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Industry 4.0 skills: A perspective of the South African manufacturing industry

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Orientation: Industry 4.0 (I4.0) is causing significant changes in the manufacturing industry, and its adoption is unavoidable for competitiveness and productivity.

Research purpose: This study investigated I4.0 skills using the views of professionals in the manufacturing industry and experts in digital transformation practising in South Africa.

Motivation for the study: I4.0 was coined originally for the manufacturing industry, and skills availability significantly influences its successful adoption. Furthermore, I4.0 is relatively new in the South African manufacturing industry, and there is still limited empirical research on the subject.

Research approach/design and method: A qualitative descriptive research design was used, and participants were enrolled using purposeful sampling via email, telephone and LinkedIn. Twenty semi-structured interviews were conducted face-to-face or telephonically, and thematic analysis was used to analyse the data.

Main findings: This study found that I4.0 demands higher skills than in conventional manufacturing, and companies should take the lead in facilitating upskilling and reskilling of their employees to preserve jobs. Experiential training could enhance I4.0 skills development in the manufacturing industry.

Practical/managerial implications: Agile changes in I4.0 require constant re-alignment of employees' skills in the manufacturing industry. This requires companies to make the human resource (HR) management function an integral part of business strategy.

Contribution/value-add: The study can help HR practitioners and manufacturing professionals in strategising and innovate technology to manage the evolving I4.0 skills requirements and preserve jobs. The study also asserts a foundation for further investigation of I4.0 skills competencies' development in the South African manufacturing industry.

Keywords: Industry 4.0; industrial revolution; manufacturing industry; skills sets; competencies; experiential training; human resource management; South Africa.

Introduction

The progression in industrial revolution has resulted in an incremental change in job complexity and skills requirements (Selamat, Alias, Hikmi, Puteh, & Tapsi, 2017). Industry 4.0 (I4.0), a Fourth Industrial Revolution initiative, is transforming the manufacturing industry into a more competitive environment in various ways that include the skills mix, attitudes and experiences required in the workforce (Baker, 2016; Gehrke et al., 2015; World Economic Forum, 2016). Skills requirements and skills development are amongst the factors that significantly influence successful adoption of I4.0 (Hartmann & Bovenschulte, 2013; Maisiri & Van Dyk, 2019). Thus, human resources (HR) and its management become vital in manufacturing companies (Paine, 2009).

The South African manufacturing industry makes a noticeable contribution to the country's economy (Republic of South Africa, 2018a, 2018b), and the adoption of I4.0 principles and technologies is unavoidable for survival and competitiveness. The South African manufacturing industry is currently characterised by significant numbers of unskilled and semi-skilled workers (MerSETA, 2018). Thus, the impact of I4.0 on skills requirements cannot be ignored and calls for an investigation.

In a recent study, Dhanpat, Buthelezi, Joe, Maphela and Shongwe (2020) considered HR professionals' roles in I4.0. Their study presented the skills required by HR professionals in I4.0 using the views of practising HR professionals (Dhanpat et al., 2020). This study complements the work of Dhanpat et al. (2020) by focusing on I4.0 skills requirements in the manufacturing industry using the views of manufacturing professionals and digital experts. The findings of this study could enhance the role of HR professionals in I4.0.

Purpose

A systematic literature review aimed at exploring I4.0 skills requirements (Maisiri, Darwish, & Van Dyk, 2019) revealed a lack of empirical studies on this subject in the South African manufacturing industry, and thus the issue is poorly understood. Dhanpat et al. (2020) emphasised the lack of scientific empirical research on I4.0 in South Africa 'although there are workshops and seminars in the field' (Dhanpat et al., 2020, p. 1). Therefore, this article seeks empirical evidence of I4.0 skills requirements in the manufacturing industry using the views of professionals and experts practising in South Africa.

Guided by the work of Kim et al. (2017), as well as Sandelowski (2000), the following research questions are set:

1. What is the impact of I4.0 on jobs and skills requirements in the manufacturing industry in South Africa?
2. Which skills are regarded as critical for I4.0 in the South African manufacturing industry?
3. What are the strategies organisations are implementing to mitigate the impact of I4.0 on jobs and skills requirements?

Literature review

Industry 4.0: a manufacturing industry initiative

I4.0 was coined in 2011 in Germany in a context in which ways were sought to maintain the competitiveness of Germany's manufacturing industry and its leadership in technology innovation (Kang et al., 2016; Lu, 2017; Müller, Buliga, & Voigt, 2018; Ślusarczyk, 2018). Today, the impact of I4.0 on the manufacturing industry is being experienced all over the globe.

Although there are variations in the definitions of I4.0 used by various authors, as presented by Müller et al. (2018), it is evident that it is an initiative that focuses on improving competitiveness in the manufacturing industry. Manufacturers consulted by Ślusarczyk (2018) emphasised that I4.0 will apply significantly to the manufacturing industry.

The global community has responded by developing initiatives that support the manufacturing industry in line with I4.0, for example, EU initiative Factories of the Future to maintain sustainability and boost production (Müller et al., 2018), Made in China 2025 (Internet Plus) to enable state-of-the-art manufacturing (Bartodziej, 2016) and Manufacturing Innovation 3.0 in South Korea (Kang et al., 2016). These initiatives support the concept that I4.0 is a manufacturing initiative that is driving the Fourth Industrial Revolution.

In response to the global adoption of I4.0, the South African Department of Trade and Industry has launched the new Intsimbi Future Production Technologies initiative to build capacity to meet I4.0 requirements (INSTIMBI, 2019; Republic of South Africa, 2018c).

The manufacturing industry in South Africa

The manufacturing industry is the fourth largest industry in South Africa. It comprises 10 sectors (Republic of South Africa, 2018b), including the metals sector, the automotive sector and the plastic manufacturing sector (MerSETA, 2018). The manufacturing industry contributes approximately 14% to the South African gross domestic product (Republic of South Africa, 2018a): a significant input to the countries' economy.

The manufacturing industry further provides a considerable number of jobs (MerSETA, 2018) and contributes approximately 1 in every 10 employees to the country's workforce (Republic of South Africa, 2018b). A general decline in the total number of employees has been noticed as follows: 1.44, 1.19 and 1.1 million in the years 2005, 2014 and 2019, respectively (Plastic & Chemical Trading, 2019).

The manufacturing industry is identified as an employment generator (Kleynhans & Sekhobela, 2008). It has the potential of employing 1.7 million people (Republic of South Africa, 2018a) if the country's installed capacity is fully utilised as opposed to the current 81% capacity utilisation (Plastic & Chemical Trading, 2019). The partial capacity utilisation has been attributed to a lack of skills, amongst other factors (Plastic & Chemical Trading, 2019). I4.0 adoption has the potential of worsening the skills challenge in the manufacturing industry. This emphasises the need to investigate I4.0 skills requirements in the South African manufacturing industry.

Industry 4.0 and the workforce

'People are the true authors of the digital story' (Accenture Consulting, 2017, p. 2). Talent and skills are identified as the drivers of successful adoption of I4.0. The vision of advanced manufacturing can be realised through a skilled and prepared workforce. I4.0 success not only depends on technology but also on people (Accenture Consulting, 2017).

According to Selamat et al. (2017), an upward trend of increasing job complexity has been observed during the progression of industrial revolution. A significant change in the competencies' requirements, employee motivation and unemployment rates will be noted in the manufacturing industry with the adoption of I4.0 (Accenture Consulting, 2017; Calitz, Poisat, & Cullen, 2017; Maisiri et al., 2019). However, none of the studies cited ventured into examining the subject of I4.0 skills in the South African manufacturing industry.

The changes in the job requirements because of the increased complexity of the workplace has the potential of threatening semi-skilled and unskilled jobs (Maisiri et al., 2019) in the manufacturing industry because of the replacement of manual and standard repetitive tasks with automation.

Workforce digital capability and skillset is at the core of successful adoption of I4.0 in manufacturing industries and other hybrid industries (Accenture Consulting, 2017). Further to this, Accenture Consulting (2017, p. 10) highlighted that 'people are at the centre of technological change, and their willingness and readiness to support digital transformation is key to success'. This is supported by Selamat et al. (2017) when stating that the best talent is achieved through the collaboration of machines and humans. Hence, an investigation of the I4.0 skills requirements in the South African manufacturing industry is essential.

Research design

The purpose of this article is to scrutinise the subject of I4.0 skills in the manufacturing industry, using the views of manufacturing industry professionals and digital transformation experts practising in South Africa. Qualitative descriptive research has been 'identified as important and appropriate for research questions focused on discovering the who, what, and where of events or experiences' (Kim, Sefcik, & Bradway, 2017, p. 23), and in collecting data from participants 'regarding a poorly understood phenomenon' (Kim et al., 2017, p. 23).

Research approach

This study followed a qualitative descriptive research approach in investigating the issue of I4.0 skills in the South African manufacturing industry. The descriptive research approach was used instead of other qualitative research approaches because it seeks to explore and provide comprehension and guidance for future studies (Magilvy & Thomas, 2009). 'straight description and comprehensive summary' (Kim et al., 2017, p. 27) and maintained low-inference interpretation during data analysis (Sandelowski, 2010).

Research method

The research method section discusses the following: research setting, entrée and establishing researcher roles, research participants and sampling methods, data collection methods, data recording, strategies employed to ensure data quality and integrity, data analysis and reporting style.

Research setting

This study was undertaken in South Africa through semi-structured interviews with manufacturing industry professionals and digital transformation experts practising in the country. The participants in the semi-structured interviews were mainly from the manufacturing industry.

Entrée and establishing researcher roles

A request for an appointment with prospective participants was communicated via email, telephone and LinkedIn. The invitation was accompanied by a one-page introduction to the study and an informed consent document. Potential participants were not coerced or persuaded to take part in the study, and participation was solely voluntary. The researcher, as the instrument of the study (Magilvy & Thomas, 2009), facilitated the study by arranging, conducting and recording the semi-structured interviews, transcribing the recorded interviews and conducting the data analysis.

Research participants and sampling methods

Manufacturing industry professionals and digital transformation experts were picked to participate in this study using purposeful sampling (Etikan, Musa, & Alkassim, 2016; Neergaard, Olesen, Andersen, & Sondergaard, 2009). Thirty-nine potential participants were contacted to take part in the study, but only 20 participants (Kim et al., 2017; Magilvy & Thomas, 2009) participated in the semistructured interviews, giving a total response rate of 51%. Most participants were from the manufacturing sector (Table 1).

Data collection methods

Semi-structured interviews, commonly used in a qualitative descriptive research approach (Magilvy & Thomas, 2009), were used as the data collection instrument. The semi-structured interviews were conducted by the researcher using face-to-face or telephonic interaction. Semi-structured interviews were chosen because they allow for flexibility by both the researcher and the participant (Miguel, 2011) whilst providing a guide to the issue being investigated.

Data recording

With consent from the participants, the semi-structured interviews were audio-recorded, and the researcher took field

TABLE 1: Participants' industry and responsibilities.

Participant	Industry	Responsibility/position
P1	Research innovation	Research and development manager
P2	Science technology	Technology agreements facilitator
P3	Manufacturing	IT strategist
P4	Manufacturing	Manufacturing execution executive
P5	Manufacturing	Digital factory expert
P6	Technology innovation	Research specialist
P7	Non-governmental organisation	Digital energy solutions expert
P8	Manufacturing	Business transformation and 4IR support consultant
P9	Manufacturing	Advanced technologies expert
P10	Industry and trade	Skills development
P11	Skills development	Fourth Industrial Revolution skills expert
P12	Emerging digital services consultancy	Executive product manager – IoT and digital services
P13	Digital services consultancy	Digital transformation expert
P14	Digital transformation consultancy	Digital solutions specialist
P15	Telecommunications	Information society evaluation and impact assessment deputy director
P16	Manufacturing	Digital factory expert
P17	Manufacturing	Technical trainer and skills facilitator
P18	Manufacturing	Digital control
P19	Manufacturing	Manufacturing execution
P20	Manufacturing consultancy	Innovation executive

IoT, Internet of Things, 4IR, Fourth Industrial Revolution.

notes during participant observation. Only one participant (P5) did not permit the interview to be recorded, and field notes were used to represent this participant's views.

Strategies used to ensure data quality and integrity

Measures were taken to ensure credibility and integrity of the study findings during the data collection, data analysis and reporting (Golafshani, 2003; Neergaard et al., 2009). The semi-structured interviews were audio-recorded and transcribed verbatim to avoid distortion of the participants' views (Braun & Clarke, 2006). Transcription accuracy was enhanced by reading the transcription and comparing it with the audio recording. Any detected discrepancy was immediately corrected.

A systematic method of data analysis was used to ensure that the rigour of the study findings was upheld (Braun & Clarke, 2006). This was enhanced by using ATLAS.ti to minimise the chances of bias in the analysis. In line with the nature of a qualitative descriptive study, the researcher maintained low-inference interpretation during data analysis (Neergaard et al., 2009; Sandelowski, 2000, 2010).

The integrity of the study was further ensured by minimising the researcher's subjectivity and by maintaining neutrality in the data analysis (Neergaard et al., 2009). The participants' opinions were emphasised by the researcher maintaining a passive voice.

Data analysis

In a qualitative descriptive study, the researcher must stick close to the data and provide a comprehensive summary of the issue under study (Sandelowski, 2000, 2010). Therefore, thematic analysis, as commonly used in the descriptive research approach (Sandelowski, 2010), was adopted in this study instead of other data analysis approaches because it provides the researcher with an opportunity to stay close to the data, 'with minimal transformation during analysis' (Kim et al., 2017, p. 24) and with minimum inference (Sandelowski, 2000).

A data analysis process was followed of listening to audio recordings, transcribing, reading and re-reading the transcriptions and field notes, identifying codes and classifying them into categories and themes (Magilvy & Thomas, 2009).

Braun and Clarke's (2006) six-step data analysis framework, as applied by Maguire and Delahunt (2017) and Coetzee, Jonker, Van der Merwe, and Van Dyk (2019), was used in this study (Coetzee et al., 2019; Maguire & Delahunt, 2017). The analysis followed the process of data familiarisation, initial codes' generation, reviewing the codes, searching for categories, reviewing of categories and themes' generation.

The researcher familiarised himself with the data by listening to the audio transcription and generating preliminary concepts and ideas. Interesting quotations were noted, and patterns of meaning identified at a semantic level.

Semi-structured interview transcripts were imported into ATLAS.ti, and the researcher read through the transcripts, and an initial code list was generated. The researcher used both open coding and *in vivo* coding to maintain the views of the participants. The codes were reviewed by renaming, merging and splitting, where necessary, until patterns in the data could be identified.

The relationship between codes was established by using the function links and networks in ATLAS.ti (Friese, 2019). Patterns and similarities were identified, and categories were formulated. The categories were reviewed, and themes established from the identified patterns. The themes' relevance to the research questions was ascertained at this stage.

Reporting style

In line with the objective of this study, and the research approach followed, straight descriptions of the participants' views (Sandelowski, 2000) on I4.0 skills will be presented. A table summarising the themes, sub-themes and related codes is presented followed by comprehensive description summaries (Kim et al., 2017; Neergaard et al., 2009; Sandelowski, 2000) of the themes and their related sub-themes and codes. The participants' exact words were quoted so that the researcher could stay as close to the data as possible.

Study findings

Three themes emerged from the data analysis: I4.0 impact, skills requirements and skills development (Table 2). The themes are further described using the participants' views.

TABLE 2: Emerging themes, categories and associated codes.

Theme	Category	Example of associated codes
I4.0 impact	Working practices	Agile methodologies, ecosystem of skills, working in networks, absorbing more content
	Employees' opportunities	Enhancing job experience and productivity, making jobs more meaningful and interesting, requiring mindset change
	Jobs and skills	Higher skills level, job opportunities and task replacement
Skills requirements	Digital skills	Advanced digital skills, basic digital skills, application of technology, integration of ICT, transition skills
	Soft skills	Social skills, thinking skills and personal skills
	Domain skills	Engineering skills and digital skills
	Entrepreneurial skills	-
Skills development	Workplace learning	Upskilling, reskilling, on-the-job training, attitude towards change
	Experiential training	Work-integrated learning, apprenticeships, experiential training, internships, learn a trade, practical training
	Teaching and learning strategy	Creating a platform for people to learn, mentorship, micro-credentialling and use of technology
	Education system	Alignment between skills requirement and skills development, education quality, curriculum change and industry demand driven

ICT, information, communication and technology.

Industry 4.0 impact

The theme of I4.0 impact comprised three categories: working practices, employees' opportunities, and jobs and skills. Rapid changes in I4.0 technologies require companies, teams and individuals 'to adopt agile methodologies which entail agile business models, agile teams and agile decision-making' (P3). This requires that employees have the 'ability to work in an agile way' (P8).

I4.0 requires a new working practice of establishing an ecosystem of skills and working in networks. Some companies are viewing I4.0 as an 'enabler to take on more work content and volume without reducing or increasing headcount' (P18). This is achieved through localising certain components and bringing some of the previously outsourced jobs on board.

The augmentation of humans and technology enhances employees' experience by 'taking away the safety issue of a job, or the risk of a job' (P1), 'taking more thinking away from operators but ensuring more consistency and quality' (P18) and increases their 'productivity and efficiency' (P7, P9).

Participants pointed out that I4.0 makes jobs more meaningful and interesting by enabling 'lower-skilled people to do higher-skilled jobs' (P6) using technologies such as augmented reality and virtual reality. I4.0 technologies enable employees 'who have been stuck in low paying jobs and menial labour' (P7) to be more relevant and perform higher functions in their companies. Employees become more visible:

> '[*A*]s decision-makers and not just as somebody who presses the button but [*somebody who is*] actually in charge of a machine, ensuring that the machine provides the correct kind of data.' (P7)

A significant number of participants emphasised that technology could 'create more opportunities for us' (P9) by 'not taking away jobs' (P1) and companies will 'still need more people, but it will be more on a different skill level' (P18). Some companies are automating routine functions 'not in order to reduce the workforce and take away peoples' work, but to [*enable employees*] … to innovate and come up with new ideas to solve problems.' (P3).

It was noticed that:

> '[*Y*]oungsters or the new people that are coming to the new workplace are expected to be on a higher level in terms of the information technology (IT) understanding, [*and*] understanding how [*the*] Internet of Things (IoT) is going to affect them.' (PP17)

There will be significant job transitioning and task replacement with the adoption of I4.0 technologies, but this does 'not mean replacing the person doing the job' (P1). Other participants pointed out that 'I4.0 does not have [*a*] negative impact on employee headcount' (P18) in their companies. However, 'if they're gonna be no change in the skills development system, in the next 3 to 4 years, we gonna have massive retrenchment coming up for South Africa, massive retrenchments' (P17).

Skills requirements

Participants emphasised that 'soft skills alongside technical skills are even more important than technical skills alone in I4.0' (P20) and 'those soft skills we find lacking' (P3); 'those softer skills are missing' (P13) in the employees. The soft skills were grouped into thinking skills, social skills and personal skills.

Thinking skills such as 'problem-solving' (P2–P4, P9, P12–P14, P17, P18, P20), 'critical thinking' (P3, P4, P9, P11, P13, P20), 'creativity and innovation' (P1, P3, P8, P9, P11, P14), 'application of knowledge' (P4) and 'agile decision-making and accountability' (P3, P7–P9, P13, P18) were indicated to be critical in I4.0.

Social skills such as 'collaboration' (P1–P3, P7–P9, P12, P14), 'communication' (P3, P4, P7, P9, P20), 'cross-cultural ability' (P20) and teamwork (P1, P7, P8, P20) were seen as essential to participate in I4.0 meaningfully.

Participants emphasised the importance of personal skills such as 'ability to quickly adjust to change and act' (P1, P3, P4, P8, P13, P18), 'emotional intelligence' (P9, P17), 'lifelong learning' (P2–P4, P6–P7, P13, P17–P18, P20), 'multi-skilling' (P1–P2, P6, P8–P9, P18) 'prioritisation' (P3), 'self-directedness and less taking [*of*] orders' (P8, P18) and 'personal evaluation' (P3–P4) in I4.0. Other companies are 'trying to implement that every day you have to teach something new to someone else or every day you have to learn something new' (P3) so that employees become aware of the ongoing trends and 'continuously keep up to skills' (P3).

Advanced digital skills related to big data analytics, advanced robotics, artificial intelligence, augmented reality and machine learning, amongst others, were pointed out to be vital in I4.0 (P1–P4, P7–P8, P11–P12, P14, P17).

'So skills in big data analytics, augmented reality, more use of the cloud, better use of the industrial Internet of Things, … and robotics as well; if we are able to implement those things in the manufacturing industry, then it will, of course, benefit the country in all sort[*s*] of way[*s*] because those companies will reduce their cost' (P14).

Digitals skills such as coding skills, data analytics, human–machine interaction and understanding information technology were regarded as basic skills in the sense that they will be commonly required in the manufacturing industry by employees (P1–P2, P7–P8, P12–P13, P17, P19). These skills will be needed as 'part and parcel of the adjustment, and people with these transitional skills are those you need basically' (P2).

Regarding information, communication and technology (ICT), it was pointed out that 'any formal skilling needs to, in one way or the other, have ICT at the centre' (P2). The question will be 'whether or not you are properly skilled in digitalisation and ICT' (P2).

There will be a difference between an 'artisan versus a skilled I4.0 artisan, a technician versus a skilled I4.0 technician, a technologist versus a skilled I4.0 technologist and an engineer versus an I4.0 engineer' (P4) regardless of the engineering focus, be it mechanical, industrial, electrical or electronic.

Employers need to 'start a lot more of entrepreneurship skilling' (P20) to strengthen their employees' entrepreneurial skills, which will empower them to deal with possible unemployment that can arise from the impact of I4.0.

Skills development

Participants emphasised that the possible negative impact of I4.0 on jobs and skills requires a significant implementation of skills development both in the workplace and skills development institutions. Workplace training, which includes 'reskilling' (P1–P3, P6, P17–P19), 'upskilling' (P1–P4, P17–P19) and 'on job training' (P2, P4, P19), was identified as critical in developing relevant I4.0 skills. Companies should take the lead in facilitating the upskilling and reskilling of their employees:

> 'So, what we have found as an organisation as well is, we need now to upskill our own people now. We have embarked on creating small programs where we introduce these new technologies to our workforce, and we are creating a lot of training programs so that our workforce understands what's coming and how I4.0 will also impact them.' (P17)

Participants observed that 'generally people themselves are not keen or eager to spend out of their own time and money to upskill themselves for the future' (PP19) and this attitude varied with 'older age group, let's say above 35 years … [*who*] don't want change to take place in the workplace because their normal working day is gonna be upset.' (P17).

Participants emphasised that I4.0 skills will be a significant requirement and hence educational institutions must promote experiential training (P1, P4) in the form of 'practical training' (P8, P13, P17–P18), 'internships, apprenticeships' (P1–P2) and 'work-integrated learning' (P5–P7). Skills will be recognised more than abstract knowledge because 'that is the only way we can create more jobs, and [*it is an*] economic enabler for us to move ahead' (P17).

Companies should 'create opportunities for people to learn' (P19) and 'give people access whether it can be free internet access and free access to information because accessibility is a challenge' (P3). 'Innovation centres, technology stations' (P7), 'D labs' (P6) and 'learning factories' (P1) were regarded as instruments for making information available.

Both workplace training and institutional training should adopt I4.0 technologies such as 'augmented reality and virtual reality' (P6–P7, P9) to 'accelerate training' (P6) and skills development. Conducting such training could considerably improve skills development turnaround in terms of time and quality:

> 'And in some cases what we have seen as well, which can be a good example again, on the other hand, is with the manufacturing of spare parts for equipment, … we have seen that … augmented reality glasses and virtual reality glasses have been effectively used in accelerating training.' (P7)

Micro-credentialling (P3–P4, P6, P13, P17), short courses (P2, P4, P17–P18) and mentorships (P4, P19) were identified as other essential strategies that can be used to enhance the development of I4.0 skills in the South African manufacturing industry.

Shortage of I4.0 skills in the South African manufacturing industry was attributed to a significant lack of alignment between skills requirements and skills development (P2–P3, P7–P8, P11, P13–P14, P17). P9 stated that 'we are preparing our students and our people for the first, second and third industrial revolution'. Participants emphasised that 'the quality of teaching and learning is not great and is intensified by organised labour in the education sector that is largely resistant to change' (P6) and that this lack of quality widens the skills challenge in the country.

Curricular alignment to I4.0 skills requirements, from early childhood training to tertiary education, was recommended as an urgent action in the country (P1–P3, P11–P14, P17, P20). The curriculum must be 'industry skills demand-driven' (P11) and must offer broad assessment criteria (P9):

> 'So, if you look at automotive manufacturers how they predict the cars and how the cars get introduced, I mean they work on a plus or minus 12-year cycle. So, in a 12-year cycle, they know exactly what technology they need 12 years from now. So, if industry get much closer to education and they say guys in 12 years.' (P17)
>
> 'time, this is what we think that gonna come in order for these youngsters to be able to work at a certain level they need.' (P17)

Discussion

Outline of the findings

The findings of this study accentuate that the adoption of I4.0 in the South African manufacturing industry is essential, thus confirming findings in other studies (Calitz et al., 2017). Some South African manufacturing companies are adopting I4.0 without affecting their workforce headcount, and learning from this experience is paramount. These companies are innovating technology in such a way that jobs are saved. This is achieved by implementing various strategies, such as automating routine functions to provide employees with opportunity and time for innovation and problem-solving; absorbing more content and bringing in previously outsourced functions by leveraging the capability of I4.0 technologies; focusing on technologies that simultaneously augment humans and enhance competitiveness and productivity; and in-house reskilling and upskilling.

This study points out that the impact of I4.0 on jobs and skills depends significantly on the individual company's innovativeness and its strategy towards employees' well-being. Technology innovation to save jobs requires joint efforts from manufacturing professionals, digital experts and HR practitioners who are change agents and strategic partners (Paine, 2009).

Incremental learning, where employees are encouraged to learn something small and new every day or teach someone something new every day, is being adopted by other manufacturing companies in South Africa. Employees are given sufficient time to learn through experimentation and are given opportunities to make mistakes and rectify them promptly. This shortens employees' learning cycle, thus increasing their relevance to the organisation. In the process, jobs are preserved, and this is of significance to South Africa, which faces notable unemployment challenges (Rambe, 2018).

The findings of this study intimate that I4.0 demands higher skills levels in the workforce than conventional manufacturing. The South African manufacturing industry is characterised by a significant percentage of the low-skilled workforce (MerSETA, 2018). Workplace training has the potential of achieving higher workforce productivity levels (Van Zyl, 2017) and could assist in mitigating I4.0 skills challenges in the South African manufacturing industry. To this end, HR practitioners need to align their training strategies towards the facilitation and promotion of reskilling and upskilling of the workforce in meeting I4.0 skills requirements (Dhanpat et al., 2020).

The education system has a notable contribution to minimising I4.0 skills challenges in the manufacturing industry. The potential lies in aligning skills development with industry requirements. Such alignment was pointed out to be missing in the South African education system. The alignment can be achieved when the education system and other skills development institutions are industry-driven. In the same respect, there was an emphasis on strengthening the development of workplace employability skills. This supports the relevance of work-integrated learning (Rambe, 2018) and other practical models that are relevant in developing I4.0 skills for the manufacturing industry.

The study confirms the importance of soft skills such as problem-solving, critical thinking, collaboration, communication, cross-cultural ability, teamwork, emotional intelligence, lifelong learning and multi-skilling in I4.0 (Carter, 2017; Kazancoglu & Ozkan-Ozen, 2018; Krot, Mazgajczyk, Rusińska, & Woźna, 2018; Maisiri et al., 2019). Soft skills such as agile decision-making and accountability, ability to quickly adjust to change and act, self-directedness and a reduced taking of orders, which were identified in this study, are rarely found in the literature.

Mindset change in the workforce was identified to significantly contribute to the successful adoption of I4.0 in the manufacturing industry. To manage the change process, the workforce requires transitional skills, such as coding skills, data analytics, human–machine interaction and understanding of information technology. The strategic role of HR practitioners (Davis, 2017; Rimanoczy & Pearson, 2010) in collaborating with manufacturing professionals becomes important in ensuring that employees acquire the needed transitional skills.

Practical implications

The quick changes in the use of technologies in the manufacturing industry require constant alignment of employees' skills and demand that companies make the HR management function an integral part of their business strategy.

This study provides information on I4.0 skills that can be used by both manufacturing professionals and HR practitioners in strategising on future employment practices in their companies.

The study further provides practical solutions to ensuring the competitiveness of the manufacturing industry through the successful adoption of I4.0, facilitated by skills availability and skills development. The findings of this study could enhance strategies to develop I4.0 skills for both workplace training and institutional training.

Limitations and recommendations

The study focused on the broad subject of I4.0 skills in the South African manufacturing industry and did not venture into distinguishing between disrupted environment-specific skills and generic permanent skills. Further to this, the study only focused on skills and not on the whole subject of competencies (skills, knowledge and personal attitudes) of employees in I4.0 (Rambe, 2018). Thus, the study lays a foundation for further investigation into the subject of I4.0 competencies' requirements and development. A comprehensive study on an I4.0 competency maturity model is suggested.

A sample size of 20 participants may be identified as a limitation towards getting broader views on the subject investigated. However, the study design minimised the possible effect of small sample size by purposefully selecting participants regarded as experts in this subject. Although there might be variations in how I4.0 impact on various sectors in the manufacturing industry, the study did not focus on a particular manufacturing industry sector in South Africa. Although this could be sufficient for this study, future studies should consider looking at how I4.0 is impacting on skills in different manufacturing industry sectors in South Africa.

Conclusion

The study investigated the subject of I4.0 skills in the South African manufacturing industry, and the findings reveal that I4.0 has a potential to have a negative impact on jobs if no action is taken to align workforce skills with industry skills requirements. However, a notable number of South African manufacturing companies are innovating the technologies they use and implementing strategies that minimise or even eliminate workforce headcount reduction. It can be concluded that the role of HR practitioners in collaborating with manufacturing professionals becomes increasingly relevant in managing the evolving I4.0 skills' requirements and preservation of jobs.

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Competing interests

The authors declare that they have no competing interest that may have inappropriately influenced them in writing this article.

Authors' contributions

W.M. was responsible for data collection, data analysis and preparing the manuscript – the work is based on his PhD studies. L.V.D. supervised the study. All authors discussed the findings and contributed to the final manuscript.

Ethical consideration

In compliance with North-West University's ethical clearance process, participants were enrolled voluntarily, and no participants were persuaded or coerced to participate. This was achieved by providing the prospective participants with an informed consent document, which they had to sign before participating in the research. The research overview, expectations from the participants, risks involved and how the risks would be minimised, as well as the handling and use of the data collected, were stated in the informed consent document. Participants were offered the liberty to withdraw from the study during or after the interview. The researcher adhered to the statements contained in the informed consent document at all stages of the study.

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Data availability statement

Data sharing does not apply to this article, as no new data were created or analysed in this study.

Disclaimer

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