under Industry 4.0. *Journal of Intelligent Manufacturing, 30,* 1809–1830.

Zhong, R. Y., Xun, X., Klotz, E., & Newman, S. T. (2017). Intelligent manufacturing in the context of industry 4.0: A review. *Engineering, 3,* 616–630.

Zhou, K., Liu, T., & Zhou, L. (2015). Industry 4.0: Towards future industrial opportunities and challenges. In *IEEE, 12th international conference on fuzzy systems and knowledge discovery (FSKD)* (pp. 2147–2152).