



Developing and evaluating a people capability maturity model for a South African automotive manufacturing organisation

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FOR THE READER'S ATTENTION

The reader is reminded of the following:

- This thesis was submitted in the form of a research article. This thesis consists of five chapters. Chapter 1 is an introduction, Chapter 2 contains the research article 1, Chapter 3 research article 2, Chapter 4 research article 3, Chapter 5 discussed the conclusions, limitations and recommendations.
- The compilation of the thesis was completed following the guidelines prescribed by the School of Industrial Psychology and Human Resource Management at North-West University (Potchefstroom Campus). The referencing guidelines of the Publication Manual (7th ed.) of the American Psychology Association (APA) were followed.
- Each chapter of this thesis is accompanied by its own reference list.

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God Bless You All.

DECLARATION BY THE RESEARCHER

I, Lebogang Billy Olifant, hereby declare that '*Developing and evaluating a people capability maturity model for a South African automotive manufacturing organisation*' is my own work and that the views and opinions expressed in this study are those of the author and relevant literature references as indicated in the reference list.

I further declare that the content of this research has not been and will not be submitted for any other qualification at any other tertiary institution. Furthermore, I declare that the language of this thesis has been edited by Ms Magrietha Maria Engelbrecht and refined using Grammarly Pro.



Lebogang Billy Olifant

November 2025

DECLARATION BY THE LANGUAGE EDITOR

26 November 2025

Lebogang Billy Olifant
North-West University

Good day

Declaration of language editing

I, Magrietha Maria Engelbrecht, hereby declare that I personally read through the thesis:

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automotive manufacturing organisation**

by **Lebogang Billy Olifant** in November 2025 and highlighted language errors.

Yours sincerely



26 November 2025

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LIST OF ABBREVIATIONS

Addictive Manufacturing – AM

Artificial Intelligence – AI

Brazil, Russia, India, China and South Africa - BRICS

Capability Approach – CA

Capability Maturity Model - CMM

Council for Scientific and Industrial Research - CSIR

Cyber-Physical Production System – CPPS

Cyber-Physical System - CPS

Department of Trade and Industry - DTI

Fourth Industrial Revolution – 4IR

Human Resource Development – HRD

Human Resource Management - HRM

Industrial Development Corporation - IDC

Information and Communication Technology - ICT

Internet of Things – IOT

Machine Learning – ML

People Capability Maturity Model - P-CMM

Software Engineering Institute – SEI

World Economic Forum – WEF

SUMMARY

Title: Developing and evaluating a People Capability Maturity Model for a South African automotive manufacturing organisation

Keywords: Automotive, assembly, capabilities, talent development, employees, Fourth Industrial Revolution, Industry 4.0, manufacturing, skills, People Capability Maturity Model, South Africa

The automotive manufacturing industry is among the sectors most affected by the ongoing digital transformation driven by the Fourth Industrial Revolution (4IR). This rapid digital transformation significantly affects assembly employees' ability to keep pace with technological trends. Many assembly workers in the automotive manufacturing industry are not yet benefiting from digital transformation and innovation because of the high demand for new skills introduced by the 4IR. It is essential for automotive manufacturing organisations to equip their assembly employees with the capabilities necessary to adapt to 4IR digital assembly plant operations. Additionally, the 4IR digital era requires assembly employees to develop new capabilities in human-machine interaction and cyber-physical production systems (CPPS) for smart automotive manufacturing, including autonomous and hybrid vehicles.

Line managers in the automotive manufacturing industry are currently not experiencing the same benefits as managers in other sectors, due to strong competition and the substantial impact of the 4IR-driven digital transformation on the capabilities of assembly employees. Line managers should be involved in developing People Capability Maturity Models (P-CMMs) for automotive manufacturing organisations to facilitate innovative programmes for the ongoing development of assembly employees' skills and the prioritisation of their capability development. Together with process improvements, this will enable smooth adaptation to the 4IR. Furthermore, it is crucial to evaluate P-CMMs as implementation guides for automotive manufacturing industries to meet the growing demand for new capabilities among assembly employees driven by the 4IR.

The objective of this research project was to explore the perceptions of assembly employees regarding the capabilities needed for the 4IR in a South African automotive manufacturing organisation. A further objective was to examine line managers' perceptions of the capabilities and talent development required for the 4IR among assembly employees. Additionally, the study sought to develop and evaluate a P-CMM for the 4IR capabilities required by assembly employees in a South African automotive manufacturing organisation.

This study employed a qualitative research design grounded in constructivism. Purposive sampling was utilised during data collection. Firstly, data for research article 1 were gathered from assembly employees (N=13) currently employed in an automotive manufacturing organisation in South Africa. Secondly, data for research article 2 were collected from line managers (N=7) working in the same industry and country. Thirdly, data for research article 3, which involved the development of a P-CMM, were obtained from line managers (N=7) in a similar setting. Lastly, data for the evaluation of the P-CMM were collected from a panel of talent development experts and the advisory board in an automotive manufacturing organisation in South Africa (N=9). Data were gathered through face-to-face, semi-structured interviews. ATLAS.ti 23 software was used to organise and code the data and thematic analysis was employed to interpret it.

First, this study found that assembly employees would need a range of essential capabilities to adapt to the 4IR. The required 4IR capabilities were categorised into areas such as skills, knowledge, behaviours, attitudes, equipment, physical workplace changes, training opportunities, and support. The capabilities required for the 4IR and how assembly employees in an automotive manufacturing organisation could acquire them were discussed in detail.

Second, this study highlighted the importance of inclusive talent development for assembly employees to adapt to the 4IR in an automotive manufacturing organisation. The study found that assembly employees would require several significant capabilities across the following categories: skills, knowledge, behaviours, attitudes, equipment, physical workplace changes, training opportunities, and support.

Third, various essential capabilities that underpin the P-CMM and would enable assembly employees to adapt to the 4IR in an automotive manufacturing organisation were identified and discussed. The findings for the development of the P-CMM were derived from its five Maturity Levels, revealing that assembly employees would require diverse critical capabilities presented under different categories such as skills, knowledge, behaviours, attitudes, equipment, physical workplace changes, training opportunities, and support. Furthermore, the evaluation of the P-CMM highlighted the main pathways for adopting and applying this model through policy, process, decision-making, and recommendation categories.

The findings of this study provide a deeper understanding of the capabilities needed for the 4IR and how to support assembly employees to develop new skills in an automotive manufacturing assembly

plant. Recommendations to improve the efficiency of capabilities development programmes are based on the perspectives of assembly employees and line managers, and practical implications for South African automotive manufacturing organisations are discussed. Recommendations for future research and practice are offered, and a P-CMM conceptual model and evaluation are proposed to serve as a framework for capabilities development programmes for assembly employees and for enhancing practices in South African automotive manufacturing organisations.

CHAPTER 1

INTRODUCTION

INTRODUCTION

This research project developed and evaluated a People Capability Maturity Model (P-CMM) for a South African automotive manufacturing organisation. The project proceeded in three phases. First, the researcher explored the perceptions of assembly employees regarding the capabilities required for the Fourth Industrial Revolution (4IR) in a South African automotive manufacturing organisation. Second, the researcher explored line managers' perceptions regarding assembly employees' capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation. Third, the researcher developed and evaluated a P-CMM of the 4IR in a South African automotive manufacturing organisation.

Chapter 1 includes the contextualisation and problem statement, research objectives, research questions, research approach, research design, and division of chapters.

1.1 Contextualisation and problem statement

The 4IR manifests in the automotive manufacturing industry as disruptive, complex, demanding and volatile (Lorenz & Kraemer-Mbula, 2021; Schulze-Cleven & Vachon, 2022). The automotive manufacturing industry comprises organisations and activities related to designing and assembling parts to manufacture cars (Rae & Binder, 2023; Samani, 2023). The industry is currently facing extreme challenges in adapting to technological innovations (Stofla et al., 2020; Umar et al., 2021). Cyber-physical manufacturing and digitalisation in the automotive manufacturing industry require new capabilities from employees (Chigbu & Nekhwevha, 2020; Cohen et al., 2019; Stofla et al., 2020). The 4IR technological innovations, characterised by production systems that include technological connectivity, the Internet of Things (IoT), artificial intelligence (AI) and robotics (Dutt et al., 2020), significantly impact current employee capabilities in the automotive manufacturing industry (Mazurchenko & Zelenka, 2022). The influence of such 4IR innovations on assembly employees' talent development and capability growth in the automotive industry is a major concern (Mazurchenko & Zelenka, 2022). Additionally, the rapid adoption of AI, robotics and machine learning (ML) requires the industry to reconsider its employees' skills, existing system knowledge, and understanding of 4IR requirements (Chigbu & Nekhwevha, 2021; Wyman, 2018). Developing the new set of skills, knowledge and abilities needed for the 4IR represents the greatest challenge for the automotive manufacturing industry in recognising the opportunities arising from this transformation (Madsen et al., 2016; Thames & Schaefer, 2016). Furthermore, employees' traditional capabilities, such as communication, critical thinking and technical, personal, collaborative and negotiation skills (World Economic Forum, 2018), will need to be aligned with the new digital production systems.

In the South African automotive manufacturing industry, automating repetitive tasks is detrimental to current employees' employability (Gastrow, 2019). To address the risk, employees in this industry are expected to increase their capabilities, knowledge and expertise to adapt to digital manufacturing systems in the 4IR (Gillwald, 2021; Hufkie, 2021). However, assembly employees lack 4IR capabilities to effectively respond to technological advancements in digital manufacturing systems (Chaka, 2020). To bridge this gap, the capability approach (CA) can be considered.

CA, familiarised by Sen, consists of three key elements, namely: functionings, capabilities and freedom (Sen, 1993). Functionings represent various things that individuals can *do* or *be* in leading their lives (Sen, 1993); values are paramount (Van der Klink et al., 2016). Capabilities denote the combination of functionings that individuals can achieve, or choose from (Sen, 1993). Freedom has a dual meaning, because it relates to the possibility of crafting one's life and environment (process) as well as accomplishing cherished goals (opportunity) (Sen, 2009). The CA offers a framework where values complement work and employability functionings (Sen, 1983). Central to the concept of capability is that individuals can realise the *doings* and *beings* they value (Sen, 1980). Capabilities include all the personal resources (i.e., skills, knowledge, behaviours and attitudes), material resources (such as tools, machines and computers), physical resources (appropriate workplaces) and social environment resources (e.g., training and support) (Sen, 1980; Van der Klink et al., 2016). Therefore, the crux of the capability concept is (a) being able to, (b) having opportunities and (c) being facilitated and allowed to (Van der Klink et al., 2016). Being able and enabled ensures valuable work outcomes, such as work functioning, work performance, workability and the number of hours worked, which are important for sustainable employability (Abma et al., 2016; Van der Klink et al., 2016). Two types of capabilities are distinguished, namely: innate and developed (Deloitte, 2022). The CA was employed as the theoretical framework for this research project and served to understand the capabilities (being able) and talent development (having opportunities and being facilitated and allowed) required for the 4IR in a South African automotive manufacturing organisation.

A survey among chief information officers, conducted by Klynveld et al. (KPMG, 2018), found that employees' current capabilities were inadequate for the 4IR in the South African manufacturing industry. Specifically, the survey indicated that 65% of employees in the South African manufacturing industry lacked the relevant capabilities to adapt to 4IR technological innovations (KPMG, 2018). Alarmingly, Deloitte found that the paucity of relevant digital capabilities of employees in the South African automotive industry required urgent talent development attention for adaptation to the 4IR (Deloitte, 2019).

There is substantial literature on the impact of the 4IR on South Africa (Chigbu & Nekhwevha, 2021; Pasara, 2020; Sutherland, 2020). Much of the research focuses on the significant effect of the 4IR

on unemployment rates (Hufkie, 2021; Maisiri & Van Dyk, 2021; Rapanyane & Sethole, 2020). To mention but a few, Bianca et al. (2020) primarily examined the substantial productivity benefits of job automation in South Africa's automotive industry. The study by Kapp (2018) explored human intelligence in this industry; however, it did not examine the capabilities employees would need to develop to meet the demands of the 4IR.

Nevertheless, a report commissioned by the Department of Trade and Industry (DTI) acknowledges that the South African automotive manufacturing industry is lagging behind its competitors in technological skills development (Barnes et al., 2018). This finding is supported by Ansara and Davids (2018). According to the DTI report, the local automotive industry needs a significant shift in both the number of employees and their skills, particularly among black South Africans, if the goals of the South African automotive industry masterplan to 2035 are to be achieved. Therefore, it is vital to develop a technology and skills roadmap to ensure a continuous supply of relevant capabilities (Ansara & Davids, 2018; Barnes et al., 2018; Lorenz et al., 2019). However, the specific capabilities required are not clearly defined. Studies focusing on the development of employee capabilities in the South African automotive manufacturing industry are limited (Butler-Adam, 2018; Carbonero et al., 2020; Chaka, 2020). A summary of available South African studies is provided below.

There is a reported lack of evidence regarding employees' new digital capabilities, which are necessary to adapt to 4IR applications and foster innovation as a driver of economic success in the South African automotive manufacturing industry (Cave & Dihal, 2019; Cirera & Maloney, 2017). However, achieving manufacturing goals may be challenging due to employees' limited range of 4IR skills within this industry (Gleason, 2018). Studies emphasise the importance of developing and integrating employees' digital knowledge and abilities (Cirera & Maloney, 2017; Deloitte, 2019; Hufkie, 2021). Such reskilling will support smooth coordination and adaptation to the rapid technological changes brought about by the 4IR in South African automotive manufacturing (Cirera & Maloney, 2017). Consequently, there is a clear need for South African research to focus specifically on the capabilities required by employees to bridge this gap and effectively adapt to the 4IR in this industry (Gleason, 2018).

The 4IR commenced during the 21st century and represents smart organisations and smart industries characterised by technological advancements (Anshari & Almunawar, 2021; Olutoyin et al., 2021; Sinxadi et al., 2021). The 4IR is defined as the cooperative interrelation between analogue manufacturing and the digital environment that reconsiders the total manufacturing process and includes a cyber-physical production system (CPPS) characterised by an interface of computer and human systems (Wolter et al., 2015). Afrianto (2018) further defines the 4IR as a CPPS in which interconnected processes of digital machines, AI, information and communication technology (ICT), intelligent networks, IoT, augmented reality and virtual reality interrelate and interact. Moreover,

Schwab (2018) defines the 4IR as the convergence of different digitalisation, physical and biotic technological systems that have transformed how we do things, manufacture and interrelate. The 4IR is at the heart of the automotive manufacturing industry, driving digital transformation and innovative operations and procedures (Chigbu & Nekhwevha, 2020). These 4IR technological innovations require the automotive manufacturing industry to ensure effective human-robot collaboration (Chigbu & Nekhwevha, 2020).

From the above definitions of the 4IR, the operational definition can be formulated and summarised as follows: The 4IR is the interface between humans and smart machines (humans to machines “H-to-M” and machines to humans “M-to-H”) (Rouse, 2016) that operates within the digital manufacturing industry and comprises various technological interfaces (Nardo et al., 2020).

It remains unclear how the 4IR technological innovations and transformations will alter people's lives and the world of work (Schwab, 2016). There is concern about what job profiles and job descriptions will look like and the kinds of capabilities employees will need (Schwab, 2016). Many manufacturing organisations still lack clarity about these issues as they grapple with understanding the integration of the components of this revolution, such as the IoT (Schwab, 2016). Therefore, the main challenge for the manufacturing industry is to redesign employee capabilities while simultaneously facing the uncertainty of how the rapid evolution of the 4IR will unfold (Cerika & Maksumic, 2017).

The new technological trends associated with the 4IR now serve as a strategic layer across all facets of manufacturing organisations (Ajayi & Laseinde, 2023). These trends generate numerous technological innovations within organisations aimed at improving productivity, service delivery, and transformation (Whysall et al., 2019; Wolter et al., 2015). However, the technological innovations negatively impact the manufacturing industry by creating a demand for a new set of employee capabilities to fully adapt to the 4IR (Whysall et al., 2019; Wolter et al., 2015).

In his 2018 State of the Nation Address, the President of South Africa, Mr Cyril Ramaphosa (2018a), highlighted the uncertainties that the 4IR would cause for both private and public industries and the consequences, like employee capability mismatches and potentially high unemployment rates for repetitive tasks. Mr Ramaphosa further stated that South Africa was experiencing challenges and occasional difficulties in implementing industrial policies, which might lead to significant delays in the country's full adaptation to the 4IR (Ramaphosa, 2018b). The production industries and the World Economic Forum (WEF) engaged in campaigning to persuade countries to alter their current economic policies to embrace the 4IR (Nagtegaal, 2020; Sutherland, 2020). This was aimed at helping countries like South Africa mitigate unfavourable socio-economic consequences, such as employee redundancies due to the lack of capabilities required for the 4IR (Nagtegaal, 2020; Sutherland, 2020). It would address issues such as unemployment, difficulties in acquiring relevant

skills, and access to education (Sutherland, 2020). Benioff (2017) agrees with Nagtegaal (2020) and Sutherland (2020) that the impacts of the 4IR will affect employees, particularly regarding the need for new capabilities to adapt to significant organisational changes and uncertainties.

These socio-economic consequences are a major concern for countries like South Africa, which is currently struggling with high unemployment rates (Stats SA, 2025b). In South Africa, the unemployment rate in the third quarter of 2025 was 31.9% (Stats SA, 2025b). Studies conducted by the Industrial Development Corporation (2023), Nagtegaal (2020) and Olaitan et al. (2021) found that South Africa's readiness to adopt the 4IR was limited, due to its economic challenges and inconsistent policies on implementation procedures. The lack of skilled workers, the rising unemployment and the inadequate technological infrastructure were identified as significant barriers to the adoption of the 4IR in South Africa (Industrial Development Corporation, 2023; Nagtegaal, 2020; Olaitan et al., 2021). Without investing in employee training to develop relevant skills, any plans for the 4IR in South Africa are likely to remain theoretical rather than driven by action (Industrial Development Corporation, 2023; Nagtegaal, 2020). Currently, South Africa remains rooted in traditional agriculture, mining, and the relatively relaxed manufacturing sector, while facing extreme unemployment. A large proportion of the population lacks new digital skills and often even basic skills (Schwab, 2017a). While South Africa is part of BRICS (Brazil, Russia, India, China and South Africa), careful comparison with the other major developing economies shows that its readiness and capacity to adapt to the 4IR is questionable (Schwab, 2017b).

In a study conducted by Deloitte (2015), 16 representatives from the Council for Scientific and Industrial Research (CSIR), Meraka Institute, Department of Science and Technology, Industrial Development Corporation (IDC) and Manufacturing Circle, as well as executives from Bigen Africa, Ford, Hualamin, Nampak, Nissan, Toyota South Africa and other manufacturing companies, were interviewed (Deloitte, 2015, p. 17). It found that the most significant issue in Africa, and particularly in South Africa, was connectivity and access to technological innovations (Deloitte, 2015). It also highlighted a lack of basic digital and ICT skills that left South Africa unprepared for the adoption of the 4IR (Deloitte, 2015). Additional challenges were employees' lack of digital skills, knowledge and abilities in both the private and public sectors (Deloitte, 2015). This skills gap can be addressed by developing existing talent within the South African automotive industry.

Talent development is described as a broad framework that supports the evolution of employees from traditional manufacturing roles to improvement initiatives (Benham, 1993). It is defined as the process of selecting and implementing an advanced approach for the entire talent pool in the manufacturing industry (Garavan et al., 2012). This aims to ensure that the industry has the current and future talent needed to achieve key goals, while developmental projects align with the industry's talent development procedures (Garavan et al., 2012). Alternatively, talent development also refers

to a process involving continuous formal and informal training in various areas, with highly dedicated efforts (Dai & Speerschneider, 2012). This is intentional for operational improvement, expanded problem-solving, and employee development, following the new set of capabilities required to perform innovative tasks (Dai & Speerschneider, 2012).

Panda and Sahoo (2015, p. 16) argue that talent development is considered “a planned acquisition, development, retention, engagement and deployment of talent in an organization”. Moreover, Gagné (2004) defines talent development from an employee perspective as an active procedure in which the old capabilities are developed into talents that are suitable and compulsory for specific operational requirements. Gagne (2004) adds that talent development is a process in which the advancement of employees' capabilities is achieved through on-the-job training and informal training.

From the above definitions, the operational definition of talent development can be formulated and summarised as follows: A process in which organisations focus on specific operational requirements of an area of capabilities with an attempt to transform and develop employees' capabilities to meet these requirements (Dai & Speerschneider, 2012).

Talent development in the automotive manufacturing industry is seen as an essential process where employees must enhance their digital skills to keep up with the digitalisation of the 4IR (Lorenz & Kraemer-Mbula, 2021). Similarly, talent development here is described as training programmes aimed at improving employees' digital skills, as they are affected by the ongoing digitalisation of the 4IR (Mazurchenko & Zelenka, 2022). Furthermore, talent development in the automotive manufacturing sector is recognised as a key factor in successfully adapting to the technological innovations of the 4IR (Cusano & Starrs, 2017; Chigbu & Nekhwevha, 2020).

Technological innovations significantly influence employees' talent development programmes due to the high demand for new 4IR capabilities in the automotive manufacturing industry (Mazurchenko & Zelenka, 2022). Most previous research on talent development focused on the impact of technological innovations on the productivity of manufacturing operations systems (Craveiro et al., 2019; Oesterreich & Teuteberg, 2016) and the technological transformation landscape (Garcia de Soto et al., 2019) within some manufacturing industries. However, limited research has been conducted on developing employees' capabilities to adapt to the disruptive technological advancements of the 4IR in the automotive industry (Hernandez-de-Menendez et al., 2020).

A significant digital skills gap among automotive manufacturing employees has developed, along with a lack of understanding of the benefits of 4IR technological innovations (Hernandez-de-Menendez et al., 2020). The skills gap and failure to appreciate the advantages of upskilling pose a

risk to the success of the automotive manufacturing industry and are reflected in the limited focus on talent development strategies within the sector (Soukupova et al., 2020).

The 4IR has started to impact the South African automotive manufacturing industry through a significant shift in employees' skills, competencies and knowledge due to digitalisation (Lorenz et al., 2019). Employees' traditional skills are becoming obsolete and developing new capabilities is essential for digital production in the local industry (Ansara & Davids, 2018). The emergence of 4IR technological innovations and their applications, such as robots, smart machines and AI, requires well-organised and adapted plant structures and arrangements in the South African automotive manufacturing industry (Lorenz et al., 2019). These changes involve not only upgrading technical and smart machines but also improving employees' ability to adapt to 4IR technological innovations (Ansara & Davids, 2018; Lorenz et al., 2019).

The technological upskilling and capabilities development for the 4IR constitute a significant challenge for the South African automotive manufacturing industry (Barnes et al., 2018; Olutoyin, 2020). The difficulty arises from the strong technological influence of multinational corporations and original equipment manufacturers (Barnes et al., 2018; Olutoyin, 2020). Talent development strategies are essential for the South African automotive industry to enhance employee skills and align them with 4IR technological innovations (Dahlan et al., 2020). However, such strategies may be affected by the rapid pace of 4IR innovations (Cerika & Maksumic, 2017) and the difficulty of retaining talented employees (Madsen et al., 2016; Stock-Homburg, 2013; Wolter et al., 2015).

The P-CMM guides organisations in managing and developing employees (Mahdavi et al., 2020). The P-CMM categorises the maturity of workforce practices, provides an agenda for continuous employee development, prioritises actions for improvement, integrates employee development with process enhancement, and creates a culture of excellence (Curtis et al., 2009; Türetken & Demirörs, 2004). The P-CMM was used in this research project to map the capabilities and talent development strategies required in the automotive organisation under study. Five maturity levels are delineated in the P-CMM (Surega, 2019). These maturity levels, outlined by Curtis et al. (2009), are succinctly described below:

The Initial Level: Maturity Level 1

Level 1 is characterised by a talent shortage, where neither employees nor managers take responsibility for skills development.

The Managed Level: Maturity Level 2

At Level 2, the organisation frequently fails at widespread improvement initiatives. Managers often lack the skills required to execute complex practices.

The Defined Level: Maturity Level 3

Level 3 is characterised by missed opportunities to standardise workforce practices because mutual knowledge and skills for performing business activities are not identified. However, an organisation-wide competency framework is being developed for the workforce.

The Predictable Level: Maturity Level 4

At Level 4, the organisation manages and utilises the capability established by the workforce capability framework. Additionally, the most critical competencies for organisational success are measured quantitatively. Furthermore, baselines are set for essential competency-based processes.

The Optimising Level: Maturity Level 5

Maturity Level 5 signifies a collective emphasis on ongoing organisational enhancement. These improvements target the skills of individuals and workgroups, focusing on competency-based processes. At Level 5, change management is regarded as a standard business practice that should be executed systematically and reliably.

From the contextualisation above, the problem that guided the research project is summarised in the following statement:

In practice and in the literature, there is a lack of understanding of assembly employees' capabilities and the talent development required for the 4IR in a South African automotive manufacturing organisation. Furthermore, it is unclear how a P-CMM could be designed for these employees within such an organisation.

1.2 Research questions

Based on the contextualisation and problem statement, the following research questions were formulated:

Research Article 1: *Exploring the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation.*

- How are capabilities, the 4IR, and capabilities required for the 4IR in the automotive manufacturing industry conceptualised according to the literature?
- What are the perceptions of assembly employees regarding the skills and knowledge required for the 4IR in a South African automotive manufacturing organisation?

- What are the perceptions of assembly employees regarding the behaviours required for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of assembly employees regarding the attitudes required for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of assembly employees regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of assembly employees regarding training and other opportunities required for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of assembly employees regarding the support required for the 4IR in a South African automotive manufacturing organisation?
- What are recommendations for future research and practice?

Research Article 2: *Exploring line managers' perceptions regarding assembly employee capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation.*

- How are talent development and in particular talent development within the automotive manufacturing industry conceptualised according to the literature?
- What are the perceptions of line managers regarding the skills and knowledge required by assembly employees for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of line managers regarding the behaviours required by assembly employees for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of line managers regarding the attitudes required by assembly employees for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of line managers regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of line managers regarding training and other opportunities required by assembly employees for the 4IR in a South African automotive manufacturing organisation?
- What are the perceptions of line managers regarding the support required by assembly employees for the 4IR in a South African automotive manufacturing organisation?
- What are recommendations for future research and practice?

Research Article 3: *Developing and evaluating a People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation.*

- How is a P-CMM conceptualised according to the literature?

- What are the 4IR capabilities for automotive assembly employees at the P-CMM Initial Level: Maturity Level 1?
- What are the 4IR capabilities for automotive assembly employees at the P-CMM Managed Level: Maturity Level 2?
- What are the 4IR capabilities for automotive assembly employees at the P-CMM Defined Level: Maturity Level 3?
- What are the 4IR capabilities for automotive assembly employees at the P-CMM Predictable Level: Maturity Level 4?
- What are the 4IR capabilities for automotive assembly employees at the P-CMM Optimising Level: Maturity Level 5?
- How would a panel of talent development experts evaluate a People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation, and what recommendations can they make?
- What recommendations can be made for future research and practice?

1.3 Research objectives

Based on the research questions, the following general and specific research objectives were established.

Research Article 1: *Exploring the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation.*

General objective

The objective of this study was to explore the required capabilities of assembly employees in a South African automotive manufacturing organisation in light of the Fourth Industrial Revolution. To achieve this general objective, the following specific objectives were set:

Specific objectives

- To conceptualise capabilities, the 4IR, and capabilities required for the 4IR in the automotive manufacturing industry according to the literature.
- To explore the perceptions of assembly employees regarding the skills and knowledge required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding the behaviours required for the 4IR in a South African automotive manufacturing organisation.

- To explore the perceptions of assembly employees regarding the attitudes required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding training and other opportunities required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding the support required for the 4IR in a South African automotive manufacturing organisation.
- To make recommendations for future research and practice.

Research Article 2: *Exploring line managers' perceptions regarding assembly employees' capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation.*

General objective

The objective of this study was to explore line managers' perceptions of assembly employees' capabilities and the talent development required for the 4IR in a South African automotive manufacturing organisation. To achieve this general objective, the following specific objectives were set:

Specific objectives

- To conceptualise talent development and in particular talent development within the automotive manufacturing industry according to the literature.
- To explore the perceptions of line managers regarding the skills and knowledge required by assembly employees for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of line managers regarding the behaviours required by assembly employees for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of line managers regarding the attitudes required by assembly employees for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of line managers regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of line managers regarding training and other opportunities required by assembly employees for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of line managers regarding the support required by assembly employees for the 4IR in a South African automotive manufacturing organisation.
- To make recommendations for future research and practice.

Research Article 3: *Developing and evaluating a People Capability Maturity Model of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation.*

General objective

The objective of this study was to develop and evaluate a P-CMM of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation. To reach this general objective, the following specific objectives were articulated:

Specific objectives

- To conceptualise a P-CMM according to the literature.
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Initial Level: Maturity Level 1
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Managed Level: Maturity Level 2
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Defined Level: Maturity Level 3
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Predictable Level: Maturity Level 4
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Optimising Level: Maturity Level 5
- To obtain, from a panel of talent development experts, an evaluation of the People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation and recommendations in this regard.
- To make recommendations for future research and practice.

1.4 Research methodology

1.4.1 Research approach

Research articles 1, 2 and 3

Research methodology refers to the process that the researcher follows to achieve the study's objectives. This process includes selecting the research approach, study subjects, inquiry plan to be followed, and data collection and analysis methods (Babchuk, 2019; Creswell & Báez, 2020). Studies

on the 4IR in South Africa have not paid much attention to the capabilities necessary for assembly employees to adapt to the 4IR within the automotive manufacturing industry. This calls for research with a greater emphasis on employees' and line managers' perceptions of the capabilities required for the 4IR and how talent development can support adaptation to 4IR technological innovations in the automotive industry.

To address this, a qualitative research approach was adopted for this project. Qualitative research begins with propositions and a collection of interpretive or theoretical frameworks that illuminate the research problems and explore the meanings that individuals or groups attribute to social or human issues (Creswell, 2021; Kyngäs, 2019). Qualitative research contributes to the development of theories through real-life exploration and investigation, aiming to gain a broader understanding of the phenomenon under study (Creswell & Báez, 2020). Furthermore, qualitative research is conducted within a specific context, relies on the researcher to collect data, employs various methods, and focuses on participants' points of view, meanings, and insights; it is also considerate and interpretive (Creswell, 2021; Harrison et al., 2020).

The researcher chose a qualitative research approach because it could uncover current perceptions of the required capabilities of assembly employees for the 4IR in an automotive manufacturing organisation. During this research project, the qualitative approach enabled conversations with participants to determine their understanding and perceptions of the required capabilities of assembly employees and of collective talent development for the 4IR.

There are, however, certain disadvantages to using the qualitative research approach; for instance, the study findings are not verifiable in an impartial manner (Kyngäs, 2020; Mayer, 2015; Rahman, 2020). An additional drawback of qualitative data collection is that it requires a significant amount of time and is labour-intensive; manual tasks, such as transcribing interview responses, are expensive. However, the qualitative research approach establishes an interaction between the literature and the data, which helps achieve representativeness across a broader range of situations (Babchuk, 2019; Rallis & Rossman, 2012).

1.5 Research paradigm

Research articles 1, 2 and 3

Constructivism served as the research paradigm in this project. Constructivism suggests that an individual's reality is socially constructed (Aliyu et al., 2014; Kumatongo & Muzata, 2021). The researcher selected the constructivist research paradigm because it enables the generation of qualitative data (Creswell, 2021).

The ontological assumptions (nature of reality) of constructivism assert that multiple realities exist and that reality is socially constructed (Chilisa & Kawulich, 2012). The researcher collected data from assembly employees, line managers, and learning and development experts when developing the P-CMM in the South African automotive manufacturing industry.

The epistemological assumptions of the constructivist paradigm are as follows: (a) knowledge is created through exploring and understanding the meanings individuals assign to phenomena and how they interpret them; (b) researchers develop their interpretations based on the meanings generated by the people they study; (c) interpretation is primarily inductive, as it requires analysing the collected data; (d) a completely objective study is impossible because the research process inevitably influences subjectivity, making it challenging to separate truths and principles; (e) social research is governed by individual meanings and measures rather than by natural laws; (f) it is impossible to fully capture or accurately analyse social reality since broader perspectives and understandings often differ (Ormston et al., 2014).

The researcher examined the perceptions of assembly employees and line managers regarding the capabilities and talent development needed for the 4IR. Furthermore, line managers and learning and development experts were asked about their understanding of the five levels of the P-CMM within an automotive manufacturing organisation in South Africa. The meanings these individuals attributed to the five maturity levels and how these levels related to the 4IR capabilities required of the participants to contribute to the creation of new knowledge were explored.

1.6 Research designs

1.6.1 Literature review design

The literature review is described as a well-organised procedure of reviewing and evaluating the present body of knowledge about the subject under study (Collins & Hussey, 2014; Guetterman et al., 2019).

The following academic sources were consulted when conducting the literature reviews: Emerald, Google Scholar, Ebsco Host, ProQuest, SAe Publications, Science Direct and Host. The sources reviewed in this research project comprised published academic articles, books, reviews, dissertations and theses, monographs, government and private-sector reports, abstracts, surveys, diverse research reports, and authentic computerised media information. Moreover, scientific research articles published in accredited, double-blind journals were used. Examples of such journals include the following: *South African Journal of Human Resource Management (SAJHRM)*,

South African Journal of Information Management (SAJIM), *African Journal of Science, Technology, Innovation and Development (AJSTID)*, *International Journal of Human Resource Management (IJHRM)*, *Journal of Strategic Human Resource Management (JSHRM)*, *International Journal of Business and Management (IJBm)*, *Journal of Management Development Review (JMDR)*, *Journal of People Management (JPM)* and *Journal of Management Studies and Inquiry (JMSI)*. The search for published scientific research articles which were mainly utilised covered the period between 2011 and 2022.

1.6.2 Qualitative empirical design

Research articles 1, 2 and 3

This research project employed a qualitative descriptive design due to its suitability for research that aims to collect data directly from the individuals who are encountering the phenomenon under exploration in circumstances where time and resources are restricted (Hu et al., 2020; Neergaard et al., 2009; Siedlecki, 2020). The objective of the qualitative descriptive design is to provide a broad summary of the daily conditions and specific circumstances encountered by people or teams (Lambert & Lambert, 2012; Siedlecki, 2020). Qualitative descriptive design is a beneficial approach and useful technique on its own, without the support of ethnography, phenomenology, or grounded theory (Lambert & Lambert, 2012).

The qualitative description design is an inductive procedure that delineates the phenomenon under exploration and can also build on participants' understanding and perceptions (Saunders et al., 2019; Sullivan-Bolyai et al., 2005). The qualitative descriptive design is subjective (Goh et al., 2021; Sullivan-Bolyai et al., 2005), as assembly employees and line managers may hold different perspectives on the capabilities required for the 4IR in the automotive manufacturing industry. The qualitative research design, as it is subjective, also acknowledges the researcher's experience and not only the participants' experiences (Saunders et al., 2019; Sullivan-Bolyai et al., 2005).

The investigator selected the qualitative descriptive design because it made it possible to be enthusiastic throughout the study process (Saunders et al., 2023; Sullivan-Bolyai et al., 2005). This approach also permitted the investigator to engage with the 4IR phenomenon under investigation through direct communication with participants while observing their behaviour (Saunders et al., 2023; Sullivan-Bolyai et al., 2005). The qualitative descriptive design was suitable for this study due to its emic perspective, acknowledging influence by the researcher despite its inherent subjectivity, particularly during interpretation (Hu et al., 2020; Sullivan-Bolyai et al., 2005). It was considered appropriate, as the study was conducted in a natural environment with assembly employees and line managers experiencing the 4IR phenomenon (Saunders et al., 2019; Siedlecki, 2020; Sullivan-

Bolyai et al., 2005). The investigator chose this design to explore and understand the 4IR phenomenon, including the procedures, viewpoints and perceptions of the assembly workers and line managers involved (Caelli et al., 2003; Merriam, 1998; Saunders et al., 2023).

1.6.3 Research context

The study was conducted at a large automotive manufacturing organisation in South Africa. To protect the anonymity of the organisation, the province in which the manufacturing operations are located is not mentioned. The organisation has a number of plants which assemble passenger and commercial vehicles for the local and export markets.

Data were collected on the premises of the automotive organisation, during daytime and in an office where interviews could be conducted confidentially and without interruptions. The privacy provided by the office was conducive to candid discussion in a relaxed atmosphere.

1.6.4 Participants

Research article 1

The criteria employed to select knowledgeable assembly employees for participation in this study are outlined below. The inclusion criteria pertained to employees who:

- Had been tasked with the assembly of automotive vehicles for at least twelve concurrent months
- Could understand and speak English
- Were willing and able to participate in this study.

The exclusion criteria pertained to employees who:

- Did not assemble vehicles on the assembly line
- Had been appointed to the position for less than 12 months
- Were not willing or able to participate in the study.

Research articles 2 and 3

Line managers in an automotive manufacturing organisation in South Africa were the target population for these two research articles. The inclusion criteria were line managers who:

- Managed automotive vehicle assembly employees
- Had been appointed to the position for at least 12 months
- Were assembly line operations managers
- Were assembly production and quality manufacturing engineering line managers.

The exclusion criteria for participation in this study were line managers who:

- Did not currently manage assembly employees
- Had been appointed to the position for less than 12 months
- Worked in machine and fabrication plants
- Worked in paint and finishing plants.

The participants for the evaluation of a P-CMM were the talent development experts and members of the advisory board. Inclusion criteria for the talent development experts and advisory board were the senior managers and/or managers:

- In human resources, production/operations, learning and development and talent management at an automotive manufacturing organisation
- Who had been appointed to the position for at least 12 months.

Exclusion criteria were managers who:

- Had been appointed to the position for less than 12 months.

1.6.5 Procedure

Research articles 1, 2 and 3

The investigator requested permission from the decision-making authority at the South African automotive manufacturing organisation to conduct research at the organisation. The application was accompanied by the North-West University Economic and Management Sciences Research Ethics Committee (NWU-EMS-REC) clearance certificate. Upon receipt of permission, the researcher requested the email address of a coordinator who was able to distribute information to potential participants on behalf of the researcher. This information included a consent form, demographic questionnaire and list of interview questions. The distributed information assisted the potential participants to make an informed decision regarding participation in the study.

The coordinator made appointments with the assembly employees, line managers, talent development experts and advisory board for individual face-to-face interviews with the researcher. The coordinator obtained the participants' permission to participate in the interviews through the informed consent form.

Before conducting interviews, the investigator explained the ethical considerations to the participants. The participants were given the chance to ask questions. Interviews were recorded with the participants' permission, as explained in the consent form. The research questions were provided to the participants in advance to give them sufficient time to prepare for the interviews.

1.6.6 Data collection methods

Research Articles 1, 2 and 3

In the study, individual face-to-face, open-ended, semi-structured interviews were utilised as they allowed new thoughts, perceptions and beliefs to be conveyed throughout the interview process (Seabi et al., 2021). Saunders et al. (2016) state that the investigator should ask short and clear questions. The structured interview has a strict, fixed question structure and does not permit the investigator to deviate from the protocol. In contrast, individual open-ended semi-structured interviews are guided by a few preselected questions, allowing further probing and exploration during the interview (Rugg & Petre, 2007; Seabi et al., 2021).

The individual open-ended, semi-structured interviews were conducted with approximately twenty (20) to twenty-five (25) assembly employees, ten (10) to fifteen (15) line managers and seven (7) to ten (10) talent development experts and members of an advisory board in the South African automotive manufacturing organisation. The individual interviews took approximately 20-30 minutes (research article 1), 45-60 minutes (research articles 2 and 3) and 20-30 minutes (research article 3 for evaluation of P-CMM) and were conducted at a time most convenient to the participant.

The participants were chosen utilising a non-probability purposive sampling technique. The purposive sampling helped the investigator to identify specific participants of interest and sample those who were best suited to the requirements of the study (Lamm & Lamm, 2019; Tansey, 2007).

For the evaluation, data were collected through qualitative surveys with open-ended questions, enabling talent development experts to provide detailed, nuanced responses in their assessment of the developed People Capability Maturity Model. A qualitative survey is a data collection method that employs open-ended questions to gather detailed, written responses from participants (Braun et al., 2021). The advantages of qualitative surveys are that they give participants the opportunity to express their opinions thoughtfully, reducing the likelihood of interviewer influence or answer bias (McCombie et al., 2024; Povee & Roberts, 2013).

The qualitative survey took approximately 20-30 minutes to complete and was done at a time most convenient to the participant.

Interview guides

Research article 1: *Exploring the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation*

The researcher introduced the interview sessions by saying: “Thank you for providing me with this opportunity to ask you a few questions. Before I start with the questions, I want to read you a short statement. Please think about this statement for a moment. My questions will be based on this statement”.

Statement:

Technology is advancing very fast. Building cars is getting more and more complex. In the future, new skills and knowledge might be required to build modern cars. This might also have an influence on the behaviours and attitudes of people who need to build these cars.

Interview questions for assembly employees:

1. In your opinion, please describe the **skills**, if any, that you will need to do your job well in the next five to ten years.
2. In your opinion, please describe the **knowledge**, if any, that you will need to do your job well in the next five to ten years.
3. In your opinion, please describe the **behaviours** if any, that you will need to do your job well in the next five to ten years.
4. In your opinion, please describe the **attitudes**, if any, that you will need to do your job well in the next five to ten years.
5. In your opinion, please indicate what **tools, machines, computers, etc.**, if any, you will need to do your job well in the next five to ten years.
6. In your opinion, will your **physical workplace** have to change in the next five to ten years, so that you will be able to do your job well? Please motivate your answer.
7. In your opinion, what **training**, if any, will you need to do your job well in the next five to ten years?
8. In your opinion, what **opportunities**, if any, will you need to do your job well in the next five to ten years?
9. In your opinion, what **support**, if any, will you need to do your job well in the next five to ten years?

Research article 2: *Exploring the perceptions of line managers regarding assembly employee capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation*

The researcher introduced the interview sessions by saying: “Thank you for providing me with this opportunity to ask you a few questions. Before I start with the questions, I want to read you a short statement. Please think about this statement for a moment. My questions will be based on this statement”.

Statement:

Technology is advancing very fast. Building cars is getting more and more complex. In the future, new skills and knowledge might be required to build modern cars. This might also have an influence on the behaviours and attitudes of people who need to build these cars.

Interview questions for line managers

1. In your opinion, please describe the **skills**, if any, that assembly employees will need in the next five to ten years.
2. In your opinion, please describe the **knowledge**, if any, that assembly employees will need in the next five to ten years.
3. In your opinion, please describe the **behaviours**, if any, that assembly employees will need in the next five to ten years.
4. In your opinion, please describe the **attitudes**, if any, that assembly employees will need in the next five to ten years.
5. In your opinion, please indicate what **equipment** (tools, machines, computers, etc.), if any, assembly employees will need in the next five to ten years.
6. In your opinion, will the **physical workplace** have to change in the next five to ten years, so that assembly employees will be able to do their job well? Please motivate your answer.
7. In your opinion, what **training**, if any, will assembly employees require to remain employable in the next five to ten years?
8. In your opinion, what **opportunities**, if any, will assembly employees require to remain employable in the next five to ten years?
9. In your opinion, what **support**, if any, will assembly employees require to remain employable in the next five to ten years?

Research Article 3: *Developing and evaluating a People Capability Maturity Model of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation*

The researcher introduced the interview sessions by saying: “Thank you for providing me with this opportunity to ask you a few questions. I will begin by reading a short statement. I will also read you

a short statement before each question. Please think about the statement before answering the question”.

Statements:

The People Capability Maturity Model (P-CMM) comprises 5 levels, namely: Initial, Managed, Defined, Predictable and Optimising.

The Initial Level: Maturity Level 1

Level 1 is characterised by a **talent shortage** where **neither employees nor managers take responsibility for skills development**.

Interview question 1

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the **Initial Level** (Level 1) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

The Managed Level: Maturity Level 2

At Level 2, the organisation **frequently fails** at widespread **improvement initiatives**. Managers often **lack the skills** required to execute complex practices.

Interview question 2

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the **Managed Level** (Level 2) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

The Defined Level: Maturity Level 3

Level 3 is typified by **missed opportunities to standardise workforce practices** because **mutual knowledge and skills** to perform business activities **are not identified**. **However, an organisation-wide competency framework is being built for the workforce**.

Interview question 3

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the **Defined Level** (Level 3) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

The Predictable Level: Maturity Level 4

At Level 4 the organisation **manages and utilises** the capability established by the workforce capability framework. In addition, the competencies that are **most critical** for organisational success

are **measured quantitatively**. Moreover, **baselines are established for critical competency-based processes**.

Interview question 4

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the **Predictable Level** (Level 4) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

The Optimising Level: Maturity Level 5

Maturity Level 5 denotes a **collective focus on constant organisational improvement**. Such improvements are made to the capabilities of **individuals and workgroups and to competency-based processes**. At Level 5, **change management is viewed as a normal business process that should be performed systematically and consistently**.

Interview question 5

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the **Optimising Level** (Level 5) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

Interview question 6

What is the **current 4IR capability level** of assembly employees in **this** South African automotive manufacturing organisation?

Qualitative survey questions for talent development experts and the advisory board

1. What **recommendations** can you make regarding a People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?
2. What **observations** can you make about a People Capability Maturity Model regarding its potential to impact **policy** in a South African automotive organisation? Please motivate your answer.
3. What **observations** can you make about a People Capability Maturity Model regarding its potential to impact **process** in a South African automotive organisation? Please motivate your answer.
4. What **observations** can you make about a People Capability Maturity Model regarding its potential to impact **decision-making** in a South African automotive organisation? Please motivate your answer.

Demographic questionnaires were used to describe the characteristics of the participants. For assembly employees (research article 1) the following demographic information was requested: Age, gender, ethnicity, and tenure. The demographic information of line managers (research articles 2 and 3) comprised the following categories: Age, gender, ethnicity, and tenure. Talent development experts and members of the advisory board's demographic information (research article 3) consisted of the following elements: Age, gender, ethnicity, and tenure. This demographic information was required to accurately describe the characteristics of the sample. Please note that the designations for ethnicity were used in line with the terminology of the Employment Equity Act, 55 of 1998, for designated and non-designated groups. No offence is intended.

1.6.7 Data analysis

Research articles 1, 2 and 3

Qualitative data analysis involves the procedure of arranging and transcribing gathered information into content transcripts for critical analysis and reducing it to themes by processing and categorising codes (Babchuck, 2019). Creswell (2021) concurs with Babchuk (2019) that data analysis within a qualitative study includes arranging and preparing the collected data for analysis, subsequently coding it into themes, and finally interpreting it and reporting it by means of frames or structures.

Thematic analysis was utilised to categorise the raw data into codes and subsequently refining it into semantic themes. Boyatzis (1998) explains thematic analysis as a technique that identifies, analyses and reports themes, and interprets the diverse characteristics of the phenomenon under study. The thematic analysis differs from other analytical techniques that seek to report patterns in qualitative data, as it is not theoretically limited (Smith et al., 1999; Smith & Osborn, 2003). In the present study, the intention was not to generalise the findings but to ensure that it was representative of the participants' perspectives.

Thematic analysis is the procedure for determining and evaluating designs or themes that are formed within the data, as well as interpreting contrasting characteristics of the phenomenon being explored (Braun & Clarke, 2016). This thematic analysis procedure allows investigators to maintain participants' unaltered responses throughout data analysis. The data are thus not divided into contrasting segments for the aim of choosing theoretical features (as suggested by Guest et al., 2012).

In the present study, the investigator adopted the following data analysis process as determined by Creswell (2014):

Step 1. Organising, categorising and preparing data for analysis. This step included the verbatim transcription of the recorded individual open-ended semi-structured interviews. Thereafter, the data were classified in accordance with the research objectives of the articles.

Step 2. Reading the entire dataset and familiarising oneself with the data to obtain a common feeling thereof and reflecting on its broader meaning. The investigator repeatedly scrutinised and reviewed the entire dataset and familiarised himself with the contents and meaning of what had been said.

Step 3. Coding and analysing the whole dataset by first determining codes. In this study, the investigator organised the data into segments prior to linking meaning to the data. A catalogue of classifications was created to serve as quotations during the data analysis of the current research.

Step 4. Describing and identifying themes. Descriptions were generated of themes obtained from the classifications. The themes represented the range of perspectives of participants, supported by verbatim quotations.

Step 5. Representing and presenting findings on data analysis. In the present study, narratives were utilised to convey the findings for all the study stages. The narratives comprised rigorous explanations of some themes and sub-themes, or a compilation of the perceptions of participants and supporting quotations. Tables accompanied the narratives.

Step 6. Interpreting the meaning of the data. In this study, the investigator was led by the research question: What are employees' perceptions regarding the capabilities required for the 4IR in the South African automotive manufacturing industry? The investigator answered this question himself by describing his personal perceptions and assumptions.

ATLAS.ti 23 was used for coding and analysing the data. The data analysis was conducted in conjunction with the promoter.

Based on the purpose of the study, the recommendation by Saunders et al. (2016a) to use an inductive approach to data analysis was adopted. This approach ensured that diverse themes that transpired from the data were evaluated as the data were gathered. The thematic analysis was also data-driven, because in this approach the data were gathered for the particular objective of the study (Braun & Clarke, 2016). The determined themes might not have any resemblance to what questions the study participants were asked (Braun & Clarke, 2016).

Coding was utilised to categorise the data that had shared meanings and connections (Saunders et al., 2016). This was performed by discerning feasible patterns, recognising pertinent codes, and

deciding which data represented the codes. When this was done, the codes were classified into feasible themes (Braun & Clarke, 2016). The themes and the fashion in which they related were assessed, which entailed arranging codes under themes and determining their connection to one another. This involved identifying whether they met the intended aims and purpose or not (Saunders et al., 2016).

1.6.8 Trustworthiness

Research articles 1, 2 and 3

Trustworthiness in research implies the confidence that an individual may have in the study and the data results and is consequently defined by the analysers and examiners of the research study (Petty et al., 2012). Trustworthiness is described as the process in which qualitative study investigators ensure the quality and reliability of the study through confirmability, transferability, dependability and credibility (Korstjens & Moser, 2018). It is used to assess the standard of the collected data and analysis (Leedy & Ormrod, 2016). In this study, trustworthiness was achieved through:

Credibility, which means ensuring that findings are reliable and trustworthy from the perspective of the research participants. As qualitative research explores peoples' ideas, experiences, views, affections and assumptions, research participants are the ideal individuals to determine whether the research findings appropriately reflect their beliefs and feelings (Kumar, 2014). The investigator demonstrated the credibility of this study by utilising data triangulation, which is the use of different data sources in one research study. Hence, the data were transcribed verbatim after having been gathered from different research participants. In addition, the investigator used a co-coder to enhance credibility.

Transferability, which concerns the validity of a research study (Leedy & Ormrod, 2016). In qualitative studies, findings are context-sensitive; predicated on that, qualitative investigators do not set out the course of action or wish to generalise their data conclusions (Yin, 2014). The qualitative investigator is responsible for providing broad explanations of the study to ensure its transferability. The researcher collected rich and illustrative data within the context of the South African automotive manufacturing industry that can be compared to other available contexts to which transferability may be considered. According to Guba (1981), rich and expressive data should be collected based on the judgment of the researcher to align with the standards of the other available contexts, as this is important for transferability. In addition, the transferability of the findings of this study was enhanced by using purposive sampling to acquire detailed data from the research participants, who had a broad comprehension of the research topic of this study (Maxwell, 2013).

Dependability, which is concerned with whether other investigators can arrive at comparable findings if analogous processes are duplicated (Trochim & Donnelly, 2016). The investigator increased the dependability of the study by providing clear descriptions of participants' responses and of the decisions made throughout the study (Creswell, 2021; Leedy & Ormrod, 2016).

Confirmability, which is described as a point where other investigators may confirm the findings (Kumar, 2014). Confirmability is also described as the process in which the data reflect the focal point of the exploration and not the investigator's biases (Lincoln et al., 2017). This confirmability procedure is regarded as an "audit trail" (Petty et al., 2012; Lincoln et al., 2017) – the findings are read by a reliable investigator to establish the confirmability of the study findings. The "audit trail" clearly represents the stages from the beginning of the study to the development and presentation of the findings (Lincoln et al., 2017). The confirmability audit trail approach confirms that the data underpin each analysis and that the analysis is consistent with the accessible data (Akkerman et al., 2008; Carcary, 2020). The confirmability "audit trail" in this study is a track record of how this research was conducted and how the investigator came to the conclusions (Carcary, 2020; Given et al., 2023). The confirmability "audit trail" clearly represents the steps taken throughout the study, supporting an accurate compilation of applicable authentication (Given et al., 2023; Sinkovics, 2012). An "audit trail" is not only an affirmation that the study procedure was accurate but also allows people to assess the quality of the study on their own (Carcary, 2020; Given et al., 2023; Sinkovics & Alfoldi, 2012).

In this study, qualitative trustworthiness processes as recommended by Gibbs (2007) were followed:

- The investigator scrutinised the manuscripts to ensure that no obvious inaccuracies resulted from the transcribing process.
- The investigator made sure that there was no drift in the explanation of codes.
- The investigator ensured that there was no deviation in the meaning of codes during the coding process by consistently contrasting data with the codes and memoranda explaining the codes.

The investigator used a co-coder to ensure that the themes and subthemes accurately represented the collected data. The researcher guarded against personal bias throughout the study to ensure credibility.

1.6.9 Ethical considerations and the protection of personal information

Research articles 1, 2 and 3

Ethical considerations involve the institution and its partners that approve the study, the investigators that perform the study, and the respondents who furnish investigators with the needed data (Sekaran

& Bougie, 2016). The investigator should stay impartial throughout data collection and ensure that the information given are safeguarded (Saunders et al., 2016). Busher and James (2012, p. 91) caution that "research should be conducted to ensure the professional integrity of its design, the generation and analysis of data, and the publication of results". They add that investigators must meet ethical obligations, showing respect to and understanding of study participants, adhering to democratic values, maintaining high standards of research and upholding scholarly independence. Participants should be protected from any harm and should have confidence in the data collection procedure to attain reliability of the study results (Busher & James, 2012).

This study complied with the ethical requirements, rules and regulations stipulated by the North-West University Research Ethics Committee to guide the investigator through the study process in which individuals were the participants:

- The investigator completed the ethical clearance application forms for approval by the NWU Research Ethics Committee.
- The Ethical Clearance Certificate was obtained from the NWU Research Ethics Committee before the commencement of the data collection.

All the aforementioned approval letters for data collection for this research study are attached as appendices.

Confidentiality and privacy

According to Maree and Pietersen (2011, p. 41), "confidentiality of the results and findings of the study and the protection of the participants' identities are an essential ethical aspect of any study". All participants in this research study were requested to sign the informed consent form in which they agreed to partake in the study. It was clearly indicated in the informed consent form that the "privacy, meaning confidentiality and anonymity" of participants would be safeguarded at all times. To adhere to this regulation, the investigator ensured that the participants would remain anonymous and their identities would not be revealed for any reason, as this could be considered as a breach of their privacy and render them vulnerable. The investigator anonymised the study participants by using pseudonyms. Furthermore, the investigator ensured the anonymity of the data gathered from the participants by not gathering or storing any data identifying participants (e.g. name, address, ethnicity, email address, etc.). The data were stored under the pseudonyms and reported as group data, and the investigator did not link the individual responses with the research participants' identities. This ensured de-identified and anonymised data.

The investigator also safeguarded participants' vulnerability by obtaining informed consent only from participants with sufficient decision-making capability, to avoid any risk of exploitation. Participants

participated in the research study with full understanding of what it entailed. The investigator adhered to the Protection of Personal Information (POPI) Act's minimum standards regarding accessing and processing any personal information belonging to another.

Data storage

Data storage involves transcripts and audio files that must be marked in ways that accommodate anonymity (Ritchie & Lewis, 2013). Participants' anonymity was protected using pseudonyms. The investigator and the promoter both stored copies of the data of this research (recordings, transcriptions and documents) in a secured electronic file on a computer with a protected password. The data will be stored for a period of five years after the completion of the study, as per the standard time frames for retaining research data. The data collected were stored for data analysis and verification. As recommended by Bryman (2014), the investigator also has a backup of the data, including saved transcripts and audio-recorded interviews, stored on a computer, Google Drive, a flash drive, and an external hard drive.

Voluntary participation and informed consent

The investigator verbally explained the following important elements to each participant before the commencement of the interview:

- *Informed consent* means that research participants must at all times be fully informed of the research process and purposes and must consent to their participation in the research.
- *Privacy* means that the *confidentiality* and *anonymity* of human respondents will be protected at all times.
- *Trust* implies that human respondents will not be subjected to any acts of deception or betrayal in the research process or its published outcomes.
- Research participants must complete the consent forms to voluntarily partake in the study and return it to the researcher.
- The information is strictly confidential and only for use in this study.
- To assure anonymity, the investigator will safeguard the study participants from the inadvertent breach of confidentiality by using the procedure of anonymisation. The investigator will be anonymising study participants by using pseudonyms.
- Data collected from participants will be safeguarded and will not be shared with other parties.
- The investigator will ensure anonymity of the data gathered from the study participants by not storing any identifying data of persons (e.g., name, address, ethnicity, email address, etc.) or themes derived from them.

- The data will be stored under pseudonyms and reported on as group data, and the researcher will not link individual responses with the research participants' identities. Thus the data will be completely deidentified and anonymised.
- The data will be stored for a period of five (5) years, as per the requirements.
- Participation in the study is voluntary. Voluntary participation in research means that the withdrawal of participation in the study is allowed at any time.
- The information received during the study will only be used for the research purposes of this study and will not be released for any employment assessments or disciplinary purposes.
- Research participants' *safety during participation* is assured and the research study will not cause harm of any kind to those involved or impact participants or the organisation negatively.
- Interviews will be recorded to make the transcription of the responses easier and faster.
- Should research participants wish to read the findings of the study, they will be emailed to them.

1.7 The expected contribution of the study

1.7.1 Contributions to human resources management (HRM) literature

Considering that the topic of this study has not been thoroughly addressed by local researchers (Butler-Adam, 2018; Chaka, 2020), the articles in this study add value to the scientific body of knowledge on the perceptions of employees and line managers regarding the capabilities required for the 4IR in the South African automotive manufacturing industry. This study contributes to the current HRM literature on talent development, specifically in the automotive manufacturing industry. There is limited research on the new capabilities required for the 4IR in the South African automotive manufacturing industry and in African nations in general, which is of great concern (Carbonero et al., 2020). This study assists in this regard due to its exploration of the perceptions of assembly employees and line managers regarding the capabilities which employees in the South African automotive manufacturing industry are required to have in the era of the 4IR.

As was discussed previously, the South African automotive manufacturing industry is lagging behind its competitors in adapting to the 4IR in terms of capabilities development (Ansara & Davids, 2018). This study contributes significantly to the current literature on HRM by documenting the talent development strategies for effective adaptation to the 4IR in both the South African context and internationally. The findings of this study further contribute to the HRM literature by providing insights, knowledge and understanding of what capabilities will be needed for assembly workers to adapt to the 4IR in the automotive manufacturing organisation.

1.7.2 Contributions to the organisation

This study could significantly contribute to the automotive manufacturing organisation by clearly describing how the required capabilities of employees can be cultivated through talent development strategies to address the capabilities gap. The South African automotive manufacturing organisation could benefit from the findings of this study through the practical implications highlighted in the study and recommendations offered to adapt to the 4IR. The automotive manufacturing organisation will be provided with a contextualised understanding of the perceptions of the employees and line managers regarding the capabilities required for 4IR. This study could also help improve the organisation's work performance by providing employees with new relevant capabilities required for the 4IR for continued competitive advantage.

In addition, the most important contribution of this thesis is the development of the P-CMM pertaining to the 4IR capabilities of assembly employees and its evaluation. The maturity model could contribute to the South African automotive manufacturing organisation by informing the talent acquisition, retention and development strategies and policies to address the issue of the required capabilities of employees for the 4IR. This will enhance the body of knowledge available to the automotive manufacturing organisation to ensure that the talent development process functions more effectively.

1.7.3 Contributions to the individual

The 4IR requires talent development as well as reshaping employees' thinking so that they realise the importance of enhancing their capabilities in the automotive manufacturing organisation (Sen, 2020) to adapt to the 4IR technological innovations. This study could contribute to individuals' work commitment and motivation through the talent development required for the 4IR. The recommendations in this thesis could also create awareness that human capital is still valuable and appreciated, hence the talent development to adapt to the 4IR. Therefore, individual employees will be assured of their employability and reduced chances of being redundant in the 4IR new world of work. Individual employees could benefit from the findings of this study by being involved, engaged and committed and by participating in the process of adapting to the 4IR. Consideration of their shared perceptions regarding the required capabilities for the 4IR could enhance their personal development.

1.8 Chapter division

The chapters of this thesis are outlined as follows:

Chapter 1: Introduction.

Chapter 2: Research article 1: *Exploring employees' perceptions regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation.*

Chapter 3: Research article 2: *Exploring line managers' perceptions regarding employee capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation.*

Chapter 4: Research article 3: *Developing and evaluating a People Capability Maturity Model of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation.*

Chapter 5: Conclusions, limitations and recommendations.

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CHAPTER 2

RESEARCH ARTICLE 1

EXPLORING THE PERCEPTIONS OF ASSEMBLY EMPLOYEES REGARDING THE CAPABILITIES REQUIRED FOR FOURTH INDUSTRIAL REVOLUTION IN A SOUTH AFRICAN AUTOMOTIVE MANUFACTURING ORGANISATION

Orientation: The advancement of the digitalisation associated with the Fourth Industrial Revolution (4IR) continues to significantly impact the automotive manufacturing industry, driving mass technological transformations and innovations aimed at gaining a competitive edge in producing smart vehicles. However, it remains unclear which new capabilities the 4IR requires, posing a substantial challenge for assembly employees to accept, adapt to, and effectively operate in digital environments. Additionally, there is limited literature, understanding and conceptualisation of the specific capabilities required by assembly employees for the 4IR. This presents the risk that employees may operate in digital automotive assembly lines without the necessary skills, potentially making them irrelevant and therefore redundant.

Research purpose: The general objective of this study was to explore the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation.

Motivation for the study: The automotive manufacturing industry is one of the sectors most affected by the ongoing digital transformation driven by the 4IR. The rapid digital transformation of the 4IR significantly impacts assembly employees' current ability to keep pace with technological advancements. Assembly employees in the automotive manufacturing industry are not enjoying the benefits of smooth capabilities development from digital transformation and innovation, due to the strong demand for new skills required by the 4IR. It is essential for automotive manufacturing organisations to equip their assembly workers with the skills needed to adapt to 4IR digital plant operations. Furthermore, the 4IR digital era calls for new skills in human-machine interaction and cyber-physical production systems (CPPSs) for smart automotive manufacturing plants, such as those producing autonomous and hybrid vehicles.

Research approach/design and method: This study employed a qualitative research design grounded in constructivism as a paradigm. Purposive sampling was used during data collection. The data were collected from 13 assembly employees (N=13) currently employed at an automotive manufacturing organisation in South Africa through face-to-face, semi-structured interviews. ATLAS.ti 23 was used to organise and code the data and thematic analysis was applied to analyse it.

Main findings: First, the contextualised capabilities, the 4IR, and capabilities required for the 4IR in the automotive manufacturing industry according to the literature were presented. Second, the study revealed that assembly employees would need a range of crucial capabilities to adapt to the 4IR. Third, the required 4IR capabilities were categorised into skills, knowledge, behaviours, attitudes,

equipment, physical workplace changes, training opportunities, and support. Last, the capabilities required for the 4IR and how assembly employees would acquire them in an automotive manufacturing organisation were discussed in detail.

Practical/managerial implications: For the management of the South African automotive manufacturing organisation, this study provides the opportunity to incorporate assembly employees' capabilities development plans into strategic planning for 4IR digitalisation. Furthermore, this study offers management a broader understanding of how to implement expanded capabilities for assembly employees to adapt to the 4IR.

Contribution/value add: This study adds to the scientific body of knowledge on assembly employees' perceptions of the capabilities required for the 4IR in the South African automotive manufacturing industry. It adds value to the current HRM literature on talent development, specifically in the automotive manufacturing industry.

INTRODUCTION

Automotive manufacturing organisations are constantly facing disruptive technological changes due to the Fourth Industrial Revolution (4IR) (Ahmadi et al., 2023; Roberts & Cullinane, 2023; Silvestri et al., 2021). Currently, these organisations are racing to keep up with ongoing 4IR technological innovations to enhance car production systems (Dupuis et al., 2024; Roberts & Cullinane, 2023; Sundarrajan & Krishnan, 2024). The major digital shifts driven by 4IR require these organisations to transform their entire business models to meet current and future customer demands (Dupuis et al., 2024; Sundarrajan & Krishnan, 2024; Utku, 2023). Furthermore, this disruptive 4IR technology also influences the skills of automotive manufacturing employees, especially those involved in assembly (Dupuis et al., 2024; Niyaz & Ali, 2024; Sundarrajan & Krishnan, 2024).

The assembly line is a crucial element in automotive manufacturing as it connects various plant processes to create a complete vehicle (Nelfiyanti et al., 2023; Niyaz & Ali, 2024; Rasib et al., 2025). Therefore, this research aims to examine the 4IR capabilities of assembly employees in a South African automotive manufacturing company. The implementation of 4IR digitalisation in automotive manufacturing depends on the new skills of assembly employees for the efficient operation of the assembly line (Ligarski et al., 2021; Nelfiyanti et al., 2023; Niyaz & Ali, 2024). Currently, the skills of automotive assembly employees are shaped by 4IR digitalisation, which includes a wide range of artificial intelligence (AI) technologies, such as machine learning (ML), robotics, internet of things (IoT), cyber-physical production systems (CPPS), smart machines, and tools (Ligarski et al., 2021; Nelfiyanti et al., 2023; Rutherford, 2023).

While automotive manufacturing organisations strive to keep pace with the 4IR digitalisation for innovative product development, quality, safety, customer experience, and performance of smart cars, the focus and challenge lie in developing the capabilities of assembly employees (Leva et al., 2022; Rutherford, 2023; Utku, 2023). This will ensure the smooth adaptation and operation of digital automotive assembly plant lines with human-machine interaction for producing smart cars such as hybrid electric and autonomous vehicles (Leva et al., 2022; Rutherford, 2023; Utku, 2023). Automotive manufacturing organisations need to equip assembly employees with the new capabilities required for 4IR digitalisation and CPPSs involved in building smart cars (de Assis Dornelles et al., 2022; Starecek et al. 2023; Tian et al., 2024). Since assembly employees differ from robots, smart machines, and tools, they require positive encouragement to engage in lifelong learning to acquire new skills for collaboration with 4IR technological innovations (Cantrell et al., 2022; Leesakul et al., 2022; Starecek et al., 2023).

The smooth adaptation of the automotive manufacturing organisation in South Africa depends on the effectiveness of providing the assembly employees with the new capabilities required by 4IR. This will also address the assembly employees' capability gap identified for automotive manufacturing organisations.

Research purpose and objectives

The objective of this study was to explore the required capabilities of assembly employees in a South African automotive manufacturing organisation in light of the Fourth Industrial Revolution. To achieve this general objective, the following specific objectives were set:

- To conceptualise capabilities, the 4IR, and capabilities required for the 4IR in the automotive manufacturing industry according to the literature.
- To explore the perceptions of assembly employees regarding the skills and knowledge required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding the behaviours required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding the attitudes required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding the physical workplace change required for the 4IR in a South African automotive manufacturing organisation.
- To explore the perceptions of assembly employees regarding training and other opportunities required for the 4IR in a South African automotive manufacturing organisation.

- To explore the perceptions of assembly employees regarding the support required for the 4IR in a South African automotive manufacturing organisation.
- To make recommendations for future research and practice.

Literature review

Capabilities

The term 'capabilities' can be difficult to define because it is used with different intentions in various contexts (Baiyere et al. 2025; Hirvonen & Majuri, 2020). The capability approach (CA), introduced by Sen, consists of three main elements: functionings, capabilities, and freedom (Sen, 1993). Functionings refer to the different aspects of what a person can do or be in leading a fulfilling life (Sen, 1993), where values are essential (Van der Klink et al., 2016). Capabilities describe the combination of functionings that individuals can achieve or choose from (Sen, 1993). Freedom has a dual meaning because it relates to both the opportunity to shape one's life and environment (process) and the possibility of achieving valued goals (opportunity) (Sen, 2009). The CA provides a framework where values complement work and employability functionings (Sen, 1983). Central to the concept of capability is the idea that individuals can realise the doings and beings they value (Sen, 1980). According to Sen (2005), capabilities are defined as the real freedom individuals have or the opportunities and options available to them. Capabilities are also described as the things to do and the beings that individuals may attain if they wish; their chances to perform or be, such as being healthy, being educated, securing a job, having a marital status, being, or travelling, are capabilities already acquired (Sen, 2004). Capabilities include all personal resources (i.e., skills, knowledge, behaviours, and attitudes), material resources (such as tools, machines, and computers), physical resources (appropriate workplaces), and social environment resources (e.g., training and support) (Sen, 1980; Van der Klink et al., 2016). Therefore, the core of the capability concept is (a) being able to, (b) having opportunities, and (c) being facilitated and enabled to (Van der Klink et al., 2016). Being able and enabled ensures valuable work outcomes, such as work functioning, work performance, workability, and the number of hours worked, which are important for sustainable employability (Abma et al., 2016; Van der Klink et al., 2016). Two types of capabilities are distinguished: innate and developed (Deloitte, 2022). Furthermore, capabilities have also been described as actual or significant freedoms, as they represent the freedoms that have been accessible despite possible barriers, in comparison to basic official rights and essential social commodities (Sen, 1999).

The CA will serve as the theoretical framework for this study to understand the perceptions of assembly employees regarding the capabilities (being able) required for the 4IR in a South African automotive manufacturing organisation.

In this study, the researcher defines capabilities as the combination of organisational procedures, skills, knowledge, behaviours, attitudes, manufacturing structures, workspace, equipment, and technology training (Gama & Magistretti, 2025; Hirvonen & Majuri, 2020; Jagadisen et al. 2022). Capabilities also refer to the factors and abilities that enable organisations to produce products and services, adapt to evolving customer expectations, and maintain a competitive edge (Gama & Magistretti, 2025; Jagadisen et al., 2022; Rotjanakorn et al., 2020). For manufacturing organisations with mass production systems, the emphasis may be broader, focusing on the technical capabilities of equipment to improve productivity (Hirvonen & Majuri, 2020; Jagadisen et al., 2022; Modgil et al., 2025). Alternatively, capabilities can also relate to human resources, including the skills, knowledge, behaviours, attitudes, technological applications, and processes that organisations can leverage to achieve their goals (Gama & Magistretti, 2025; Jagadisen et al., 2022; Modgil et al., 2025).

Dynamic capabilities further explain and clarify the concept, making it easier to understand (Cataltepe et al., 2023; Dobrovnik et al., 2025; Joussem et al., 2025). They involve creating new work activities and managing change in response to shifting environments (Cataltepe et al., 2023; Joussem et al., 2025; Modgil et al., 2025). Capabilities encompass a combination of new skills, knowledge, behaviours, and attitudes, often integrated with equipment, enabling manufacturing organisations to adapt to external changes. Achieving these capabilities requires integrating training and development opportunities with digital workplace tools (Dobrovnik et al., 2025; Joussem et al., 2025; Rincon-Guio et al., 2025). Organisations must support employees' skills development through training on IoT and big data analytics, along with providing advanced equipment and proper support structures (Dobrovnik et al., 2025; Joussem et al., 2025; Rincon-Guio et al., 2025).

Additionally, resources within an organisation must come together effectively to achieve goals and gain a competitive advantage (Chatterjee et al., 2025; Lassen & Larsen, 2025). The resource-based view emphasises that organisational resources and operational capabilities are key strategies for production and effectiveness, which are essential for competitive positioning (Chatterjee et al., 2025; Grant, 1991; Lassen & Larsen, 2025). However, distinguishing between resources and capabilities can be complex, and identifying where one ends, and the other begins is often challenging (Chatterjee et al., 2025; Nascimento et al., 2025; Winter, 2003). Capabilities are seen as forming hierarchical production systems, with operational capabilities driving and primarily contributing to daily manufacturing processes (Chatterjee et al., 2025; Nascimento et al., 2025; Winter, 2003). These capabilities are vital for manufacturing organisations to support digital innovation in Industry

4.0 and to enhance productivity and performance (Lassen & Larsen, 2025; Nascimento et al., 2025; Wang et al., 2022).

The Fourth Industrial Revolution

The 4IR was introduced by Klaus Schwab in 2016 during the World Economic Forum as a concept representing rapid technological advances in the 21st century (Kruger & Steyn, 2025; Schwab, 2017). It is defined as the fastest phase of technological development, driven by digital trends such as AI and IoT, that is changing our lifestyles and work methods (Kayembe & Nel, 2019; Khoza, 2025; Opesemowo et al., 2025). The 4IR is said to be leading individuals and organisations into a highly digitalised world through modern technological innovations (Kademteme & Twinomurinzi, 2019; Matlala, 2025; Parra-Sanchez, 2025). However, research on the application of this technology pattern and its benefits has faced some challenges, especially regarding organisational restructuring to align with current 4IR trends (Matlala, 2025; Padeli et al., 2025; Parra-Sanchez, 2025). The 4IR has introduced advanced technological innovations that enable manufacturing equipment to become smarter and more efficient, making them highly attractive for various manufacturing environments (Kruger & Steyn, 2025; Matlala, 2025; Parra-Sanchez, 2025).

The 4IR is characterised by increased coherence in digital systems and highly advanced automation capabilities (Kruger & Steyn, 2025; Hajoary, 2020; Oosthuizen & Motsatsi, 2025). However, to reap the benefits of 4IR, organisations must equip employees with the necessary new skills and also provide operational manufacturing capabilities such as advanced equipment (Belletier et al., 2021; Herjuna et al., 2024; Oosthuizen & Motsatsi, 2025). The technological advancements and transformation brought about by the 4IR in manufacturing systems also have a significant impact on employees' behaviours and attitudes, influencing their acceptance and adaptation with full trust in the capabilities and job security (Oosthuizen & Motsatsi, 2025; Padeli et al., 2025; Singh et al., 2020). The 4IR represents the most crucial technological advancement to affect human lives, manufacturing, and business societies over the past three revolutions, driven by major digital developments—from the utilisation of machines, telecommunications, and electricity to create intelligent technological innovations (Maimela & Thutse, 2025; Samuels & Singh, 2025; Wilson, 2025).

The automotive manufacturing industry is currently experiencing a significant digital transformation driven by 4IR technological innovations and trends, aimed at gaining a competitive edge amid the rise of smart cars such as hybrid electric and autonomous vehicles (Gorcun et al., 2024; Nayan, 2025; Niyaz et al., 2025). The key 4IR smart technologies impacting this sector include AI, IoTs,

cybersecurity, additive manufacturing, software-defined vehicle production methods, cyber-physical systems (CPS), big data analytics, cloud computing, smart robotics, Python, and programming (Gorcun et al., 2024; Nayan, 2025; Niyaz et al., 2025). Numerous other technological applications are employed worldwide in automotive manufacturing to enhance vehicle efficiency, quality, performance, productivity, and to implement modern manufacturing models and systems, as well as monitoring and control systems (Gorcun et al., 2024; Llopis-Albert et al., 2024; Nayan, 2025). Concurrently, the industry faces the challenge of developing employees' new skills and integrating modern equipment (Llopis-Albert et al., 2024; Nayan, 2025; Piromalis & Kantaros, 2022). Consequently, automotive manufacturing organisations must provide adequate training to employees on CPPSs and human-machine interaction processes (Llopis-Albert et al., 2024; Piromalis & Kantaros, 2022).

Capabilities required for the Fourth Industrial Revolution in the automotive manufacturing industry

The capabilities that are crucial and required for 4IR in the automotive manufacturing industry are digital capabilities for growing a worldwide competitive advantage for designing and building modern cars (Naidoo & Pretorius, 2025; Rotjanakorn et al., 2020; Zheng et al., 2025). The digital capabilities for 4IR automotive manufacturing industry include data analytics, cloud computing, quantum computing, ML, Python, robotics, cyber-physical production, smart machines and tools, augmented and virtual reality, additive manufacturing, AI, soft skills and the IoT (Baiyere et al., 2024; Naidoo & Pretorius, 2025; Andriuk et al., 2024). The digital capabilities required for automotive manufacturing also include a basic understanding of coding, programming languages, cybersecurity, electronics and electrical engineering, and automation and systems integration for the integration of software and electronic application devices in smart cars (Dakic et al., 2024; Gupta, 2024; Zheng et al., 2025).

The automotive manufacturing industry worldwide faces the challenge of keeping up with the constantly changing digital trends of the 4IR to remain fully operational (Dakic et al., 2024; European Parliament, 2024; Zheng et al., 2025). The 4IR technological changes in automotive manufacturing reveal a significant capabilities gap, with a current survey indicating that 85% of automotive organisations are struggling to recruit employees with the necessary digital skills (Rapl, 2023). The same survey also showed that only 34% of employees in automotive manufacturing possess the new digital capabilities required by the 4IR to produce smart cars with advanced technologies (Rapl, 2023).

Lifelong Learning

Lifelong learning is described as an ongoing, voluntary, and self-motivated pursuit of knowledge beyond formal education, aimed at developing skills for both professional and personal growth in informal or formal settings (Eriksson & Lycke, 2025; Taverna et al., 2025; Tan, 2025). Consistently practising learning and development activities is crucial for employees in automotive manufacturing organisations, especially as these companies transition to modern digital assembly systems to produce smarter vehicles for the 4IR era (Alexander, 2021; Rasool, 2022). Employees should work in organisations that foster and support a culture of lifelong learning to meet the changing demands for new capabilities required by 4IR (Cotterman et al., 2022; Fatol et al., 2020; Poschauko, 2024). Lifelong learning is vital for employees in automotive manufacturing due to rapid advancements in 4IR technologies such as AI, robotics, the IoT's, cloud computing, and CPPS (Ali & Abd Latif, 2023; Cotterman et al., 2022; Fatol et al., 2020). Employees within these organisations must be willing to support a culture of lifelong learning to gain the new skills needed for the workplace's digital transformation driven by 4IR (Cotterman et al., 2022; European Commission, 2021; Poschauko, 2024).

In addition, authors argue that employees who fail to participate in lifelong learning in response to 4IR are unlikely to thrive in the digital era with the required new capabilities (Habraken et al., 2023; Borrageiro & Mennega, 2023; Seevaratnam et al., 2023). Lifelong learning is essential for employees to keep pace with the ever-changing technologies of the 4IR, which continuously impact automotive manufacturing organisations (Borrageiro & Mennega, 2023; Lorenz & Kraemer-Mbula, 2021; Seevaratnam, 2023). Employees' willingness to participate in lifelong learning will assist automotive manufacturing organisations in addressing the new capabilities gap for effectively achieving CPPSs (Habraken et al., 2023; Inyang et al., 2023; Lorenz & Kraemer-Mbula, 2021).

The ongoing development of AI, ML, robotics, and similar technologies drives employees in automotive manufacturing organisations to pursue lifelong learning opportunities for 4IR digital transformation (Leng et al., 2023; Pardi et al., 2020; Verma & Venkatesan, 2023). The acceptance of 4IR technological innovations by employees will encourage a willingness to learn and help them stay relevant in human-machine interaction (Leng et al., 2023; Pardi et al., 2020; Verma & Venkatesan, 2023). The skills needed today may soon become obsolete; therefore, it is essential for employees to continually update their knowledge to keep pace with the changing technological landscape of the 4IR (Lenaerts, 2023; Martiskova, 2022; Pardi et al., 2020). Employees' readiness to learn, upskill, and reskill consistently will support their adaptation to 4IR technological changes in the automotive manufacturing sector (Holman & Švejdárová, 2023; Martiskova, 2022; Verma & Venkatesan, 2023).

Employees' resistance to change does not help automotive manufacturing organisations adapt to the 4IR or address the new capabilities gap (Holman & Švejdarová, 2023; Kumar et al., 2024; Lorenz et al., 2019). The strategy of automotive manufacturing organisations to win the new capabilities war is to provide effective, positive communication to employees along with ongoing learning and development practices that enable swift adaptation in the current unstable work environment characterised by many technological advancements (Gartner, 2020; Kumar et al., 2024; Sehgal, 2020). The implementation of 4IR human-machine interaction requires automotive manufacturing to equip employees with continuous learning for fundamental skills such as basic computer literacy, AI, robotics, and ML (Kumar et al., 2024; Sehgal, 2020; Szajna et al., 2021).

Digital technologies

AI is continuously transforming the automotive manufacturing industry for 4IR digital reliability, safety, and better vehicle performance (Devaraj et al., 2025; Husain et al., 2022; Moniz et al., 2022). This transformation of AI compels automotive manufacturing organisations to remain competitive and keep pace with technological innovations for developing smarter cars, including hybrid electric and autonomous vehicles (Husain et al., 2022; Devaraj et al. 2025; Kamran et al., 2022). The strategic aim of automotive manufacturing organisations is to create innovative modern cars through AI technologies such as ML, smart machines, and robotics (Antonialli et al., 2022; Devaraj et al., 2025; Kamran et al., 2022). However, this rapid transformation of AI is impacting knowledge management and employees within automotive manufacturing organisations (Felser & Wynn, 2023; Husain et al., 2022; Kamran et al., 2022).

Additionally, employees lack the new knowledge and skills required to meet AI demands within automotive manufacturing organisations and to adapt to the 4IR (Felser & Wynn, 2023; King & Cnop, 2025; Zhu, 2021). Employees need to acquire knowledge in AI, ML, and smart robots to understand how to operate digital automotive manufacturing systems for building smarter vehicles (Demlehner & Laumer, 2021; Felser & Wynn, 2023). There has been a rapid increase in AI within automotive manufacturing organisations in recent years, which requires employees' willingness and commitment to acquiring new knowledge and skills through training (Felser & Wynn, 2023; King & Cnop, 2025; Zhu, 2021). This means employees must have positive attitudes and behaviours towards innovative knowledge management strategies to meet the demands of AI (Felser & Wynn, 2023; King & Cnop, 2025; Teng-Calleja et al., 2020).

The automotive manufacturing organisations around the world prioritise a focus on smart manufacturing systems due to increasing pressures from the ongoing transformation of 4IR technological trends (Hammad et al., 2025; Inyang et al., 2023; Mashilo, 2025). Additional technologies adopted by automotive manufacturing that also influence the capabilities of assembly employees include additive manufacturing/3D printing, cloud computing, IoT, robotics, CPPSs, smart sensors, smart tools, big data analytics, ML, virtual and augmented reality, among others (Hammad et al., 2025; Inyang et al., 2023; Mashilo, 2025). These are the crucial 4IR technologies that dominate the automotive manufacturing industry, significantly impacting employee capabilities to promote competitiveness, improve manufacturing systems, and support sustainable development (Hammad et al., 2025; Mashilo, 2025; Ojubanire et al., 2025). Automotive manufacturing organisations are required to become automated to meet the standards and requirements of the 4IR digitalised assembly work environment (Mashilo, 2025; Rammai et al., 2025; Roy, 2022). Consequently, employees within automotive manufacturing organisations will need these essential new technical capabilities to connect with cloud-based services through the IoT for managing big data analytics and related functions (Demlehner et al., 2021; Krommuang & Suwunnamek, 2022; Ojubanire et al., 2025).

Positive attitude and behaviour

The ongoing technological innovations of the 4IR influence the roles and responsibilities of employees, necessitating new capabilities for automotive manufacturing organisations (Stofile et al., 2023; Faulk, 2023). As the 4IR demands that employees adapt to a new work environment, they must develop certain positive traits, confidence and behaviours that support effective talent development, since their work identity will be affected in automotive manufacturing (Faulk, 2023; Luckow et al., 2018). Key characteristics necessary for employees to adjust to 4IR in this sector include open-mindedness, adaptable and acceptable behaviour, honesty, confidence, self-awareness, integrity, resilience, transparency, and innovation (Bosch & Rossouw, 2021; Faulk, 2023; Gianolli, 2020). Scholars agree that employees need to strengthen their identification with work to effectively embrace the digital transformation driven by the 4IR, through open-mindedness and positive attitudes (Schwab, 2016; World Economic Forum, 2020). Consequently, it is argued that employees should demonstrate positive behaviours to understand how 4IR technological innovations influence their work identity (Faulk, 2023; Stofile et al., 2023). Work identity has been defined as a “work-based self-concept, comprised of a combination of organisational, occupational, and other identities that affects the roles people adopt and the corresponding ways they behave when performing their work” (Walsh & Gordon, 2008, p.1). Employees are expected to identify with their work and recognise the necessity of embracing digital change, as well as their willingness to

upskill and reskill themselves to acquire new capabilities for 4IR technological innovations (Bosch & Rossouw, 2021; Bothma et al., 2015; Walsh & Gordon, 2008).

Work identity remains a key focus within automotive manufacturing organisations as employees continually face challenges in developing the necessary new capabilities for 4IR digital transformation (Gianolli, 2020; Faulk, 2023; Van Tonder, 2018). When employees exhibit positive behaviours and attitudes towards their work, they are more likely to participate actively in training and development programmes to adapt to the evolving world of work in automotive manufacturing driven by 4IR (Bosch & Rossouw, 2021; Bothma et al., 2015; Ostin, 2023). Employees in automotive manufacturing expect full support, including information sharing, new knowledge management, and fostering positive communication, to foster a constructive work identity and acceptance of the 4IR digital transformation (Ruostela et al., 2015; Schmidt et al., 2021).

Organisations heavily rely on technology; therefore, employees need to identify with their work to accept the 4IR digital change rather than resist it (Schwab, 2016; World Economic Forum, 2020). Authors have argued that employees must take on multiple digital roles, as automation replaces some of their traditional job activities (Davenport & Kirby, 2015). Consequently, employees require positive attitudes to embrace 4IR digital change, recognise their new digital roles, and be willing to learn new capabilities (Davenport & Kirby, 2015; Ostin, 2023). Employees will view work identification as an opportunity to develop their talents, ensuring job security and remaining relevant in the 4IR digital era with the necessary new skills (Davenport & Kirby, 2015; Ostin, 2023).

Authors argue that employees are required to continuously apply their soft skills in day-to-day activities to identify with their work during the 4IR automotive manufacturing transition process (Mabe & Bwalya, 2022; Schmidt et al., 2021). The soft skills that employees need to employ include innovative thinking, complex problem-solving, emotional intelligence, critical thinking, creativity, decision-making, communication, time management, adaptability, flexibility, active listening, and negotiation skills (Clark & Gevorkyan, 2020; Mabe & Bwalya, 2022). This application of good soft skills in work identification will help employees within the automotive manufacturing organisations to accept and adapt swiftly to the demands of 4IR's new capabilities (Clark & Gevorkyan, 2020; Mabe & Bwalya, 2022; Schmidt et al., 2021). This process of employee work identity will also help them mitigate the risk of redundancy and unemployment in the 4IR's new world of manufacturing (Clark & Gevorkyan, 2020; Mabe & Bwalya, 2022). However, there is limited literature regarding the creation of a positive work identity in the light of the 4IR (Stofile et al., 2023). Conceptualising the positive behaviours and attitudes that will be required from assembly employees in a South African

automotive manufacturing organisation, from the perspective of these employees, remains poorly understood. This study aims to address this gap in theory and practice.

RESEARCH METHODOLOGY

In this section, the research approach, research paradigm, research designs, research context, participants, procedure, data collection methods, data analysis, and trustworthiness will be outlined.

Research approach

A qualitative research approach was adopted for this study. Qualitative research is defined as a foundational method in the social sciences that aims to understand complex phenomena by collecting and analysing non-quantifiable information to investigate intentions, events, backgrounds, and context (Braun & Clarke, 2025; Mizikaci, 2025; Tilman et al. 2025). It is also described as a scientific investigation that emphasises the depth and richness of context and opinion in understanding social phenomena through collaboration between the researcher and participant (Denzin & Lincoln, 2011; Lim, 2025; Lunnay et al., 2023). In this present study, qualitative research has been chosen specifically for its effectiveness in areas where matters of context, character, and explanations are predominant, enabling the researcher to develop a broader understanding of the phenomena under exploration (Braun & Clarke, 2025; Mizikaci, 2025; Tilman et al., 2025).

Qualitative research starts with assumptions and a set of interpretive or theoretical frameworks that clarify research problems and explore the meanings that individuals or groups attach to social or human issues (Creswell, 2021; Kyngäs, 2020). It also contributes to developing theories through real-life exploration and investigation, aiming to gain a broader understanding of the phenomenon under study (Creswell & Báez, 2020). Additionally, qualitative research is conducted within a specific context, depends on the researcher to gather data, uses various methods, and focuses on participants' perspectives, meanings, and insights. It is considered interpretive and reflective (Creswell, 2021; Harrison et al., 2020).

Research on the 4IR in South Africa has been conducted; however, there is a limited focus on the capabilities employees need to adapt to the 4IR in the automotive manufacturing industry. There is a greater need to explore and emphasise employees' perceptions of the capabilities required for the 4IR in the automotive industry. Therefore, the researcher used a qualitative approach to explore

emerging perceptions of the capabilities required of assembly employees in the 4IR within the automotive manufacturing sector.

There are, however, certain disadvantages to using the qualitative research approach, such as the study findings not being objectively verifiable (Kyngäs, 2020; Mayer, 2015; Rahman, 2017). An additional drawback of qualitative data collection is that it requires significant time and is labour-intensive; manual tasks, such as transcribing interview responses, are costly.

Research paradigm

The researcher employed constructivism as the framework to address the identified problem. Constructivism aims to understand individuals' subjective experiences and how they derive meaning (Kumatongo & Muzata, 2021), asserting that reality is socially constructed (William, 2024).

The ontological (nature of reality) assumptions of constructivism are that: (a) social players are continuously entrenching social phenomena and their associated meanings; (b) investigators' understanding and interaction with society are also constructions; and (c) social interactions shape individuals' understanding of the world. (Bryman et al., 2014; Matthews & Ross, 2010).

The epistemological assumptions of the constructivism paradigm are outlined as follows: (a) knowledge is created through exploration and understanding of the meanings individuals assign to a phenomenon and how they interpret it; (b) researchers develop their constructions based on the meanings and interpretations generated by the individuals they study; (c) interpretation is primarily an inductive process because establishing it requires examining the collected data; (d) a fully unbiased study is unfeasible because the research process influences subjectivity, making it challenging to separate truths and principles; (e) social research is governed by meaning and individual measures rather than by the natural laws of the world; and (f) it is impossible to fully encapsulate or accurately analyse social reality because broader perspectives and understandings may differ (Ormston et al., 2014).

The researcher chose constructivism as a research paradigm to explore the perceptions of assembly employees regarding the capabilities they would require for the 4IR in a South African automotive manufacturing organisation. The assembly employees' awareness of the rapid technological advancements in the automotive manufacturing industry, as well as their interactions with peers and line managers, shape their reality. By exploring and understanding the meanings that assembly employees attach to their future capability requirements, new knowledge was generated regarding the skills, knowledge, behaviours, attitudes, physical workplace changes and support that will be

necessary. The use of constructivism as a research paradigm, therefore, allowed the researcher to create qualitative data (Creswell, 2021).

Research Designs

Literature Review Design

A literature review is described as a research synthesis process that summarises the various findings from previous research studies on a particular subject and provides a strong point of confirmation regarding the phenomenon under investigation (Palmie et al., 2023; Smela et al., 2023). The literature review is a vital section of the research procedure (Baird, 2025). It allows the researcher to analyse the research conducted by established academics in your discipline and critically assess where your study contributes to the body of knowledge and its relevance (Baird, 2025; Booth et al. 2021).

The following academic sources were consulted during the literature review: Emerald, Google Scholar, Ebscohost, ProQuest, SAE Publications, Sciencedirect, and Host. The sources reviewed in this research include books, reviews, dissertations, theses, abstracts, surveys, and various research reports. Additionally, scientific research articles from accredited, double-blind, peer-reviewed journals were utilised. Examples of such journals include the *South African Journal of Human Resource Management (SAJHRM)*, *South African Journal of Information Management (SAJIM)*, *African Journal of Science, Technology, Innovation and Development (AJSTID)*, *International Journal of Human Resource Management (IJHRM)*, *Journal of Strategic Human Resource Management (JSHRM)*, *International Journal of Business and Management (IJBM)*, *Journal of Management Development Review (JMDR)*, *Journal of People Management (JPM)*, *Journal of Management Studies and Inquiry (JMSI)*, among others. The search for published scientific research articles focused on the period between 2003 and 2025, which will be primarily used.

Qualitative Empirical Design

A qualitative descriptive design was employed in this study, as it effectively provides insights into phenomena that are not fully understood (Kim et al. 2017). Qualitative description is typically used to generate new knowledge by allowing participants' individual perspectives (information) to be thoroughly described without significant alteration (Polit & Beck, 2020). Consequently, a qualitative descriptive design enables researchers, including beginners, to stay close to the data and present results in a clear, concise, and logical manner (Bradshaw et al., 2017; Doyle et al., 2020; Sandelowski 2010). Using this qualitative descriptive approach helps organisations to apply the

findings of this study towards improvement, policy development, and adjustment (Sullivan-Bolyai et al., 2005; Turale, 2020).

Significant descriptive responses to the 'what', 'why', and 'how' of participants' backgrounds or understandings might illuminate policy advancements and the implementation of findings (Chafe, 2017; Colorafi & Evans, 2016; Neergaard et al., 2009). Due to the communicable nature of qualitative descriptive design, it has been reported as an exceptionally convenient and relevant approach for providing a straightforward, rich explanation of experiences, circumstances, or phenomena from participants' points of view.

After analysing various qualitative designs, a descriptive approach was selected for this study to collect data on the capabilities needed for the 4IR from the perspectives of assembly employees. This method enabled the researcher to stay close to the data for a comprehensive understanding of the phenomena (Bradshaw et al., 2017; Doyle et al., 2020; Sandelowski, 2010).

The qualitative descriptive design was suitable for this study because of its emic stance (Hu et al., 2020; Sullivan-Bolyai et al., 2005). The researcher thus gained an insider's perspective by being on-site and engaging with assembly employees to understand their perceptions of the required 4IR capabilities within the automotive manufacturing organisation.

Research context

The study was carried out at a prominent automotive manufacturing organisation in South Africa. To maintain the organisation's anonymity, the province where the manufacturing operations are situated will not be disclosed. The organisation operates several assembly plants that produce passenger and commercial vehicles for both local and export markets.

Data were collected on the premises of the automotive organisation during the day shift, in an office where interviews could be carried out confidentially and privately. The office provided a secure environment where assembly employees could speak openly and feel comfortable.

Participants

Assembly employees at a South African automotive manufacturing organisation were the target population for this research. The employees had extensive experience in vehicle assembly.

Purposive sampling was employed in this study. Purposive sampling is a non-random technique where participants are chosen for their ability to provide rich information, resulting in a deeper understanding of the phenomenon under investigation (Creswell & Poth, 2017). The researcher used this approach to identify assembly employees most suited to share their perspectives on the capabilities needed for the 4IR in an automotive manufacturing organisation in South Africa. It is highly recommended that purposive sampling be complemented by carefully defined inclusion and exclusion criteria (Ahmad & Wilkins, 2024). The criteria employed to select knowledgeable assembly employees for participation in this study are outlined below.

The inclusion criteria included employees who:

- were tasked with the assembly of automotive vehicles for at least twelve concurrent months.
- could understand and speak English.
- were willing and able to participate in this study.

The exclusion criteria included employees who:

- did not assemble vehicles on the assembly line.
- were appointed to the position for less than 12 months.
- were not willing or able to participate in the study.

Thirteen ($N=13$) assembly employees participated in this research study.

TABLE 2.1: Characteristics of assembly employees ($N=13$)

Item	Category	Frequency	Percentage
Age	18-30	3	23%
	31-40	6	46%
	41-50	4	31%
Gender	Male	8	62%
	Female	5	38%
Ethnicity	African	8	62%
	Coloured	1	8%
	Indian	4	30%
Tenure (Years of work experience as assembly employee)	5-9	5	38%
	10-14	4	32%
	15-19	2	15%
	20-24	2	15%

Many participants fell within the age range of 31 to 40 years (46%), followed by those aged 41 to 50 years with (31%) and 18-30 years at (23%) as the second most common category. Regarding gender, 62% were male and 38% female. Concerning ethnicity, 62% identified as African, while 8%

were identified as coloured and 30% identified as Indian. Lastly, in terms of tenure (Years of work experience as assembly employees), those with 5 to 9 years accounted for the highest at 38%, followed by those with 10 to 14 years with 32% and 15 to 19 years and 20 to 24 years, both at 15%.

Procedure

The researcher submitted the research proposal to three committees: firstly, the WorkWell Colloquium; secondly, the Scientific Committee (SciCom); and lastly, the Economica and Management Sciences Research Ethics Committee (EMS-REC). The application was successful, and ethics approval (NWU-00717-23-A4) was obtained on 25/07/2023. Next, the researcher contacted several automotive manufacturing organisations in South Africa with an invitation to participate in the study. One organisation accepted the invitation. The researcher then requested permission to collect data at the participating organisation. Permission was granted, and the organisation appointed a coordinator to identify participants who met the inclusion criteria. The participants signed the informed written consent form, and the coordinator made arrangements for the interviews on the researcher's behalf.

Prior to each interview, the researcher explained the ethical considerations outlined in the Consent form to the participant. Participants were given the opportunity to ask clarifying questions. The researcher obtained permission from the participants to record the interview. The interview questions were shared with the participants beforehand to allow sufficient time for preparation and to ensure transparency.

The researcher fulfilled various roles during this study. As a planner, the researcher devised a comprehensive implementation plan for all aspects of the study. The researcher took on the role of data collector when conducting semi-structured interviews with assembly employees who met the inclusion criteria. As a data analyst, the researcher analysed the data and identified themes and subthemes. A co-coder assisted with the data analysis. Finally, the researcher reported the study's findings.

Data collection methods

Individual face-to-face, open-ended, semi-structured interviews were used to gather data from the participants. Semi-structured interviews are defined as a data gathering technique that depends on asking predetermined questions, where one individual, the interviewer, tries to obtain in-depth information from another individual by asking questions that enable new thoughts, feelings, perceptions, and beliefs to be expressed throughout the interview process (Karatsareas, 2022;

Longhurst & Johnston, 2023; Seabi et al., 2021). Pre-selected questions guide semi-structured interviews; however, probing and clarifying questions may be asked to gain a deeper understanding of the phenomenon (Adeoye-Olatunde & Olenik, 2021; Karatsareas, 2022). The duration of the interviews ranged between 20 and 30 minutes. Additionally, the assembly employees were asked to complete a demographic questionnaire during the semi-structured interviews. No conclusions were drawn from the demographic data in the study, as it was merely used to describe the characteristics of the participants. The demographic information included age, gender, ethnicity, and tenure. Kindly note that the designations for ethnicity follow the terminology of the Employment Equity Act, 55 of 1998, for designated and non-designated groups. No offence is intended.

Nine preselected questions were asked during the semi-structured interviews and the researcher used an interview guide outlined below.

Interview Guide for Assembly Employees

Thank you for providing me with this opportunity to ask you a few questions. Before I start with the questions, I want to read you a short statement. Please think about this statement for a moment. My questions will be based on this statement.

Statement for Assembly Employee:

Technology is advancing very fast. Building cars is getting more and more complex. In the future, new skills and knowledge might be required to build modern cars. This might also have an influence on the behaviours and attitudes of people who need to build these cars.

Interview Questions for Assembly Employees:

1. In your opinion, please describe the **skills**, if any, that you will need to do your job well in the next five to ten years.
2. In your opinion, please describe the **knowledge**, if any, that you will need to do your job well in the next five to ten years.
3. In your opinion, please describe the **behaviours**, if any, that you will need to do your job well in the next five to ten years.
4. In your opinion, please describe the **attitudes**, if any, that you will need to do your job well in the next five to ten years.
5. In your opinion, please indicate what **tools, machines, computers, etc.**, if any, you will need to do your job well in the next five to ten years.

- 6 In your opinion, will your **physical workplace** have to change in the next five to ten years, so that you will be able to do your job well? Please motivate your answer.
- 7 In your opinion, what **training**, if any, will you need to do your job well in the next five to ten years?
- 8 In your opinion, what **opportunities**, if any, will you need to do your job well in the next five to ten years?
- 9 In your opinion, what **support**, if any, will you need to do your job well in the next five to ten years?

Data analysis

The researcher employed thematic analysis to analyse the data. Thematic analysis is defined as a qualitative research technique utilised for identifying, analysing, and interpreting designs of significance within qualitative data, which are referred to as themes (Finlay, 2021; Hamel et al. 2021). The following steps recommended by Creswell (2014) were implemented to execute the analysis.

Step 1. Organising, categorising and preparing data for analysis. During this initial step, the researcher transcribed the recorded data from the semi-structured interviews. Next, the data were categorised according to the specific research objectives of the study.

Step 2. Reading the entire dataset and familiarising oneself with the data to gain a shared understanding and reflect on its broader significance. The researcher familiarised himself with the data by reading and rereading the answers of the assembly employees. This step helped the researcher to develop a deeper understanding of the assembly employees' perspectives on the capabilities required for the 4IR in the automotive manufacturing organisation.

Step 3. Coding and analysing the whole dataset by first determining codes. During this step, the researcher allocated codes to segments of the data. A code list was created to enhance the confirmability of the data analysis process. A collection of direct quotations was made to support the codes that were allocated.

Step 4. Describing and identifying themes. The researcher combined codes to form code categories and then described these categories in a qualitative narrative, which led to the emergence of themes.

Step 5. Representing and presenting findings on data analysis. In this stage, the researcher presented the study's findings in the form of a qualitative narrative. The narrative was supported by figures and direct quotations from the assembly employees.

Step 6. Interpreting the meaning of the data is the final stage. The researcher attributed meaning to the data in the discussion section of the study. According to the constructivist paradigm, knowledge creation about a phenomenon occurs when participants' unique perceptions are understood. The researcher's interpretation of the data was guided by the perceptions of assembly employees regarding the capabilities required of them for the 4IR in an automotive manufacturing organisation in South Africa.

ATLAS.ti 23 was used to organise and code the data with the researcher's promoter.

Trustworthiness

Credibility: This study adhered to the trustworthiness standard through the method of credibility, which comprises ensuring that findings are reliable and trustworthy from the perspective of the research participants in the study. As qualitative research explores people's ideas, experiences, views, affections, and assumptions, research participants are the ideal individuals to determine whether the research findings appropriately reflect their beliefs and feelings (Kumar, 2014). The investigator demonstrated the credibility of this study by describing the context in which the research was conducted, for example, the procedures used and the methods in which data were collected. Additionally, by utilising data triangulation, which involves the use of different data sources in a single research study, credibility was established. The data were, therefore, described verbatim and gathered from various research participants. Additionally, the investigator utilised a co-coder to enhance credibility.

Transferability concerns the validity of a research study (Leedy & Ormrod, 2015). In qualitative studies, findings are context-sensitive and predicated on that; qualitative investigators do not arrange and set out the course of action or wish to generalise their data conclusions (Yin, 2015). The qualitative investigator is responsible for providing broad explanations of the study to ensure its transferability. The researcher collected rich and illustrative data within the context of the South African automotive manufacturing industry, which can be compared to other available contexts in which transferability may be considered. According to Guba (1981), rich and expressive data should be collected, as it is essential for transferability, based on the researcher's judgment to fit with the standards of other available contexts. In addition, the transferability of the findings in this study was enhanced by using purposive sampling to gather in-depth data from research participants who possess a broader understanding of the research topic (Maxwell, 2013).

Dependability is concerned with whether other investigators can arrive at comparable findings of a study if analogous processes are duplicated (Trochim et al., 2016). The investigator enhanced the dependability of the study by providing a detailed description of the methodology employed.

Furthermore, the study's objectives were clear and aligned with the research methodology. Moreover, the researcher enhanced the dependability of the research by providing clear descriptions of participants' responses and by documenting the decisions made by the researcher throughout the study (Creswell, 2021; Leedy & Ormrod, 2015).

Confirmability is described as a point at which other investigators can confirm the findings (Kumar, 2014). Confirmability is also described as the process in which the data reflect the focal point of the exploration and not the investigator's biases (Lincoln et al., 2017). This confirmability procedure is regarded as an audit trail (Petty et al., 2012; Lincoln et al., 2017), which involves a reliable investigator reading the findings to establish the confirmability of the study's results. The audit trail represents the stages taken from the beginning of the study to the advancement and presentation of the findings (Lincoln et al., 2017). The confirmability audit trail approach will confirm that the data subsists in support of each analysis and that the analysis has been created consistently with the accessible data (Akkerman et al., 2008; Carcary, 2020). The confirmability audit trail in this study is reflected in the record of how the research was conducted and how the investigator arrived at the conclusions (Carcary, 2020; Given et al., 2023). The researcher ensured confirmability by remaining objective during the study and avoiding the influence of his opinions or values on any results or processes. To this end, the researcher employed a co-coder to validate the findings. In addition, the researcher scheduled regular meetings with his promoter to ensure that the data were analysed correctly and consistently.

Ethical and protection of personal information considerations

Ethical considerations in research are the standards and practices outlined to protect the rights, dignity, and well-being of participants while ensuring the morality and credibility of the research study (Akerfeldt & Boistrup, 2021; Hasan et al., 2021). The essential ethical considerations include obtaining informed consent, safeguarding participants' anonymity and confidentiality, ensuring fair participant selection, and maintaining ethical standards throughout the research by being transparent, presenting data honestly, and avoiding conflicts of interest (Farrukh, 2024; Schutte et al., 2023). Ethical conduct involves adhering to standards that protect participants, ensuring technical morality, and fostering trust through practices such as informed consent, confidentiality, harm reduction, and upholding integrity and fairness throughout the research process (Pritchard, 2021).

The researcher must also stay objective during data collection and ensure that the data are protected (Saunders et al., 2016). To maintain anonymity, the researcher safeguarded participants from

accidental confidentiality breaches through anonymisation. The researcher used pseudonyms to anonymise participants.

The researcher further ensured the anonymity of the information collected from participants by not gathering or storing any identifying details of individual subjects (e.g., name, address, ethnicity, email address, etc.). The data were stored using pseudonyms and reported as group data. The researcher did not link the individual responses to the participants' identities.

The Protection of Personal Information Act (POPIA) (Act 4 of 2013) grants South African research participants specific rights over their personal data, including the right to consent to its handling, the right to understand how their data will be used, and the right to withdraw consent at any time (Hertzog et al. 2021). For this study, the researcher followed the principles of POPIA by ensuring genuine consent was obtained, especially for sensitive data, implementing strict data security measures, and clearly informing participants about their control over their information (Hertzog et al. 2021).

This present study complied with the ethical requirements as stipulated by the North-West University Research Ethics Committee, which include the following:

- Participants were to complete the consent forms to voluntarily participate in the study and return it to the researcher.
- Participants were informed that the information was strictly confidential and solely for use in this present study.
- Participants were informed that participation in this study was voluntary.
- Participants were informed that the withdrawal of participation in this study was allowed.
- The research study would not cause harm to those involved or have a negative impact on participants or the organisation.
- Participants were assured of adherence to the Protection of Personal Information Act (Act 4 of 2013).
- Participants were guaranteed confidentiality and anonymity.
- Participants were all treated equally with full attention, dignity and respect.
- Participants were informed regarding the objectives and purpose of the present study.
- The Ethics Clearance Certificate and approval of the study were obtained from the North-West University before the commencement of data collection.
- The researcher has been granted permission by the South African automotive manufacturing organisation, with approval from the General Manager through the Human Resource Division.

FINDINGS

In this section, the findings regarding the perceptions of assembly employees' required capabilities for the 4IR in an automotive manufacturing organisation in South Africa are reported. Table 2 below presents the descriptives of the assembly employees who participated in the study.

TABLE 2.2: Descriptives of line assembly employees (*N*=13)

Participant Number	Age	Gender	Ethnicity	Tenure
1	41-50	Male	African	15-19
2	31-40	Female	African	5-9
3	18-30	Female	African	5-9
4	31-40	Male	African	5-9
5	31-40	Male	Indian	10-14
6	31-40	Female	Indian	10-14
7	31-40	Male	African	10-14
6	41-50	Male	Indian	20-24
9	41-50	Male	Coloured	15-19
10	18-30	Female	African	5-9
11	18-30	Male	African	5-9
12	41-50	Male	Indian	20-24
13	31-40	Female	African	10-14

Data were collected from employees in an automotive manufacturing organisation in South Africa. The aim was to explore the perceptions of assembly employees regarding the capabilities required for the 4IR in an automotive manufacturing organisation in South Africa. Figure 1 below shows the categories and themes extracted from the analysed data.

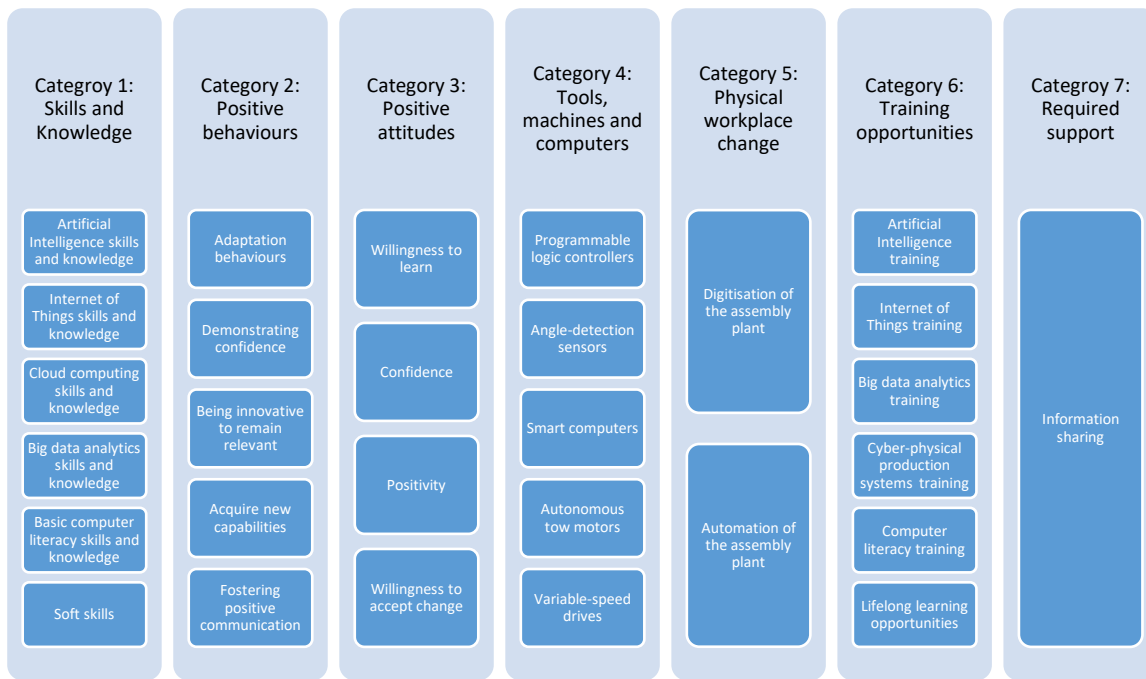


FIGURE 2.1: Overview of categories and themes – participant data

Category 1: Skills and knowledge

Note to the reader: Due to the convergence of data regarding required skills and knowledge, the researcher decided to categorise them together.

The assembly employees were asked to describe the skills and knowledge, if any, that they would need to perform their jobs well over the next five to ten years. Many assembly employees argued that they will require new skills and knowledge in artificial intelligence (AI), the Internet of Things (IoT), cloud computing, big data analytics, basic computer literacy, and soft skills to adapt to the 4IR smart automotive manufacturing.

Theme 1: Artificial intelligence skills and knowledge

Several assembly employees indicated that skills and knowledge in AI will help them operate digitally and keep pace with 4IR technologies to assemble modern, smart cars, such as hybrid and autonomous models.

“I view artificial intelligence as one of the critical skills to have for adaptation into 4IR to keep up with the pace of digitalisation, like machine learning, smart robotics and machines to assemble innovatively hybrid and autonomous cars for smart automotive manufacturing.” (P-10)

"I am also interested in knowing the artificial intelligence for digital operation, as I have once read that it has transformed many automotive manufacturing plants for making smarter cars that are driverless, safer, reliable and efficient." (P-2)

Theme 2: Internet of Things skills and knowledge

Various assembly employees indicated that skills and knowledge in IoT would be crucial, as it serves as the main interconnector for smart robots, machines, and other 4IR software systems used in assembling smart cars, such as hybrid electric and autonomous ones.

"In my view, critical new skills will include Internet of Things skills for the interconnection of branches of artificial intelligence, such as smart robotics, smart tools and machines with the electronic and software sensor components for smart cars." (P-6)

"I can assure you that the Internet of Things knowledge will be crucial for us as required for connectivity of cloud data-based services for handling big data analytics of the smart tools, machines and robotic collaboration anywhere and everywhere to assemble 4IR smart cars." (P-9)

Theme 3: Cloud computing skills and knowledge

Several assembly employees expressed that they would need to have cloud computing skills and knowledge for storing the automotive assembly line data on cloud-based services to support 4IR digitalisation. Cloud computing activities are regarded as reliable, safer, and effective for storing and accessing data anywhere and easily in the context of 4IR digital automotive manufacturing.

"Let me highlight to you that we are required to have cloud computing skills for storing the assembly line information on the cloud services for safety and reliability, as we will be operating digitally in 4IR." (P-9)

"I think cloud computing knowledge is essential for us to operate and store data on the cloud services, which are reliable and safer to handle big data digitally for assembling modern and innovative cars, such as autonomous, driver-assisted and hybrid electric." (P-5)

Theme 4: Big data analytics skills and knowledge

Many assembly employees claimed that big data analytics skills and knowledge would be essential for gathering and analysing information to identify issues for improving product quality control in the 4IR digital era of the automotive assembly plant.

"Big data analytics will help us to analyse and identify the assembly line issues and understand challenges for improvement measures for product quality as we assemble modern cars for the 4IR digital era." (P-10)

"There is no way that we can ignore big data analytics because 4IR smart automotive manufacturing is all about the digital data for operational use and smart production quality controls for improvement of assembly processes." (P-5)

Theme 5: Basic computer literacy skills and knowledge

Several assembly employees shared that they would require basic computer literacy, such as Microsoft Office, as the most fundamental new capability to adapt to a 4IR digital automotive assembly plant.

“...computer literacy skills are the fundamental skills that we need as assembly employees to function on Microsoft Office to remain employable and relevant to the 4IR.” (P-3)

“As assembly employees in this automotive assembly plant, we will need the basic computer literacy knowledge like Microsoft Word, Excel, PowerPoint, Outlook, etc., as fundamentals for transition and adaptation into 4IR.” (P-13)

Theme 6: Soft skills

Different assembly employees argued that they would need advanced soft skills to accept and relate to the new work activities in order to remain relevant for 4IR smart automotive manufacturing.

“I think creativity, decision-making, innovation, negotiation and critical thinking skills are important for me as assembly employees to remain employable by accepting and identifying with the new job activities that match the new capabilities required for 4IR.” (P-1)

“...will still require creative, communication, innovative, complex problem solving, critical decision-making, active listening, active learning and creativity skills for relevancy and adaptation in the new job identification for 4IR smart automotive manufacturing.” (P-13)

Category 2: Positive Behaviours

The assembly employees were asked to describe the behaviours, if any, they would need to perform their jobs well over the next five to ten years. The participants elaborated on positive behaviours that would be essential for an employee working in the assembly plant. These positive behaviours include adapting, demonstrating confidence, being innovative to stay relevant, acquiring new capabilities, and fostering positive communication.

Theme 1: Adaptation behaviours

Several assembly employees argued that they would need to develop adaptation behaviours to identify with the new work functions and remain employable in the 4IR smart automotive manufacturing environment.

“I believe positive behaviours, adaptable approach, open mind-sets, integrity, resiliency and transparency will help us to be acceptable and acquire new capabilities to identify with our new work roles.” (P-12)

"I doubt that we will adapt into 4IR without positive behaviours and good open minds will help us flourish and keep our jobs." (P-8)

Theme 2: Demonstrating confidence

Varied assembly employees suggested that confident behaviour towards new digital job tasks would be essential for 4IR automotive manufacturing.

"...need to have enough confidence for talent development to acquire new capabilities by showing positive behaviours to adapt into 4IR smart automotive manufacturing with modern assembly line responsibilities..." (P-7)

"I think we will need to be confident and behave well with honesty, resiliency and transparency to do well in our new digital job activities with the machine-robot interaction." (P-10)

Theme 3: Being innovative to remain relevant

Many participants observed that they would need to be innovative to stay relevant for 4IR automotive manufacturing.

"I think we should be more innovative with positive behaviours...for 4IR new work duties for digital change and be relevant for the future of this automotive assembly plant." (P-8)

"I believe that we must behave positively with innovative thinking to adopt 4IR new work functions and roles with the acquired new capabilities." (P-9)

Theme 4: Acquire new capabilities

Many assembly employees acknowledged that they would need to acquire new 4IR capabilities to perform their roles in a digital automotive manufacturing environment.

"As we all know, 4IR technologies are currently affecting our daily operations in the automotive manufacturing plant; it is important that we behave positively to acquire new capabilities for the adoption of new work duties." (P-13)

"I strongly believe that 4IR is real and it is important for us to learn more about 4IR and its era as our capabilities and work activities will definitely be affected by automation." (P-10)

Theme 5: Fostering positive communication

Participants mentioned that it will be important to communicate positively about new capabilities that will be required in the 4IR automotive assembly plant.

"I think we must always...show positive communication towards 4IR because reality is that the digital world of automotive manufacturing requires new capabilities for modern assembly job functions." (P-13)

"...so we rather communicate positively and be prepared with new capabilities for 4IR new work responsibilities within the digital assembly automotive plant." (P-2)

Category 3: Positive Attitudes

The assembly employees were asked to describe any attitudes they would need to perform their jobs well over the next five to ten years. The participants argued that the following positive attitudes would be essential in the 4IR era: willingness to learn, confidence, positivity, and a willingness to change.

Theme 1: Willingness to learn

Many participants indicated that assembly employees would need to be willing to acquire new capabilities to adapt to the 4IR automotive manufacturing plant.

“...willingness to learn will help us to obtain required new capabilities for 4IR digitalisation in order to perform our new work tasks in this automotive manufacturing plant.” (P-2)

“I think we should be willing to learn to get the new capabilities to adapt in 4IR technologies and do well in our new work assignments for smart automotive manufacturing...” (P-9)

Theme 2: Confidence

Various participants emphasised the importance of having a confident attitude to engage with the new job tasks introduced by the 4IR.

“...need to have positive attitudes and high confidence to identify with our new job during the era of 4IR in this automotive manufacturing as assembly employees.” (P-13)

“...robots cannot compete or be creative like us, robots cannot solve problems like us human beings if we can show positive attitudes for 4IR to perform new job activities that machines and robots cannot do.” (P-1)

Theme 3: Positivity

Many assembly employees believed that 4IR-related tasks should be approached positively.

“I view positive attitude as the fundamental approach to the 4IR technologies in this automotive manufacturing plant for meeting the requirements of the new work functions for assembling smarter cars.” (P-5)

“I think what is important is to have positive attitudes to enable us to determine 4IR new work roles and be creative enough, considering the advantages of 4IR in mind.” (P-1)

Theme 4: Willingness to accept change

Most participants stated that assembly employees would need to accept the reality of the 4IR and its implications for their capabilities and responsibilities.

“We need positive attitudes to accept the new world of work to acquire new capabilities and recognise the 4IR digital work functions which are characterised by human-machine interaction.” (P-1)

“...we should accept that the 4IR is here and not resist its transitions and effective processes for improvement of our new capabilities with an opportunity to describe smart digital work responsibilities.” (P-10)

“I recommend that we have acceptable positive behaviours to acquire new capabilities and adapt to 4IR in this automotive manufacturing organisation, as our roles and job descriptions will evolve due to digitalisation.” (P-11)

“...it is about time that we behave in a way to accept that the technological transformation for 4IR is here..., so we must obtain new capabilities to adapt to our new work duties to assemble smart cars.” (P-2)

Category 4: Tools, machines and computers

The assembly employees were asked to indicate what tools, machines, computers, etc., if any, they would need to perform their jobs well over the next five to ten years. The participants argued that the following tools, machines, and computers would be essential for the 4IR era: programmable logic controllers, angle detection sensors, smart computers, autonomous tow motors, and variable-speed drives.

Theme 1: Programmable logic controllers

Various assembly employees stated that they would require programmable logic controllers to effectively implement 4IR digital production systems in collaboration with robotic functions within the automotive manufacturing assembly plant.

“I believe that if they give equipment and tools like programmable logic controllers, we will learn to use, excel and be able to deliver digital production for a new strategic business focus on 4IR.” (P-10)

“...we need to adopt smart tools such as programmable logic controllers for effective communication, monitoring, controlling complicated digitalised systems like conveyers, heat control and robotic functions in this automotive manufacturing assembly plant.” (P-6)

Theme 2: Angle-detection sensors

Various assembly employees mentioned that they would require angle-detection sensors to handle sensitive electrical and other mechanical technologies related to 4IR for vehicle fitment parts within the automotive manufacturing assembly plant.

“This automotive manufacturing plant must provide us with the angle-detection sensors as we will be making modern cars with many sensitive electrical and other mechanical technologies.” (P-4)

“I think the angle-detection sensors will be very crucial for the 4IR technological car fitment parts and for assembling of the smart vehicles.” (P-6)

Theme 3: Smart computers

Most of the assembly employees emphasised that having smart computers is fundamental for 4IR digital operations and the interconnected processes of technological innovations in the automotive manufacturing assembly plant.

“We also need smart computers for connecting to the internet of things for big data storage on cloud computing in this automotive manufacturing plant.” (P-4)

“I am of the view that the smart computers will be required for us to operate digitally, as we will be interacting with the smart machines and robotics.” (P-8)

“Tools start from smart computers as the foundation for this automotive manufacturing organisation for implementation of the 4IR tools and machines like robots.” (P-11)

Theme 4: Autonomous tow motors

Several assembly employees indicated that they would require autonomous tow motors to transport car parts to the automotive manufacturing assembly plant.

“As we are moving towards digital transformation of the 4IR with building the hybrid cars, then we also need the autonomous tow motors and hybrid tow motors.” (P-5)

“I think the autonomous tow motors, the driverless tow motors or electric tow motors without a driver will be crucial for us to deliver parts within this automotive assembly lines.” (P-4)

Theme 5: Variable-speed drives

Different participants indicated that they would require variable-speed drives to control the speed of smart tools during 4IR smart car assembly.

“Tools such as variable-speed drives will be crucial for controlling the speed of smart tools when manufacturing the hybrid and electronic cars for the future, and as it is required by the 4IR.” (P-5)

“I trust that the variable-speed drives will help us in the automation world to control the speed of smart machines and digital tools when assembling cars for 4IR in this automotive assembly plant.” (P13)

Category 5: Physical workplace change

The assembly employees were asked whether the physical workplace will need to change over the next five to ten years so they can do their jobs well. The assembly employees were also asked to motivate their answers.

Theme 1: Digitisation of the assembly plant

Different assembly employees argued that the physical workplace will have to be changed from traditional production operating systems to digitalisation to meet the technological requirements of 4IR for smart automotive manufacturing.

“Yes, this automotive manufacturing assembly plant will have to be automated and digitalised to save time and reduce defects to meet the technological requirements of 4IR with the interaction of humans, smart machines and robots.” (P-3)

“Yes, the current physical workplace has to change as it must be prepared for 4IR to look very innovative and digitalised with the latest automotive manufacturing technologies like robots and smart tools.” (P-4)

Theme 2: Automation of the assembly plant

Participants stated that the assembly plant would be automated by incorporating smart machines and robots.

“Yes, I think the physical workplace has to change because the traditional systems of production will not be relevant anymore due to smart machines and robots that we will be using to assemble parts for modern cars.” (P-12)

“With no doubt, the physical workplace has to be automated because robots need their space and flexibility to perform their tasks; our current workstations need to be aligned with those of robots and smart machines.” (P-1)

Category 6: Training opportunities

The assembly employees were asked what training and other opportunities, if any, they would require to excel in their jobs over the next five to ten years. The participants indicated that the following training and opportunities will be essential: AI, IT, big data analytics, cyber-physical, computer literacy, and lifelong learning.

Theme 1: Artificial intelligence training

Various assembly employees emphasised the importance of AI training, as it involves robotics and smart machines that will be central to 4IR digital automotive manufacturing of smarter vehicles and lifelong learning opportunities.

“I think continual learning and training on artificial Intelligence will be important for us to adapt to 4IR smart automotive manufacturing of assembling hybrid electric and autonomous cars.” (P10)

“Management of this automotive manufacturing must make sure that we attend ongoing training related to technological innovations, like the branch of artificial intelligence.” (P-13)

Theme 2: Internet of Things training

The participants revealed the importance of training on the IoT for assembly employees as it interconnects digital automotive tools, robots, smart machines and multiple car devices anywhere and everywhere.

"I will need continuous Internet of Things skills training as it will be crucial for me to adapt to the 4IR technologies within the modern automotive assembly plant of assembling smarter cars." (P-4)

"...most importantly, I will recommend the ongoing training on Internet of Things...as the fundamental stage of the 4IR in this automotive assembly plant." (P-8)

Theme 3: Big data analytics training

Participants indicated that training in big data analytics would be beneficial for assembly employees.

"...management needs to pay attention to equipping us with the relevant skills, knowledge and abilities such as big data analytics to work effectively on digital data for the 4IR digital automotive assembly plant." (P-12)

"Continual training and development programmes on big data analytics...will be beneficial for us to adapt to 4IR digitalisations of hybrid and autonomous cars within this automotive manufacturing plant." (P-9)

Theme 4: Cyber-physical production systems training

Various assembly employees emphasised the importance of having training programmes on cyber-physical production systems to enable the integration of 4IR physical and digital components.

"...life-long learning on the cyber-physical production systems and operation will be most relevant training for the future of automotive manufacturing" (P-5)

"Cyber-physical production systems will be a relevant training and important for ongoing learning to keep up with ever-changing 4IR for human-machine interaction during the digital automotive assembly line...processes." (P-2)

Theme 5: Computer literacy training

Several assembly employees noted that basic computer literacy training will be necessary for them to perform 4IR digital operations on computers in a smart automotive manufacturing assembly plant.

"I am of the view that 4IR digital operations will need to be performed electronically on a computer, so computer literacy training will be important for adaption in this automotive manufacturing organisation." (P-12)

"...basic computer literacy training should be the first priority for us as we will be transitioning into a 4IR smart automotive assembly plant, which requires everyone to be computer literate." (P-4)

Theme 6: Lifelong learning opportunities

Several assembly employees revealed that lifelong learning would be required to participate in 4IR smart automotive manufacturing.

"...this automotive manufacturing...must give us opportunities for life-long learning to participate and support the culture of continuous learning and training programmes to adapt into a 4IR digital assembly plant for making smart cars." (P-12)

“Opportunity and culture of continuously learning through skills and development training can help me to get new capabilities and keep up with the demanding and ever-changing technological innovations of 4IR.” (P-5)

Category 7: Support

The assembly employees were asked to describe what support, if any, they would need to do their job well in the next five to ten years.

Theme 1: Information sharing

Various assembly employees indicated that they would require support in the form of information and knowledge sharing on 4IR digital automotive manufacturing capabilities.

“I believe the smooth talent development for new capabilities relies on positive communication for sharing new knowledge on the 4IR technological change process of software components like artificial intelligence, internet of things, smart robots and machines.” (P-6)

“I guess management of this assembly plant should approach the 4IR digital implementation journey by positively communicating to share information regarding the purpose of change to support us in getting new capabilities.” (P-4).

DISCUSSION

In this section, the discussion of the findings will be guided by the study's specific objectives.

Outline of findings

Objective 1: To conceptualise capabilities, the 4IR, and capabilities required for the 4IR in the automotive manufacturing industry according to the literature

Capabilities are defined as the combination of organisational procedures, skills, knowledge, behaviours, attitudes, manufacturing structures, workspace, equipment, and training in technology (Gama & Magistretti, 2025; Hirvonen & Majuri, 2020; Jagadisen et al., 2022). Capabilities are also described as the factors and abilities of the organisations to manufacture products and services to adapt to the ever-changing customer expectations and create a competitive advantage (Gama & Magistretti, 2025; Jagadisen et al., 2022; Rotjanakorn et al., 2020). In the case of manufacturing organisations with mass production systems, the focal point can be broader on the technical capabilities of equipment to execute the productivity (Hirvonen & Majuri, 2020; Jagadisen et al.,

2022; Modgil et al., 2025). On the other hand, the concept capabilities can be described by the field of human resources to focus deeply on the collection of skills, knowledge, behaviours, attitudes, technological applications, and processes that the organisation can draw from to achieve goals (Gama & Magistretti, 2025; Jagadisen et al. 2022; Modgil et al. 2025).

The dynamic capabilities also clarify the concept, enabling a better understanding of capabilities (Cataltepe et al., 2023; Dobrovnik et al., 2025; Joussem et al., 2025). Dynamic capabilities are the ability to make new work activities and manage change in accordance with the changing climate (Cataltepe et al., 2023; Joussem et al., 2025; Modgil et al., 2025), while capabilities include the combination of new skills, knowledge, behaviours, and attitudes that are frequently and constantly combined with the equipment that gives manufacturing organisations the capacity to adapt to the changing external climate.

The 4IR refers to rapid technological advancements characteristic of the latest industrial era, driven by digital trends such as AI and IoT, and marked by creativity and innovation that change how we live and work (Kayembe & Nel, 2019; Khoza, 2025; Opesemowo et al., 2025). It is also seen as guiding individuals and organisations into a highly digitalised world through cutting-edge technological breakthroughs (Kademteme & Twinomurizi, 2019; Matlala, 2025; Parra-Sanchez, 2025). However, studying and applying these technologies remains challenging, especially as organisations undergo restructuring to align with 4IR trends (Matlala, 2025; Padelì et al., 2025; Parra-Sanchez, 2025). The 4IR has introduced innovations that turn manufacturing equipment into intelligent, efficient systems, making them appealing in various manufacturing settings (Kruger & Steyn, 2025; Matlala, 2025; Parra-Sanchez, 2025).

The 4IR is characterised by increased digital system coherence and highly advanced automation capabilities (Hajoary, 2020; Kruger & Steyn, 2025; Oosthuizen & Motsatsi, 2025). However, realising the benefits of 4IR requires organisations to equip employees with the necessary new skills and also develop operational manufacturing capabilities such as advanced equipment (Belletier et al., 2021; Herjuna et al., 2024; Oosthuizen & Motsatsi, 2025).

The 4IR is the most crucial and unique advancement in technology to influence human lives, manufacturing, and business societies over the past three revolutions, with major digital developments stemming from the utilisation of machines, telecommunications, and electricity to create innovative smart technologies (Maimela & Thutse, 2025; Samuels & Singh, 2025; Wilson, 2025).

The capabilities required for the 4IR in the automotive manufacturing industry, according to the literature, include adopting a culture of lifelong learning, acquiring skills and knowledge related to digital technologies, and fostering positive attitudes and behaviours. Each of these elements will be briefly summarised below.

Lifelong learning in the automotive industry, especially within a 4IR framework, involves the continuous development of skills related to modern digital assembly systems used in creating smarter vehicles (Alexander, 2021; Rasool, 2022). Essential knowledge and skills include computer literacy, AI, robotics, ML, IoT, cloud computing, and CPPSs (Kumar et al., 2024; Leng et al., 2023; Verma & Venkatesan, 2023). Scholars caution that automotive manufacturing workers who do not engage in lifelong learning during the transition to 4IR digital assembly systems are unlikely to thrive in this evolving digital landscape (Habraken et al., 2023; Borrageiro & Mennega, 2023; Seevaratnam et al., 2023).

Assembly employees currently lack the knowledge and skills required for the 4IR demands of automotive manufacturing. (Felser & Wynn, 2023; Wijaya & Suasih, 2020; Zhu, 2021). These employees need to acquire knowledge in AI, ML, IoT, cloud computing, CPPS, big data analytics, robotics and smart machines to understand how to operate digital automotive manufacturing systems for building smarter vehicles (Demlehner et al., 2021; Felser & Wynn, 2023; Krommuang & Suwunnamek, 2022). Employees in digital automotive manufacturing organisations will need these new technical capabilities to connect cloud-based services via the IoT (Bhatia & Kumar, 2020; Demlehner et al., 2021; Krommuang & Suwunnamek, 2022). Apart from technological capabilities, employees will also need soft skills to succeed in the 4IR automotive manufacturing environment. These soft skills include innovative thinking, complex problem-solving, emotional intelligence, critical thinking, creativity, decision-making, communication, time management, adaptability, flexibility, active listening, and negotiation skills (Clark & Gevorkyan, 2020; Mabe & Bwalya, 2022). The application of these soft skills will help employees establish a sense of identity with their work during the 4IR automotive manufacturing transition process (Schmidt et al., 2021).

The ongoing technological advancement in the automotive manufacturing sector will demand positive attitudes and behaviours from employees (Faulk, 2023). Essential attitudes and behaviours include open-mindedness, adaptability, honesty, confidence, self-awareness, integrity, resilience, transparency, and innovation (Bosch & Rossouw, 2021; Faulk, 2023; Gianolli, 2020). Scholars argue that employees need to strengthen their identification with work through positive attitudes and behaviours to adapt to the digital transformation driven by the 4IR (Stofile et al., 2023; World Economic Forum, 2020). Work identity is defined as a work-related self-concept, composed of

organisational, occupational, and other identities that influence the roles individuals adopt and their behaviour when performing tasks (Walsh & Gordon, 2008).

Objective 2: To explore the perceptions of assembly employees regarding the skills and knowledge required for the 4IR in a South African automotive manufacturing organisation

The themes that emerged from the data were AI skills and knowledge, IoT skills and knowledge, cloud computing skills and knowledge, basic computer literacy, and soft skills.

Assembly employees reported that AI skills and knowledge would be essential for success in their work over the next five to ten years. This finding is confirmed by Demlehner et al. (2021) and Felser and Wynn (2023), who report that employees are required to acquire new knowledge of AI, ML, and smart robots to understand how to operate digital automotive manufacturing systems for building smarter cars.

Participants also noted that assembly workers need skills and knowledge in IoT and cloud computing. This finding is supported by Bhatia and Kumar (2020), Cronin et al. (2019), and Krommuang and Suwunnamek (2022), who state that employees in automotive manufacturing must develop new capabilities in IoT, cloud computing, CPPS, and big data analytics.

Additionally, the assembly employees reported that basic computer literacy would be crucial. In support of this finding, Kumar et al. (2024), Sehgal, (2020), Szajna et al. (2021) report that the implementation of 4IR human-machine interaction requires automotive manufacturing to equip employees with continuous learning for fundamental skills such as basic computer literacy, AI, robotics, and ML.

Furthermore, the participants indicated that soft skills such as creativity and innovation, critical thinking, complex problem-solving and decision-making, as well as active listening and communication skills, will be vital for assembly employees during the 4IR. This finding is supported by Mabe & Bwalya (2022); Schmidt et al. (2021), who report that employees are required to continuously apply their soft skills in daily activities to relate to their work during the 4IR automotive manufacturing transition process. The findings are further supported by Clark & Gevorkyan (2020) and Mabe and Bwalya (2022), who report that the soft skills employees need to employ include innovative thinking, complex problem-solving, emotional intelligence, critical thinking, creativity, decision-making, communication, time management, adaptability, flexibility, active listening, and negotiation skills. Lastly, Clark and Gevorkyan (2020), Mabe and Bwalya (2022), and Schmidt et al. (2021) argued that the application of strong soft skills in work identification will help employees in

automotive manufacturing organisations accept and adapt swiftly to the demands of 4IR's new capabilities.

Objective 3: To explore the perceptions of assembly employees regarding behaviours required for the 4IR in a South African automotive manufacturing organisation

The themes that emerged in this category were adaptation behaviours, demonstrating confidence, being innovative to remain relevant, acquiring new capabilities, and fostering positive communication.

Assembly employees reported that they would be required to have adaptation behaviours, demonstrating confidence, and also being innovative to remain relevant during the digital era of 4IR within the automotive assembly plant. This finding is supported by Bosch & Rossouw, (2021), Faulk, (2023) and Gianolli, (2020), who report that the key characteristics necessary for employees to adjust to 4IR in this sector include open-mindedness, adaptable and acceptable behaviour, honesty, confidence, self-awareness, integrity, resilience, transparency, and innovation.

Participants indicated that fostering positive communication would be crucial for a 4IR automotive assembly plant involved in the manufacturing of smart vehicles. These findings are confirmed by Ruostela et al. (2015) and Schmidt et al. (2021), who report that employees in automotive manufacturing expect full support, including information sharing, new knowledge management, and fostering positive communication, to develop a constructive work identity and acceptance of the 4IR digital transformation.

Objective 4: To explore the perceptions of assembly employees regarding attitudes required for the 4IR in a South African automotive manufacturing organisation

The following themes emerged from the data level: willingness to learn, confidence, positivity, and willingness to accept change.

Assembly employees indicated that they would require a willingness to learn and acquire new capabilities necessary for adaptation into 4IR smart automotive manufacturing. This finding is supported by Holman and Švejdarová (2023), Martiskova (2022), and Verma and Venkatesan (2023), who report that employees' willingness to learn, upskill, and reskill will consistently support their adaptation to 4IR technological changes within the automotive manufacturing sector.

Participants reported that confidence and positivity are essential in the digital era of 4IR smart automotive manufacturing. These findings are supported by Faulk (2023) and Luckow et al. (2018), who argued that for employees to adapt to a new work environment, they must develop certain positive traits, confidence, and behaviours that support effective talent development, as their work identity will be impacted in automotive manufacturing.

Furthermore, the participants indicated that the willingness to accept digital change would be crucial to acquiring new capabilities for adaptation in a 4IR smart automotive manufacturing assembly plant. These findings are supported by Schwab (2016) and the World Economic Forum (2020), who report that organisations heavily rely on technology; therefore, employees need to identify with their work to accept the 4IR digital change rather than resist it.

Objective 5: To explore the perceptions of assembly employees regarding the physical workplace change required for the 4IR in a South African automotive manufacturing organisation

The themes that emerged from this category were digitisation of the assembly plant and automation of the assembly plant.

Assembly employees expressed that the current assembly plant must be digitalised and automated. These findings are supported by Mashilo (2025), Rammai et al. (2025), and Roy (2022), who report that the automotive manufacturing organisations are required to be automated to meet the standards and requirements of the 4IR digitalised assembly work environment.

Objective 6: To explore the perceptions of assembly employees regarding training and other opportunities required for the 4IR in a South African automotive manufacturing organisation

The following themes emerged from this category: AI training, IoT training, big data training, CPPSs training, computer literacy training, and lifelong learning opportunities.

Assembly employees indicated that AI training is essential for adapting to a 4IR digital automotive assembly plant. This finding is supported by Felser and Wynn (2023), King and Cnop (2025), and Zhu (2021), who report the rapid growth of AI in automotive manufacturing organisations in recent years, necessitating employees' willingness and dedication to acquiring new knowledge and skills through training.

Participants shared that IoT and big data analytics training would be essential for implementing 4IR digitalisation within the automotive assembly plant. These findings are confirmed by Dobrovnik et al. (2025), Joussem et al. (2025), and Rincon-Guio et al. (2025), who report that organisations are required to develop employees' capabilities through training and development opportunities on IoT and big data analytics, as well as providing adequate support structures and advanced equipment.

Assembly employees demonstrated that training in CPPSs is crucial for adopting the 4IR digital assembly plant, which is used for assembling autonomous and hybrid electric vehicles. This finding is supported by Llopis-Albert et al. (2024) and Piromalis and Kantaros (2022), who state that automotive manufacturing organisations must provide adequate training on CPPSs and human-machine interaction processes.

Assembly employees indicated that the basic computer literacy training would be necessary for 4IR modern automotive manufacturing within the assembly plant. This finding is confirmed by Kumar et al. (2024), Sehgal, (2020) and Szajna et al. (2021), who state that the implementation of 4IR human-machine interaction requires automotive manufacturing to equip employees with continuous learning for fundamental skills such as basic computer literacy, AI, robotics, and ML.

Furthermore, the assembly employees revealed that the lifelong learning opportunities would be critical for effective embracement of 4IR digital transformation within the automotive assembly plant. This finding is supported by Ali and Abd Latif (2023), Cotterman et al. (2022) and Fatol et al. (2020), who argued that lifelong learning is essential for employees in automotive manufacturing due to the rapid advancement of 4IR technologies, such as AI, robotics, the IoT, cloud computing, and CPPSs.

Objective 7: To explore the perceptions of assembly employees regarding support required for the 4IR in a South African automotive manufacturing organisation

Information sharing was the only theme that emerged from the data. Participants indicated that information sharing would be required within the automotive assembly plant for 4IR digital operations. This finding is confirmed by Ruostela et al. (2015) and Schmidt et al. (2021), who report that employees in automotive manufacturing expect full support, including information sharing, new knowledge management, and fostering positive communication, to accept the 4IR digital transformation.

Practical Implications

South African automotive manufacturing organisations face significant challenges in adapting to the 4IR digitalisation; to address these, developing new capabilities, fostering positivity, providing training opportunities, and offering support for assembly are crucial. This study highlights the challenges within South African automotive manufacturing concerning the new skills required of assembly employees. It offers employers a chance to support their assembly staff in positively embracing 4IR digital changes and adapting to the increasing demand for new capabilities. Recognising the challenges of 4IR enables South African automotive manufacturers to implement capability development initiatives effectively. Additionally, this research supplies a guideline for gaining assembly employees' support in acquiring new skills. Clear communication that educates staff on the benefits and impact of 4IR digitalisation for smart automotive manufacturing—creating modern vehicles—is essential.

For policymakers involved in capabilities development, this research article offers innovative ideas on increasing awareness of new capabilities. It highlights what types of new capabilities, training opportunities, and support strategies can be integrated into automotive manufacturing organisations to assist assembly employees and raise awareness of 4IR technological innovations. It also addresses the challenges new capabilities pose for South African automotive manufacturing organisations and how the support provided to assembly employees could help them smoothly implement new capability development programmes. Additionally, this may encourage assembly employees who have not yet accepted the reality of 4IR to do so, fostering a culture of lifelong learning to adapt to 4IR smart automotive manufacturing organisations. When employees are cared for and feel valued, exploring their perceptions of the capabilities needed for 4IR might positively influence overall engagement and productivity in smart automotive manufacturing.

For the management of the South African automotive manufacturing organisation, this study provides the opportunity to include the new capabilities development plans of assembly employees in the strategic planning objectives for implementing 4IR digitalisation. This study highlights the benefits of investing in lifelong learning for assembly employees to acquire the new capabilities required by 4IR and stay up to date with the latest technological trends in the automotive assembly plant. The findings of this study guide the management of the automotive manufacturing organisation in amending and aligning its policy strategies to meet the demands for new capabilities among assembly employees. Furthermore, this study offers management a broader understanding of how to implement expanded capabilities for assembly employees to adapt to 4IR.

For learning and development practitioners, this article provides a framework for creating and fostering a culture of continuous learning that integrates technical capabilities with soft skills for human-machine interaction to adapt to a 4IR digital automotive assembly plant. This article sheds light on the types and specific crucial training areas for assembly employees to acquire the new relevant capabilities required by 4IR within a smart automotive manufacturing organisation. Learning and development practitioners can implement the findings of this study as guidance for training needs analysis, planning, designing training programmes, and implementation to adapt to a 4IR digital automotive assembly plant. This study can assist with drafting and aligning the capabilities training and development policy, procedures, and practices for assembly employees to adhere to the stipulated rules for training programmes to meet the requirements of the 4IR.

For line managers of assembly employees, this study offers a clear understanding of the behaviours and attitudes that assembly workers need as essential steps in adapting to a 4IR smart automotive assembly plant. It highlights the vital support assembly employees will require to adjust to the digital age of 4IR within automotive assembly plants. By utilising these findings, managers can help shape and update training policies, procedures, and practices for 4IR. This research can guide managers when recommending training for assembly employees to develop relevant new skills for a 4IR smart automotive assembly plant. Line managers can promote a culture of lifelong learning, agility, and innovation, aiding assembly employees in recognising the importance of acquiring the new capabilities demanded by 4IR.

Furthermore, this study shed light for line managers of the assembly employees to understand the importance of providing the assembly employees with the collaborated chain of capabilities, not limited to only skills and knowledge. Line managers can benefit from this article for improved performance assessment and good career conversations for assembly employees during the era of 4IR smart automotive manufacturing.

For assembly employees, this article highlights the responsibility, accountability, necessity, willingness, positivity, proactivity, acceptance, and confidence required to acquire new capabilities in order to remain relevant during the era of 4IR within the automotive assembly plant. The findings of this present study show that assembly employees are a crucial part of becoming more flexible and adaptable to upskill and reskill themselves for the constantly evolving world of work associated with 4IR within the automotive manufacturing sector. This article also emphasises the importance of attending essential training and development programmes and supporting a lifelong learning culture to acquire the new capabilities demanded by 4IR.

Positivity is yet another crucial recommendation made by participants in this study. Participants strongly recommended positive behaviours and attitudes to be willing to accept 4IR digitalisation and to support the culture of lifelong learning to acquire the new, relevant capabilities required by 4IR smart automotive manufacturing organisations (Faulk, 2023; Stofile et al., 2023). Positivity has also been recommended to assist the assembly employees to upskill and reskill themselves to be relevant during the digital era of 4IR smart automotive, building hybrid electric and autonomous vehicles (Bosch & Rossouw, 2021; Bothma et al., 2015; Stofile et al., 2023). Participants also recommended positive behaviours and attitudes to help them identify with their new digital work roles and responsibilities by acquiring the capabilities required by a 4IR smart automotive manufacturing organisation (Gianolli, 2020; Faulk, 2023; Van Tonder, 2018).

Limitations and recommendations

This study explored the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation. The study provided an emic view of the skills and knowledge, behaviours and attitudes, physical workplace changes, training, and other opportunities, as well as the support required for assembly employees to be successful in their tasks within the 4IR. However, the study has certain limitations and consequently recommendations that will be outlined below

The first limitation is the use of semi-structured interviews in a very busy automotive manufacturing assembly plant. Face-to-face individual interviews were not a main priority for assembly employees, and the data collection process was intermittent as the researcher waited for volunteers to share their perspectives. A recommendation for future research is to use qualitative surveys as a data collection technique. However, a limitation of such surveys might be that the researcher will not be able to ask probing and clarifying questions. Secondly, the interviews were conducted in English, which was not the first language of most participants. Some assembly employees might have expressed their perceptions more confidently if the interviews had been conducted in their mother tongue. The latter is a recommendation for future researchers. Thirdly, the study was conducted in one automotive manufacturing organisation in South Africa. A single organisation limits the generalisability of the findings. However, more automotive manufacturing organisations were invited to participate, but only one accepted. More organisations may agree to participate once the findings of this study are published. A recommendation for future research is to include more automotive manufacturing organisations. Lastly, the sample only included assembly employees. This focused sample, therefore, excluded other perspectives, such as those of line managers, who could also provide in-depth data on the capabilities required of assembly employees for the 4IR. The

researcher, however, aimed to gain a deep understanding of the perceptions of those actually performing the job. Including the perceptions of other role-players would detract from the main objective of the study. A recommendation for future research is to explore the perceptions of line managers regarding the required capabilities for the 4IR in a South African automotive organisation.

Conclusion

The study titled “Exploring the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation” concluded by presenting important findings regarding the new capabilities required by the 4IR in an automotive manufacturing industry. This study explored various critical elements of the topic, shedding light on aspects of assembly employees' perceptions regarding 4IR capabilities and organisational support and making recommendations for improvement. Limited knowledge existed regarding the impact of the 4IR on assembly employees' current capabilities, and this study provided a broader understanding of the phenomenon. The study presented contextualised definitions of capabilities for assembly employees in an automotive manufacturing organisation for the 4IR. It also provided the automotive manufacturing organisation with insights into the development strategies for adapting such capabilities for 4IR innovative automotive manufacturing organisations.

In addition, training and other support opportunities for developing new capabilities for assembly employees were identified. This study not only highlighted the new capabilities challenges that automotive manufacturing might face in the assembly plant but also offered employers suggestions to encourage assembly employees to accept 4IR digitalisation and willingly participate in training and development programmes for the new capabilities required in smart automotive manufacturing organisations. The practical implications and limitations of this study were presented, along with recommendations for future research and practice.

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CHAPTER 3

RESEARCH ARTICLE 2

EXPLORING LINE MANAGERS' PERCEPTIONS REGARDING ASSEMBLY EMPLOYEES' CAPABILITIES AND TALENT DEVELOPMENT REQUIRED FOR THE FOURTH INDUSTRIAL REVOLUTION IN A SOUTH AFRICAN AUTOMOTIVE MANUFACTURING ORGANISATION

Orientation: The rapid pace of technological innovations (4IR) in the automotive manufacturing industry associated with the Fourth Industrial Revolution poses a challenge to assembly employees' capabilities. There is a lack of understanding of the capabilities required by the 4IR for assembly employees within the automotive manufacturing industry. The automotive manufacturing industry depends mainly on line managers for developing continuous strategies to cultivate innovative talent and equip assembly employees with relevant new capabilities. However, there is no clear understanding of line managers' perceptions of the capabilities and talent development required of assembly employees by the 4IR for the smart automotive manufacturing assembly plant. This presents the risk that line managers may have to manage digitally operated assembly lines without the new capabilities required by the 4IR.

Research purpose: The purpose of this study was to explore line managers' perceptions of assembly employees' capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation.

Motivation for the study: Line managers in automotive manufacturing assembly plants face a significant challenge as the current capabilities of assembly employees are becoming outdated due to the demands and pressures of 4IR digital assembly line production systems. Understanding the new capabilities and talent development needs of assembly employees for the 4IR is essential for line managers, who play a key role in automotive plant production. These line managers are responsible for implementing fully integrated smart automotive manufacturing digital systems, with assembly employees acquiring new skills to build modern vehicles such as autonomous and hybrid cars. Furthermore, automotive manufacturing organisations depend on line managers' initiative to develop innovative talent strategies and programmes that enable assembly employees to gain new capabilities and remain relevant in the digital era of the 4IR.

Research approach/design and method: This study employed a qualitative research design grounded in constructivism as a paradigm. Purposive sampling was used during data collection. The data were collected from line managers (N=7) currently employed in an automotive manufacturing organisation in South Africa. Data were collected through face-to-face, semi-structured interviews. ATLAS.ti 23 was used to organise and code the data and thematic analysis was applied to analyse it.

Main findings: First, talent development in general and within the automotive manufacturing industry in particular was contextualised from the literature. Second, this study revealed the

importance of inclusive talent development in enhancing assembly employees' capabilities to adapt to the 4IR in an automotive manufacturing organisation. Last, this study found that assembly employees would require significant capabilities across the following categories: skills, knowledge, behaviours, attitudes, equipment, physical workplace changes, training opportunities, and support.

Practical/managerial implications: For line managers and senior executives, this study sheds light on assembly plant line managers' perceptions of the capabilities required of assembly employees to be successful over the next five to ten years. In addition, this study highlights the importance of innovative talent management strategies to ensure that assembly employees possess the required 4IR capabilities. With the aforementioned in mind, appropriate policies can be developed to address the critical need for the 4IR capability development and talent management of assembly employees.

Contribution/value add: This study contributes to the scientific body of knowledge on line managers' perceptions of the capabilities required for the 4IR in the South African automotive manufacturing industry. In addition, this study adds value to the current HRM literature on talent development, specifically in the automotive manufacturing industry. Furthermore, this study significantly contributes to the current literature on HRM by documenting the talent development strategies for effective adaptation to the 4IR in both the South African context and internationally.

INTRODUCTION

The automotive manufacturing industry is currently undergoing a profound transformational challenge that requires urgent attention to keep pace with the evolving digital world of work in this era of the Fourth Industrial Revolution (4IR) (Kheirkhah et al., 2025; Monye et al., 2023; Starecek et al., 2023). This transformation is affecting assembly employees' capabilities, placing pressure on managers to meet the high demand for new skills required for effective digital operations (Starecek et al., 2023; Verma & Venkatesan, 2023). The increased demand for 4IR skills among employees is related to the need to enhance efficiency and production within the automotive manufacturing sector in the digital age (Kheirkhah et al., 2025; Monye et al., 2023; Starecek et al., 2023). However, the accelerated technological advancements have introduced challenges to employee capabilities (Huangfu et al., 2025; Monye et al., 2023).

The success of adopting and implementing 4IR technological innovations in automotive manufacturing organisations largely depends on managers' sustained strategies for developing innovative talent and equipping employees with relevant new skills (Anshari & de Pablos, 2025; Moeketsi & Letaba, 2022; Verma & Venkatesan, 2023). These strategies are crucial for adapting to the ever-evolving digital technologies of the 4IR in the automotive manufacturing sector (Anshari & de Pablos, 2025; Moeketsi & Letaba, 2022; Verma & Venkatesan, 2023).

However, managers in the automotive manufacturing industry lack innovative strategies for employee talent development to foster technological innovation and continuous learning and development (Barkhuizen & Masale, 2022; Macpherson, 2024; Vapiwala et al., 2023). Furthermore, there is a gap in managers' understanding of the types of new capabilities needed for learning and development in relation to 4IR technological innovations within the automotive manufacturing sector (Barkhuizen & Masale, 2022; Rivera et al., 2021).

There is a need for managers in the automotive manufacturing industry to ensure ongoing talent development to improve employees' capabilities for the new world of work associated with the 4IR (Brewster & Brookes, 2024; Debebe, 2023). Managers in this industry should recognise that the 4IR not only requires employees to master new skills and undergo talent development but also calls for a shift in thinking to appreciate the importance of developing new capabilities (Brewster & Brookes, 2024; Kruger & Steyn, 2024; Sen, 2020). The South African automotive manufacturing industry needs to foster a learning culture, which is a vital strategy for managers to consider in the long-term talent development process to equip employees with the necessary new capabilities to adapt to the 4IR (Bolton et al., 2020; Boonbumroongsuk & Rungruang, 2022; Debebe, 2023).

Research purpose and objectives

The objective of this study was to explore line managers' perceptions of assembly employees' capabilities and the talent development required for the 4IR in a South African automotive manufacturing organisation. To achieve this general objective, the following specific objectives were set:

- To conceptualise talent development, and talent development within the automotive manufacturing industry, according to the literature
- To explore the perceptions of line managers regarding the skills and knowledge required by assembly employees for the 4IR in a South African automotive manufacturing organisation
- To explore the perceptions of line managers regarding the behaviours required by assembly employees for the 4IR in a South African automotive manufacturing organisation
- To explore the perceptions of line managers regarding the attitudes required by assembly employees for the 4IR in a South African automotive manufacturing organisation
- To explore the perceptions of line managers regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation

- To explore the perceptions of line managers regarding training and other opportunities required by assembly employees for the 4IR in a South African automotive manufacturing organisation
- To explore the perceptions of line managers regarding the support required by assembly employees for the 4IR in a South African automotive manufacturing organisation
- To make recommendations for future research and practice.

Literature review

Talent development

Talent has been referred to as both natural abilities and accomplished capabilities within the work environment (Gallardo-Gallardo et al., 2013; Skuza et al., 2022). Additionally, talent has been defined as an innate competence that emerges easily, while expertise involves acquired capabilities developed through study, experience and practice (d'Armagnac et al., 2020; Tansley, 2011). In the field of human resources, the term talent refers to top-performing and high-potential employees with capabilities that are beneficial and distinctive to the organisation, varying across environments (Comunian et al., 2021; Vardi & Collings, 2023).

Talent development is defined as a process of improving employees' capabilities and supporting their professional growth through training and personal development plans aligned with organisational strategic objectives (Lim et al., 2024; Nijs et al., 2024). It is also described as a strategic approach to establishing an efficient system for delivering essential training programmes that help employees reskill and upskill in the evolving world of work, driven by technological advancements (Qazi et al., 2023; Yashina et al., 2025). Furthermore, talent development is seen as a key element in supporting employees in acquiring new skills for career progression and adapting to digital transformation in the new world of work, through methods such as mentorship, succession planning, and training (Abid & Polo, 2025; Abiwu & Martins, 2025).

There are two main talent philosophies: talent as innate or developable, and talent as exclusive or inclusive, which are outlined below.

Talent: innate or developable?

The literature on management research emphasises the importance of underlying philosophies of talent, or the essential assumptions and beliefs regarding the development and value of talent (Abid, 2025; Jayaraman et al., 2018; Meyers & van Woerkom, 2014). Researchers argue that the prevailing philosophy about individual talent assumes that talent is innate and develops naturally, meaning it is gradual and predetermined (Abid, 2025; Jayaraman et al., 2018; Meyers & van Woerkom, 2014). This view is supported by the belief that individuals will always be who they are, and nothing can alter that (Dries, 2013). Authors who endorse the inborn concept of talent generally maintain that talent is limited and associated with exceptional brilliance (Abid, 2025; Dries, 2013; Jayaraman et al., 2018; Meyers & van Woerkom, 2014).

Conversely, the developable talent strategy offers many benefits for organisations and has attracted significant attention and high regard (Axiak, 2025; Garavan et al., 2023; Meyers & van Woerkom, 2014). It assumes that continuous effective training leads to high productivity and success in manufacturing industries (Axiak, 2025; Garavan et al., 2023; Meyers & van Woerkom, 2014). When talent is viewed as a developable asset, managers should focus on enhancing workforce capabilities through training programmes, mentorship and coaching, according to Dries (2013), Garavan et al. (2023) and Mabaso and Ontong (2025). The developable talent strategy has been found to be important and reliable in helping employees adapt to the ongoing technological changes associated with the 4IR (Garavan et al., 2023; Mabaso & Ontong, 2025; Pantouvakis & Karakasnaki, 2018). This can be achieved by consistently implementing and evaluating talent development strategies to keep pace with the latest technological innovations (Pantouvakis & Karakasnaki, 2018; Mabaso & Ontong, 2025; Tsaousiotis et al., 2025).

Talent is developable, especially from existing skills and current understanding of traditional manufacturing operations and procedures towards the skills and understanding associated with the 4IR digital world of work (Anshari & de Pablos, 2025; Naidoo & Pretorius, 2025; Schumacher et al., 2016; Tsaousiotis et al., 2025). Managers in manufacturing industries need to cultivate talent to develop the required new capabilities (Anshari & de Pablos, 2025; Naidoo & Pretorius, 2025; Sivathanu & Pillai, 2018). The strategy to develop talent should be applied immediately and consistently following new appointments and the commencement of new duties, as 4IR technological innovations evolve very rapidly (Anshari & de Pablos, 2025; Bayraktar et al., 2018; Hewapathirana & Almasri, 2021). Ongoing talent development ensures that current employees can quickly adapt their skills to meet the demands of the modern, innovative work environment (Anshari & de Pablos, 2025; Hewapathirana & Almasri, 2021; Mazali, 2018).

Talent: exclusive or inclusive?

There is ongoing debate in the management research domain on whether talent should be viewed as exclusive or inclusive (Abid, 2025; Dries, 2013; Tsaousiotis et al., 2025). The exclusive talent philosophy suggests that only a small segment of the workforce possesses significant talent (Abid, 2025; Meyers & van Woerkom, 2014; Shahid, 2025), categorising employees as either top achievers or top potential individuals (Bhatia & Baruah, 2020; Collings & Mellahi, 2009; Peterson et al., 2022). This knowledge-based (exclusive) theory supports prioritising resources for identified talents, especially in manufacturing industries that invest heavily in their top performers (Bonneton et al., 2020; Peterson et al., 2022). Bhatia and Baruah (2020) advocate this approach, emphasising that selecting and developing talents from this pool is essential to various talent management strategies. However, the exclusivity approach is less suitable for preparing employees for the demands of the 4IR (Balliester & Elsheikhi, 2018; Nijs et al., 2024; Peterson et al., 2022; Qazi et al., 2023), as its exclusionary criteria neglect lower-performing employees. Instead, efforts should focus on equipping all employees with the necessary new capabilities (Balliester & Elsheikhi, 2018; Nijs et al., 2024; Qazi et al., 2023).

In contrast with the exclusive talent philosophy, the inclusive talent philosophy considers every employee a potential talent (Abid & Polo, 2025; Graham et al., 2024; Qazi et al., 2023). Furthermore, these authors contend that the entire workforce should be given the opportunity to develop new capabilities and utilise their unique talents in suitable roles within the manufacturing industry (Abid & Polo, 2025; Cummings & Worley, 2014; Graham et al., 2024; Qazi et al., 2023). The primary goal of talent development is to focus on inclusive approaches, identifying both high and low performers to implement talent development strategies across the entire talent pool (Abid & Polo, 2025; Qazi et al., 2023; Shahid, 2025). Workforce development activities should align with organisational talent development plans and procedures that equip all employees with new capabilities (Lambert et al., 2020; Shahid, 2025; Shan & Wang, 2024). This approach will assist manufacturing managers in addressing gaps in employees' required capabilities and in developing and implementing inclusive talent strategies that encompass all staff (Lau et al., 2021; Ostrovska et al., 2025; Shan & Wang, 2024). It will also ensure that manufacturing managers maintain a continuous supply of talented personnel, in both the short and long term, to achieve strategic goals and objectives (Lau et al., 2021; Ostrovska et al., 2025; Shan & Wang, 2024).

The combined outcomes of the unique individual characteristics, competencies, capabilities, commitments, contributions, passions and emotional elements of the workforce are referred to as "talent" (Axiak, 2025; Merello, 2025). These individuals' attributes can be consistently developed as

innate capabilities for all people who value their roles and recognise the importance of the effort they have invested (Axiak, 2025; Merello, 2025; Nijs et al., 2024).

Talent development within the automotive manufacturing industry

The automotive manufacturing industry is experiencing rapid change due to 4IR digitalisation, necessitating the optimisation of talent development models to meet the increasing demand for new capabilities among assembly employees (Carley et al., 2022; Feng et al., 2024; Venkat et al., 2023). Improving talent development is crucial for assembly employees to acquire the new capabilities needed in 4IR digital automotive manufacturing, especially for assembling smart cars such as hybrid electric and autonomous models (Carley et al., 2022; Cotterman et al., 2022; Feng et al., 2024; Padovan, 2020). The automotive manufacturing industry should formulate innovative talent development strategies for assembly employees to adapt to the continuously evolving technological advancements of 4IR digitalisation (Carley et al., 2022; Feng et al., 2024; Morris et al. 2023).

To meet the demands of the 4IR for new capabilities among assembly employees, developing talent strategies aligned with 4IR technological applications in the automotive manufacturing industry is necessary (Morris et al. 2023; Padovan, 2020; Venkat et al., 2023). Traditional talent development approaches in automotive organisations are impacted by the 4IR transformation enabled by artificial intelligence (AI) (Moretti et al., 2021; Venkat et al., 2023). This stems from the effectiveness of AI in deploying robotics, machine learning (ML), the Internet of Things (IoT), and innovative tools and machines to produce smart cars (Ahmadi et al., 2023; Moretti et al., 2021; Prasomphan et al., 2024).

Capabilities for assembly employees in the automotive manufacturing industry

Employees in automotive manufacturing organisations need knowledge and skills in AI, smart machines, robotics, ML, IoT, big data analytics, and CPPS to adapt to 4IR digitalisation (Moeuf et al., 2020; Prasomphan et al., 2024). Assembly workers should also develop new capabilities in basic digital and computer literacy, soft skills and problem-solving to transition successfully to the 4IR era within the automotive industry (Prasomphan et al., 2024; Uduafemhe et al., 2023). Continuous training and lifelong learning are vital for talent development, equipping workers with new skills such as basic computer literacy and digital knowledge (Tzafilkou et al., 2023; Uduafemhe et al., 2023). Additionally, assembly employees need to acquire technical skills, such as electronic skills, to integrate electric car hardware with software and other technologies during the assembly of hybrid electric and autonomous vehicles (Ayres et al., 2021; Berisa, 2024; Tzafilkou et al., 2023).

Furthermore, assembly employees will need electronic skills to operate the electronic control unit which benefits drivers by enhancing safety, efficiency and comfort when using 4IR smart cars (Ayres et al., 2021; Berisa, 2024; Halder et al., 2020). Training in these new capabilities will be part of the talent development objectives aimed at adapting to the 4IR era of smart automotive manufacturing, including the assembly of hybrid electric and driverless cars (Berisa, 2024; Halder et al., 2020; Richards, 2023). The shift towards 4IR digitalisation requires automotive manufacturing to transition to smart digital assembly plant operations using smart tools, laptops and computers (Berisa, 2024; Halder et al., 2020; Richards, 2023). Automotive organisations need to identify new capabilities for assembly employees to operate digital assembly plants equipped with smart computers and laptops (Berisa, 2024; Richards, 2023, Prasomphan et al., 2024).

Individual development plan for 4IR talent development

The 4IR demands that manufacturing organisations provide employees with opportunities to develop personalised plans that foster innovation and creativity, thereby helping them acquire new capabilities aligned with organisational objectives (Agola, 2020; Loumpourdi, 2024; Weinstein, 2020). An individual development plan is regarded as an effective method for employees to identify skills and training gaps that improve talent development towards new capabilities required for the 4IR (Loumpourdi, 2024; Mukhwa, 2024; Sachdev, 2022). Employees are expected to take responsibility for their self-development through personalised plans in this era of the 4IR (Hewapathirana & Almasri, 2021; Li, 2024; Sachdev, 2022).

Furthermore, individual development plans will help employees identify gaps in their skills related to 4IR technologies to remain relevant in CPPS (Hewapathira & Almasri, 2021; Li, 2024; Sachdev, 2022). Liberal education advocates that employees should be empowered to choose and plan their own talent development goals for new capabilities (Bauman, 2003; Sachdev, 2022; Weinstein, 2020). This approach provides employees with the flexibility to select suitable adaptive training programmes to acquire the necessary capabilities for the 4IR (Bessant, 2014; Brown et al., 2020; Ludwig-Ohm et al., 2023).

Moreover, the individual development plan should be prioritised as a key talent development tool to address the capability gap in manufacturing organisations (Govender & Adegbite, 2022; Kohl & Swartz, 2019; Lejeune et al., 2021). Manufacturing organisations can focus on collective talent development needs and gaps, but they cannot overlook the responsibility for employees'

competencies and social capacity to learn in the era of the 4IR (Adolphine, 2021; Brown et al., 2020; Mayer, 2024). The individual development plans will contribute to a coherent talent development strategy and help determine employees' preferences regarding training programmes (Brown et al., 2020; Mayer, 2024; Rana & Rathore, 2023). The individual development plan system will be beneficial for manufacturing organisations in developing and supporting employees in acquiring new capabilities (Gu et al., 2023; Mayer, 2024; Wijaya et al., 2023). This will help manufacturing organisations to meet the demand for employee capabilities resulting from the onset of the 4IR (Coetzee, 2024; Gu et al., 2023; Wijaya et al., 2023).

Employee social networking

Social networks are crucial for sharing information about employees' ability to adapt to the 4IR digitalisation in the manufacturing industry (Govender & Adegbite, 2022; Park & Larson, 2022; Strikwerda, 2022). Employees in manufacturing organisations sometimes connect and interact to discuss common issues related to the new capabilities and to find solutions for 4IR digital operations (Almehairi & Suliman, 2025; Park & Larson, 2022). Manufacturing organisations should provide opportunities for their employees to network with colleagues from other organisations in the same industry regarding the 4IR's required capabilities (Almehairi & Suliman, 2025; Gorski et al., 2023; Purbasari et al., 2023). Social networking can help employees foster innovation and adapt to digital operations by sharing solutions, proposals and strategies across the industry (Almehairi & Suliman, 2025; Govender & Adegbite, 2022; Purbasari et al., 2023). Effective planning and strategies for employees' social networking structures are vital for encouraging and advancing innovative digitalisation in manufacturing to effectively respond to the 4IR (Almehairi & Suliman, 2025; Purbasari et al., 2023).

Furthermore, employee social networks can be established through participation in webinars, conferences and dialogues on new 4IR capabilities for digital manufacturing operations (Richards, 2023; Strikwerda, 2022). Employee social networking will assist organisations in effectively managing knowledge and information sharing regarding new capabilities, involving internal and external industry experts (Gorski, 2023; Schopflin & Walsh, 2019; Strikwerda, 2022). Social networking will enable employees to benchmark the required capabilities and to request them or propose them to management during engagements and consultations on 4IR implementation processes (Gorski, 2023; Govender & Adegbite, 2022). Additionally, social networking will motivate employees to acquire new capabilities, fostering a mindset that views the 4IR digitalisation as about enhancing skills rather than displacing jobs (Govender & Adegbite, 2022; MacGregor, 2018).

Employees' understanding of the business strategy for the 4IR

The rapid technological advancement of the 4IR is transforming the automotive manufacturing industry into smart automotive manufacturing worldwide, including in South Africa (Inyang et al., 2023; Nader et al., 2021). However, this transformation cannot succeed without employees' understanding of the smart automotive manufacturing business strategy (Ferreira et al., 2021; Inyang et al., 2023). The primary concerns and questions of employees often relate to what automotive manufacturing organisations need to achieve when transitioning towards the 4IR technological change (Kapp, 2018). Employees' understanding of the 4IR smart automotive manufacturing business strategy will foster greater collaboration, participation, and co-creation of innovative ideas and solutions, providing a sense of inclusion and appreciation (Ferreira et al., 2021; Wagh et al., 2023). It will also enable smooth participation in talent development programmes aimed at acquiring new capabilities associated with the 4IR (Inyang et al., 2023; Narsi, 2020). Organisations need to involve employees throughout the digital transformation journey to ensure they fully understand the 4IR manufacturing business strategy (Ferreira et al., 2021; Wagh et al., 2023). Providing employees with an understanding of the smart manufacturing business strategy is linked to the ongoing development of their talent, which is essential for acquiring the new capabilities necessary for the 4IR (Kapp, 2018; Wagh et al., 2023).

Furthermore, automotive manufacturing organisations must foster a culture of innovation by clearly communicating the business strategy to employees so they understand their new roles and responsibilities in the 4IR (Balgobind, 2020; Wagh et al., 2023). This transparent communication should demonstrate how the 4IR manufacturing strategy aligns with their redefined roles and the need for new capabilities (Balgobind, 2020). Organisations should ensure that they convey the purpose of 4IR technological change in line with their business strategy, enabling employees to grasp their accountability (Balgobind, 2020; Gomez-Trujillo et al., 2021). When employees are unaware of the manufacturing business strategy, they may find it difficult to support talent development programmes aimed at acquiring new capabilities (Balgobind, 2020; Gomez-Trujillo et al., 2021). Sharing information about the intelligent automotive manufacturing strategy will motivate employees to align with their managers' expectations during the transition to 4IR digital production systems (Balgobind, 2020; Gomez-Trujillo et al., 2021).

Positive attitudes and behaviours towards the 4IR

The 4IR technological transformations require employees to have positive attitudes towards continuous learning in order to acquire the necessary new capabilities and adapt to the evolving

digital world of work (Mthombeni, 2025; Nafukho et al., 2024; Rocco et al., 2024). A positive attitude will increase employees' willingness to accept ongoing digital transformations (Hahm, 2018; Nafukho et al., 2024; Rocco et al., 2024). These digital transformations demand certain attitudes, such as confidence and positive perceptions, from employees to develop the skills needed to remain relevant during the 4IR digital era (Nafukho et al., 2024; Rocco et al., 2024). Furthermore, the 4IR has transformed both how individuals work and live; therefore, it is essential that employees exhibit positive behaviours to acquire new capabilities for smart manufacturing organisations (Adekanmbi & Ukpere, 2022; Nyathi & Oosthuizen, 2023; Oosthuizen, 2022). One of the key behaviours required from employees is proactive engagement in talent development to adapt to 4IR digitalisation within organisations during this era (Adekanmbi & Ukpere, 2022; Nyathi & Oosthuizen, 2023; Oosthuizen, 2022).

RESEARCH METHODOLOGY

This section addresses the research approach, paradigm, designs, context, participants, procedure, data collection methods, data analysis, and trustworthiness.

Research approach

A qualitative research approach was employed for this study. Qualitative research is defined as a fundamental method in social sciences that aims to understand complex situations by collecting and analysing descriptive information (Bober et al., 2025; Tilman et al., 2025). This approach relies on gathering data through open-ended interviews and conversational interactions. It focuses on the "why" rather than the "what" individuals believe about a particular phenomenon under study (Bober et al., 2025; Tilman et al., 2025). The qualitative method seeks to uncover the core motivations, attitudes and assumptions that influence individual behaviour (Rahman, 2016).

Qualitative research commences with suppositions and a collection of interpretive or theoretical frameworks that illuminate the research problems and address the meanings individuals or groups attribute to a social or human problem (Creswell, 2021; Kyngäs, 2020). In addition, qualitative research contributes to the expansion of theories due to its real-life exploration and investigation to obtain a broader understanding of the phenomenon under research (Creswell & Báez, 2020). Moreover, qualitative research is conducted in a specific context; depends on the researcher to collect data; utilises various methods; focuses on participants' points of view, meanings and insights; and is considered and interpretive (Creswell, 2021; Harrison et al., 2020).

The researcher chose a qualitative research approach to obtain a deep understanding of line managers' perceptions of assembly employees' capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation.

There are, however, certain disadvantages to using the qualitative research approach, such as the study findings not being impartially verifiable (Kyngäs, 2020; Mayer, 2015; Rahman, 2017). An additional drawback of qualitative data collection is that it requires a significant amount of time and is labour-intensive; manual tasks such as transcribing interview responses are expensive. The qualitative research approach generates a dialogue between literature and data confirmation, which assists in realising representativeness across a broader scale of situations (Babchuk, 2019; Rossman & Rallis, 2012).

Research paradigm

The constructivist paradigm was utilised as a meta-theoretical lens through which the study's findings were interpreted. The constructivist approach aims to understand the individual's subjective experiences and meaning, how the world is interpreted, and how reality is socially constructed (Aliyu et al., 2014; Kumatongo & Muzata, 2021).

The ontological (nature of reality) assumptions of constructivism are that: (a) social actors are continually reinforcing social phenomena and their associated meanings; (b) researchers' understanding and engagement with society are also constructions; and (c) social interactions influence individuals' understanding of the world (Bryman et al., 2014; Matthews & Ross, 2010).

The epistemological assumptions of the constructivist paradigm include: (a) knowledge is created through exploration and understanding of the meanings individuals assign to a phenomenon and how they interpret it; (b) researchers develop their constructions based on the meanings and interpretations generated by the individuals they study; (c) interpretation is primarily an inductive process because establishing it requires examining the collected data; (d) a fully unbiased study is unfeasible because the research process introduces subjectivity, making it difficult to separate truths and principles; (e) social research is governed by meaning and individual measures rather than by the natural laws of the world; and (f) it is impossible to fully encapsulate or accurately analyse social reality, because broader perspectives and understandings may differ (Ormston et al., 2014).

Line managers in assembly plants engage with one another and attend regular production meetings with the management of the organisation. Moreover, local automotive manufacturing organisations do not operate in isolation but are guided by their international parent companies. There is a constant flow of information regarding vehicle assembly in the 4IR era. Additionally, line managers directly

supervise assembly workers and are well-positioned to develop a contextualised understanding of the future capabilities and talent development expected of these employees. Therefore, the researcher chose constructivism as the research paradigm to explore line managers' subjective perceptions of assembly employees' capabilities and the talent development needed for the 4IR in a South African automotive manufacturing organisation.

Research designs

Literature review design

The literature review is defined as a survey of academic writing sources on a specific subject that provides an overview of current knowledge by encapsulating and synthesising previous research, carefully evaluating and building on existing studies (Lame, 2019; Snyder, 2019). The literature review is also described as a systematic process of gathering information, identifying theories, establishing the current research position, highlighting gaps in knowledge, and demonstrating how a new study fits into broader academic discussions and debates (Cooper et al., 2018).

The following academic sources were consulted during the literature review: Emerald, Google Scholar, Ebscohost, ProQuest, SAE Publications, Sciencedirect, and Host. The sources reviewed in this research included books, reviews, dissertations, theses, abstracts, surveys and research reports. Additionally, scientific research articles from accredited, double-blind, peer-reviewed journals were utilised. Examples of such journals are the *South African Journal of Human Resource Management (SAJHRM)*, *South African Journal of Information Management (SAJIM)*, *African Journal of Science, Technology, Innovation and Development (AJSTID)*, *International Journal of Human Resource Management (IJHRM)*, *Journal of Strategic Human Resource Management (JSHRM)*, *International Journal of Business and Management (IJBm)*, *Journal of Management Development Review (JMDR)*, *Journal of People Management (JPM)* and *Journal of Management Studies and Inquiry (JMSI)*, among others. The search for published scientific research articles primarily focused on the period between 1993 and 2025.

Qualitative empirical design

The present study employed a qualitative descriptive design due to its adaptability and clarity across different social science fields, providing broad perceptions of a specific phenomenon that participants are currently experiencing (Doyle, 2020; Kiviniitty et al., 2023). Research studies utilise the qualitative descriptive approach because of its unique ability to accommodate a range of standard data collection methods (Ayton, 2023; Kostovicova & Knott, 2022). Additionally, many research

studies adopt the qualitative descriptive design primarily to offer direct representations of experiences and understandings within specific disciplines, especially when small-scale studies are relevant to the subject under exploration (Ayton, 2023; Kamau et al., 2023).

The use of a qualitative descriptive approach is essential and relevant for study questions focused on understanding perceptions of a poorly understood field, rather than a well-known topic (Ayton, 2023; Roberts, 2020). Furthermore, a qualitative descriptive approach is often used to facilitate the collection of larger qualitative data samples for the investigation and description of topics in real-life situations (Nguyen et al., 2022; Roberts, 2020). Its use is pertinent, as it provides precise perceptions of and insights into the attributes of specific circumstances, populations and phenomena (Nguyen et al., 2022; Pope & Mays, 2020).

A qualitative descriptive approach is often deemed appropriate for recognising the subjective nature of the issue and the unique experiences of participants, and for presenting findings in a way that directly reflects or closely resembles the language used in the original research question (Bradshaw et al., 2017; Cutler et al., 2021; Randall et al., 2020). Therefore, from a philosophical perspective, the qualitative descriptive method aligns most closely with constructionism and key ideologies that employ explanatory and realistic techniques (Lincoln et al., 2017).

However, the qualitative descriptive design is a valuable approach and useful technique on its own, without relying on ethnography, phenomenology, and grounded theory (Lambert & Lambert, 2012). According to Eldh et al. (2020), this design is inherently subjective; in the current study, each assembly line manager might have a different perspective on the capabilities required for the 4IR in the automotive manufacturing industry. Since the qualitative research design is naturally subjective, it recognises not only the researcher's experience, but also that of the participants (Saunders et al., 2019).

The qualitative descriptive design was adopted in this study to obtain broad, direct perceptions of line managers based on their experiences, providing rich data on the capabilities required for assembly employees to adapt to the 4IR in the South African automotive manufacturing organisation. It facilitated credible conclusions on the influence of effective talent development on the capabilities required by the 4IR and on the improvement of human resources management within the South African automotive manufacturing organisation.

The qualitative descriptive design was appropriate for this study because it was conducted in a natural setting (Saunders et al., 2019; Siedlecki, 2020), where line managers formed perceptions of assembly employees' capabilities and talent development requirements for the 4IR in a South African automotive manufacturing organisation.

Research context

The study was conducted at a well-known automotive manufacturing organisation in South Africa. To preserve the organisation's anonymity, the province where the manufacturing activities are located will not be disclosed. The organisation operates several assembly plants that produce passenger and commercial vehicles for both local and export markets.

Data collection took place on the automotive organisation's premises during the day shift. The office provided for the researcher ensured confidentiality. This office offered a secure environment where line managers could express their thoughts openly and comfortably.

Participants

This study's target population included assembly line operations managers and assembly production and quality engineering line managers in an automotive manufacturing organisation in South Africa. These participants possessed substantial experience in vehicle assembly and overseeing assembly employees.

Purposive sampling was used to select an appropriate subset of the population. The researcher applied this sampling method to ensure that line managers with knowledge of the capabilities and talent development needed for assembly employees to succeed in the 4IR were included in the study (Lamm & Lamm, 2019; Tansey, 2007). To facilitate this process, inclusion and exclusion criteria were established. These criteria are outlined below.

The inclusion criteria pertained to managers who:

- Managed automotive vehicle assembly employees
- Had been appointed to the position for at least 12 months
- Were assembly line operations managers
- Were assembly production and quality manufacturing engineering line managers.

The exclusion criteria for participation in this study pertained to line managers who:

- Did not currently manage assembly employees
- Had been appointed to the position for less than 12 months
- Were working in machine and fabrication plants
- Were working in paint and finishing plants.

Seven ($N=7$) line managers took part in the study. The sample size was determined based on sufficiency and saturation requirements. Each of these criteria is briefly discussed below.

Sufficiency

Sufficiency entails adequate numbers to reflect the range of participants and sites (Vasileiou et al., 2018; Young & Casey, 2019). The automotive manufacturing organisation employed 12 line managers; however, five did not meet the inclusion criteria. In addition, the organisation operated four plants, but only two of these were primarily used for vehicle assembly. A sample of seven assembly line managers was, therefore, sufficient to collect data. Moreover, all plants dedicated to vehicle assembly were included in the sample, ensuring an adequate number of sites were represented.

Saturation

When no new themes emerge from the data and redundancy has been achieved, the data are considered saturated (Ahmed, 2025). After the fifth semi-structured interview, the researcher observed that no new themes arose. Nevertheless, the researcher conducted two additional interviews to confirm data saturation.

TABLE 3.1: Characteristics of line managers ($N=7$)

Item	Category	Frequency	Percentage
Age	31-40	3	43%
	41-50	4	57%
Gender	Male	4	57%
	Female	3	43%
Ethnicity	African	5	72%
	Coloured	1	14%
	Indian	1	14%
Tenure (years of work experience as line manager)	10-14	3	42%
	15-19	2	29%
	20-24	2	29%

Most participants were aged between 41 and 50 years (57%), with the next largest group being 31 to 40 years (27,5%). In terms of gender, 57% were male and 43% female. Regarding ethnicity, 72% identified as African, while 14% identified as either coloured or Indian. In terms of work experience as line managers, those with 10 to 14 years made up 42%, followed by those with 15 to 19 years and 20 to 24 years, both at 29%.

Procedure

Before collecting data, the researcher obtained ethics approval (NWU-00717-23-A4) from the North-West University Economic and Management Sciences Research Ethics Committee (NWU-EMS-REC) to conduct the study.

The researcher contacted decision-making authorities at several South African automotive manufacturing companies via email, inviting them to join the study. A comprehensive letter was sent, detailing the study's goals, participant criteria, data collection methods, estimated interview duration, interview questions, data access, data usage, storage details, and associated risks. Only one organisation responded positively. The researcher then sought approval to conduct the study in that organisation. Approval was granted, and the automotive company designated a coordinator who identified potential participants and arranged interview schedules for data collection.

Before each interview, the researcher explained the ethical considerations to the participant and offered the opportunity to ask questions. Interviews were recorded with participants' permission, as stated in the consent form. The interview questions were shared with the participants beforehand, giving them enough time to prepare.

Throughout this study, the researcher assumed multiple roles. The researcher designed a detailed implementation plan addressing all research aspects. During semi-structured interviews with line managers meeting the inclusion criteria, the researcher served as the data collector. As a data analyst, the researcher examined the data to identify themes and subthemes, with a co-coder assisting. Finally, the researcher presented the study's findings.

Data collection methods

Face-to-face, semi-structured interviews were conducted to gather data. Semi-structured interviews are characterised by a few predetermined questions that enable further probing and exploration during the interview (Adeoye-Olatunde & Olenik, 2021; Longhurst & Johnston, 2023).

Each interview lasted between 40 and 60 minutes. Line managers were also asked to provide their demographic details in a questionnaire during the semi-structured interview. No conclusions were drawn from the demographic data in the study, as it was solely used to describe the sample population's characteristics. The demographic information included age, gender, ethnicity and tenure. Please note that the ethnicity classifications align with the terminology of the Employment Equity Act, 55 of 1998, for designated and non-designated groups. No offence is intended.

The semi-structured interviews were guided by nine preselected questions using an interview guide. However, the interview structure allowed for probing and exploration, yielding rich, thick data (Rugg & Petre, 2007; Seabi et al., 2021). The interview guide is outlined below.

Interview guide

The researcher introduced the interview sessions by saying: “Thank you for the opportunity to ask you a few questions. Before I start with the questions, I want to read you a short statement. Please think about this statement for a moment. My questions will be based on this statement”.

Statement

Technology is advancing very fast. Building cars is getting more and more complex. In the future, new skills and knowledge might be required to build modern cars. This might also have an influence on the behaviours and attitudes of people who need to build these cars.

Interview questions for line managers

1. In your opinion, please describe the **skills**, if any, that assembly employees will need in the next five to ten years.
2. In your opinion, please describe the **knowledge**, if any, that assembly employees will need in the next five to ten years.
3. In your opinion, please describe the **behaviours**, if any, that assembly employees will need in the next five to ten years.
4. In your opinion, please describe the **attitudes**, if any, that assembly employees will need in the next five to ten years.
5. In your opinion, please indicate what **equipment** (tools, machines, computers, etc.), if any, assembly employees will need in the next five to ten years.
6. In your opinion, will the **physical workplace** have to change in the next five to ten years, so that assembly employees will be able to do their job well? Please motivate your answer.
7. In your opinion, what **training**, if any, will assembly employees require to remain employable in the next five to ten years?
8. In your opinion, what **opportunities**, if any, will assembly employees require to remain employable in the next five to ten years?
9. In your opinion, what **support**, if any, will assembly employees require to remain employable in the next five to ten years?

Data analysis

In this study, thematic analysis was used to categorise the raw data into codes and then develop these into semantic themes. Thematic analysis is a method that involves identifying, analysing, reporting and interpreting themes of the phenomenon being examined (Boyatzis, 1998). Furthermore, thematic analysis interprets the contrasting features of the phenomenon under study (Braun & Clarke, 2016). This approach allows researchers to preserve participants' original responses throughout the analysis. The data are therefore not split into contrasting segments solely to select theoretical features (as suggested by Guest et al., 2012).

For this study, the researcher used the six-step data analysis process developed by Creswell (2014). These steps are briefly outlined below.

Step 1. Organising, categorising and preparing data for analysis. During this initial step, the researcher transcribed the recorded data from the semi-structured interviews. Next, the data were categorised according to the study's specific research objectives.

Step 2. Reading the entire dataset and familiarising oneself with the data to gain a shared understanding and reflect on its broader significance. The researcher familiarised himself with the data by reading and rereading the line managers' answers. This step enabled the researcher to develop a deeper understanding of line managers' perspectives on the capabilities and talent development required for 4IR in the automotive manufacturing organisation.

Step 3. Coding and analysing the whole dataset by first determining codes. During this step, the researcher allocated codes to segments of the data. A code list was created to enhance the confirmability of the data analysis process. A collection of direct quotations was compiled to support the allocated codes.

Step 4. Describing and identifying themes. The researcher combined codes into categories and then narratively described these categories, leading to the emergence of themes.

Step 5. Representing and presenting findings on data analysis. During this stage, the researcher presented the study's findings in a qualitative narrative. Figures and direct quotations from the assembly employees supported the narrative.

Step 6. Interpreting the meaning of the data (the final stage). The researcher attributed meaning to the data in the study's discussion section. According to the constructivist paradigm, knowledge about a phenomenon is created when participants' unique perceptions are understood. The researcher's interpretation of the data was guided by the line managers' perceptions of the capabilities and talent development required for 4IR in an automotive manufacturing organisation in South Africa.

ATLAS.ti 23 was used to organise and code the data together with the researcher's promoter.

Trustworthiness

Credibility is achieved by ensuring that findings are reliable and trustworthy from the perspective of the research participants. As qualitative research explores people's ideas, experiences, views, affections and assumptions, research participants are the ideal individuals to determine whether the research findings appropriately reflect their beliefs and feelings (Kumar, 2014). The investigator demonstrated the credibility of this study by describing the context in which the research was conducted – for example, the procedures used and the methods for data collection. Additionally, by applying data triangulation, which involves the use of different data sources in a single research study, credibility was established. The data were, therefore, transcribed verbatim after having been gathered from various research participants. Additionally, the investigator utilised a co-coder to enhance credibility.

Transferability pertains to the validity of a research study (Leedy & Ormrod, 2015). In qualitative studies, findings are context-sensitive and predicated on that; qualitative investigators do not set out the course of action or wish to generalise their data conclusions (Yin, 2015). The qualitative investigator is responsible for providing broad explanations of the study to ensure its transferability. In this study, the researcher collected rich and illustrative data within the context of the South African automotive manufacturing industry, which can be compared to other available contexts in which transferability may be considered. According to Guba (1981), rich and expressive data should be collected based on the researcher's judgment to align with the standards of other available contexts, as this is essential for transferability. In addition, the transferability of the findings in this study was enhanced by using purposive sampling to gather in-depth data from research participants with a broader understanding of the research topic (Maxwell, 2013).

Dependability is concerned with whether other investigators can arrive at comparable findings of a study if analogous processes are duplicated (Trochim et al., 2016). The investigator enhanced the dependability of this study by providing a detailed description of the methodology employed. Furthermore, the study's objectives were clear and aligned with the research methodology. The researcher also explicitly described participants' responses and documented his decisions throughout the study (Creswell, 2021; Leedy & Ormrod, 2015).

Confirmability is described as a point at which other investigators can confirm the findings (Kumar, 2014). Confirmability is also defined as the process in which the data reflect the focal point of the exploration and not the investigator's biases (Lincoln et al. 2017). This confirmability procedure is

regarded as an audit trail (Petty et al., 2012; Lincoln et al., 2017), which involves a reliable investigator reading the findings to establish the confirmability of the study's results. The audit trail represents the steps taken from the beginning of the study to the establishment and presentation of the findings (Lincoln et al. 2017). The confirmability audit trail approach confirms that the data underpin each analysis and that the analysis is consistent with the accessible data (Akkerman et al., 2008; Carcary, 2020). The confirmability audit trail in this study is reflected in the record of how the research was conducted and how the investigator arrived at the conclusions (Carcary, 2020; Given et al., 2023). The researcher ensured confirmability by remaining objective during the study and avoiding the influence of his opinions or values on any results or processes. To this end, the researcher employed a co-coder to validate the findings. In addition, the researcher scheduled regular meetings with his promoter to ensure that the data were analysed correctly and consistently.

Ethical considerations and the protection of personal information

Ethical considerations in research involve principles and rules that ensure the study is conducted responsibly, protects participants and maintains methodological integrity (Busby, 2025; Muskaan et al., 2025). They essentially constitute a combination of principles guiding the selection of research designs and practices (Busby, 2025; Muskaan et al., 2025). It is crucial that all research studies fully adhere to ethical procedures when collecting data or conducting studies involving humans (Almusaed et al., 2025; Tsungmey et al., 2023). The aim of human studies is often to understand real-life situations by exploring specific perspectives, behaviours and beliefs, which requires strict ethical procedures (Almusaed et al., 2025; Tsungmey et al., 2023). Furthermore, ethical considerations ensure that individuals' rights are recognised (Almusaed et al., 2025; Tsungmey et al., 2023).

The core principles of ethical considerations include obtaining informed consent, safeguarding participants' anonymity and confidentiality, allowing voluntary participation, ensuring the fair selection of participants, and maintaining ethical standards throughout the research by being transparent, presenting data honestly, and avoiding conflicts of interest (Kaczmarek et al., 2025; Rodrigues et al., 2024). Ethical conduct involves adhering to standards that protect participants, ensuring moral soundness and fostering trust through practices such as informed consent, confidentiality, harm reduction, and upholding integrity and fairness throughout the research process (Kaczmarek et al., 2025).

The researcher must also stay objective during data collection and ensure that the data are protected (Marlina et al., 2025). To maintain anonymity, the researcher safeguarded participants' confidentiality by using pseudonyms.

The researcher further ensured the anonymity of the information collected from participants by not gathering or storing any identifying details of individual subjects (e.g., name, address, ethnicity, email address, etc.). The data were stored using pseudonyms and reported as group data. The researcher did not link the individual responses to the participants' identities.

The Protection of Personal Information Act (POPIA) (Act 4 of 2013) grants South African research participants specific rights over their personal data, including the right to consent to its handling, the right to understand how the data will be used, and the right to withdraw consent at any time (Adams et al., 2021; Sema et al., 2025). In this study, the researcher followed the principles of POPIA by obtaining full consent, especially for sensitive data, implementing strict data security measures, and clearly informing participants about their control over their information (Adams et al., 2021; Sema et al., 2025).

This study complied with the ethical requirements of the North-West University Research Ethics Committee, which entailed the following:

- Participants had to complete the consent forms to voluntarily participate in the study and return them to the researcher.
- Participants were informed that the information was strictly confidential and solely for use in the present study.
- Participants were informed that participation in this study was voluntary.
- Participants were informed that the withdrawal of participation in this study was allowed.
- The research study would not cause harm to those involved or have a negative impact on participants or the organisation.
- Participants were assured of adherence to the Protection of Personal Information Act (Act 4 of 2013).
- Participants were guaranteed confidentiality and anonymity.
- Participants were all treated equally with full attention, dignity and respect.
- Participants were informed regarding the objectives and purpose of the present study.
- The Ethics Clearance Certificate and approval for the study were obtained from North-West University before the commencement of data collection.

- The researcher was granted permission to conduct the study by the South African automotive manufacturing organisation, with approval from the General Manager through the Human Resource Division.

FINDINGS

This section reports the findings on line managers' perceptions of the required capabilities of assembly employees for the 4IR in an automotive manufacturing organisation in South Africa. Table 2 presents the descriptive statistics of the assembly employees who participated in the study.

TABLE 3.2: Descriptives of line managers ($N=7$)

Participant number	Age	Gender	Ethnicity	Tenure
1	41-50	Male	African	20-24
2	41-50	Male	African	15-9
3	41-50	Female	African	20-24
4	41-50	Male	African	15-9
5	31-40	Male	Coloured	10-14
6	31-40	Female	Indian	10-14
7	31-40	Female	African	10-14

Data were collected from line managers in an automotive manufacturing organisation in South Africa. The aim was to explore the perceptions of line managers regarding the capabilities required for the 4IR in an automotive manufacturing organisation in South Africa. Figure 1 shows the categories and themes extracted from the analysed data.

Category 1: Skills and knowledge

Note to the reader: Due to the convergence of data on required skills and knowledge, the researcher decided to categorise them together.

The line managers were asked to describe the skills and knowledge that assembly employees would require in the next five to ten years, if any. Many line managers stated that assembly employees would need computer literacy; electronic skills and knowledge; and AI, robotics and ML skills and knowledge.

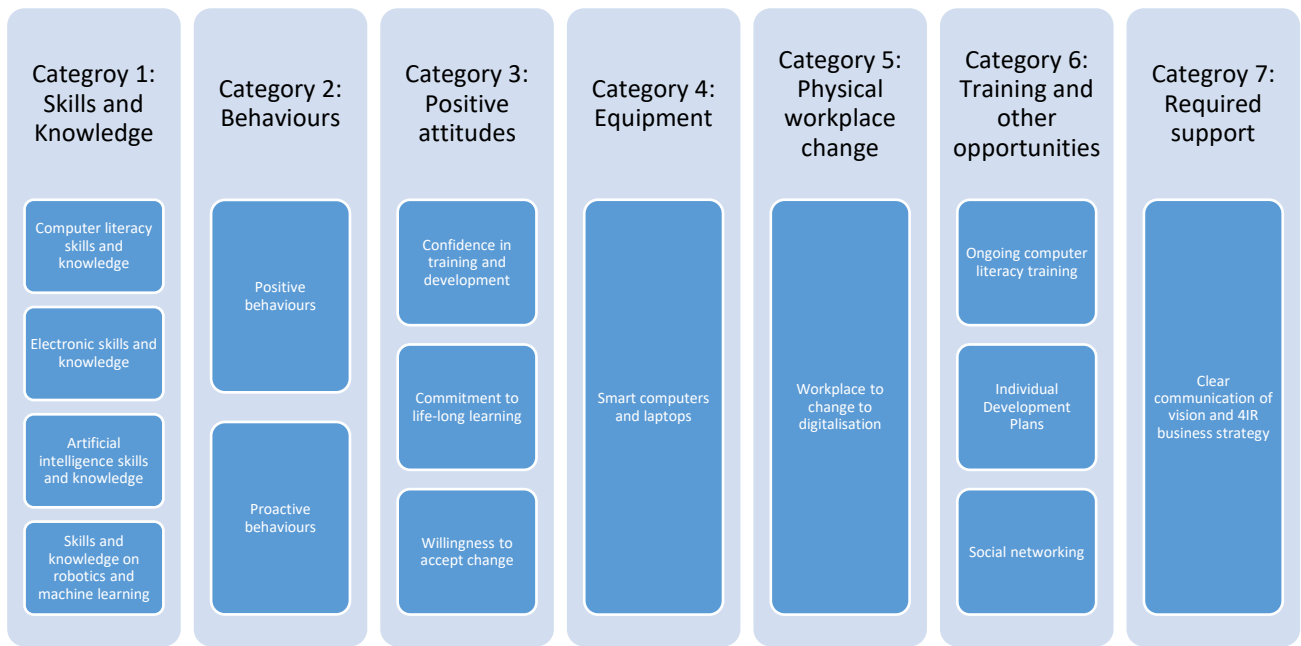


FIGURE 3.1: Overview of categories and themes – participant data

Theme 1: Computer literacy skills and knowledge

Various line managers argued that assembly employees would require basic computer literacy to develop their talents and operate 4IR digital automotive manufacturing integrated systems.

“I think computer literacy skills is very crucial for our assembly employees to develop their talents to operate smart machines, robots and integrated systems on a computer or laptop.” (P-5)

“We must not forget that our assembly employees will require basic computer literacy skills as part of talent development to function in 4IR digital operations with smart robotics and machines.” (P-4)

Theme 2: Electronic skills and knowledge

Several line managers stated that assembly employees would require talent development in electronic skills and knowledge to integrate electronic and software systems into the assembly of hybrid electric and autonomous cars.

“...our assembly employees will be required to develop their talents on electronic skills for integration of software development systems within the smart automotive manufacturing of hybrid electric cars with the latest 4IR innovative automotive trends.” (P-1)

“In my opinion, the electronic knowledge will be crucial in talent development for assembling hybrid electric cars with the integration of electronic and software computerised devices.” (P-6)

Theme 3: Artificial intelligence skills and knowledge

Different line managers highlighted the importance of AI skills and knowledge for assembly employees. Additionally, several line managers emphasised that assembly employees would need

AI skills and knowledge through talent development programmes to adapt to the 4IR digitalisation in South African automotive manufacturing.

“I strongly believe that the assembly employees will require new knowledge on artificial intelligence for 4IR talent development to assemble smart cars in this automotive assembly plant.” (P-6)

“Our assembly employees will be required to have high-level knowledge of the 4IR technological innovation through talent development for adaptation with the mass artificial intelligence systems that transform the automotive manufacturing industry.” (P-2)

Theme 4: Skills and knowledge in robotics and machine learning

Various line managers pointed out that assembly employees would need specific skills and knowledge in robotics and ML to adapt quickly to 4IR smart digital automotive manufacturing of modern cars. Furthermore, different line managers contended that skills and knowledge in ML and robotics should be incorporated into the talent development strategy and process for assembly employees.

“Assembly employees will be required to have innovative talent development to know more about machine learning, robotics systems and operations to swiftly adapt to the 4IR digitalisation of building smart cars.” (P-5)

“I guess the knowledge in the branch of artificial intelligence, such as smart robotics and machine learning, is very important for inclusion in talent development programmes for adaptation into 4IR.” (P-4)

Category 2: Behaviours

Line managers were asked to describe the behaviours, if any, that assembly employees would need in the next five to ten years. Most line managers emphasised the importance of positive and proactive behaviours.

Theme 1: Positive behaviours

Several line managers stated that assembly employees would need positive behaviours to support a culture of lifelong learning, thereby enabling talent development programmes to foster the new capabilities necessary for adapting to 4IR digital automotive manufacturing.

“It seems to me that the assembly employees must have a good and positive behaviour that effectively supports the culture of lifelong learning or their own benefits in this automotive manufacturing plant.” (P-2)

“I guess the assembly employees in this automotive assembly plant must show positive behaviour so that we can provide them with the talent development programmes to acquire new capabilities required for 4IR.” (P-6)

Theme 2: Proactive behaviours

Many line managers argued that assembly employees would require proactive behaviours and open-mindedness to develop their talents for adapting to the ongoing technological innovations of the 4IR. Furthermore, various line managers insisted that assembly employees would need proactive behaviours to prepare for widespread digital automotive manufacturing involving the assembly of autonomous and hybrid electric cars, with the integration of smart machines and robots.

“It is essential that our assembly employees behave positively and have open mindsets to develop their talents to address the issue of new capabilities and adapt to the ever-lasting technological innovations of 4IR.” (P-5)

“...positive behaviours will help our assembly employees to develop their talents and prepare themselves for the mass software digital automotive manufacturing to assemble autonomous and hybrid electric cars with the assistance of smart machines and robots in this assembly plant.” (P-4)

Category 3: Positive attitudes

Line managers were asked to describe the attitudes, if any, that assembly employees would need in the next five to ten years. Various line managers argued that assembly employees would require positive attitudes, such as confidence, a commitment to lifelong learning, and a willingness to accept change.

Theme 1: Confidence in talent development

Several line managers argued that assembly employees would need confidence in talent development programmes to acquire new capabilities for swift adaptation to digitalisation.

“I am certain that the assembly employees’ positive attitude will lead to positive learning programmes for talent development and a change management process to swiftly adapt to 4IR smart automotive manufacturing in this plant.” (P-1)

“I definitely think positive attitudes will result in the assembly employees’ smooth talent development, commitment to acquiring new capabilities for the 4IR technological era in this automotive manufacturing organisation.” (P-3)

Theme 2: Commitment to lifelong learning

Various line managers maintained that assembly workers would need positive attitudes to foster a culture of lifelong learning, helping them develop the skills necessary for new human-machine operations in 4IR digital automotive manufacturing.

“I am of the view that the positive attitudes will increase the momentum of talent development for a culture of lifelong learning for assembly employees to acquire new capabilities required to operate in 4IR digital automotive.” (P-5)

“It is crucial that our assembly employees, through a positive attitude, participate in talent development programmes for technological change and support the culture of continuous learning to acquire new capabilities required for 4IR human-machine operations.” (P-2)

Theme 3: Willingness to accept change

Several line managers argued that assembly employees would need the willingness to adopt 4IR digital automotive manufacturing, support ongoing talent development and master the new capabilities required.

“Through the acceptance and willingness to change behaviour, we will be able to assist the assembly employees to develop their talents for new capabilities required for 4IR to build hybrid electric cars.” (P-5)

“...assembly employees should be willing to accept 4IR digital automotive manufacturing and support the continuous talent development processes to acquire the required new capabilities for automation.” (P-6)

Category 4: Equipment

Line managers were asked to indicate which equipment (tools, machines, computers, etc.) assembly employees would need in the next five to ten years, if any. According to the participants, assembly employees would require smart computers and laptops.

Theme 1: Smart computers and laptops

Many line managers stated that assembly employees would require smart computers and laptops as fundamental tools for information sharing and updates through IoT connectivity.

“I can say the smart computers and laptops will be the fundamental tools that will be required for assembly employees to function digitally.” (P-4)

“I think the Internet of Things connectivity, smart computers and laptops, smart screens will be required for sharing of information and updates for smart automotive manufacturing during the 4IR digital plant production.” (P-6)

Category 5: Physical workplace

Line managers were asked whether the physical workplace would need to change over the next five to ten years so that assembly employees could do their jobs well. Line managers were also asked to motivate their answers.

Theme 1: Workplace change to digitalisation

Most line managers stated that the workplace should change to accommodate 4IR digital and software tools, as well as soft-touch machines.

“I can assure you that the physical workplace will change because we will be operating most of our assembly lines digitally with many software systems, soft touches, working on the computerised systems for what we call smart automotive manufacturing.” (P-2)

“Yes, it must change because we must represent the 4IR digital automotive production plant with the big screens inside the plant sharing information, feedback and updates of the production.” (P-4)

Category 6: Training and other opportunities

Line managers were asked what training and other opportunities, if any, assembly employees would require to remain employable in the next five to ten years. The participants indicated that basic computer literacy training would be crucial.

Theme 1: Ongoing basic computer literacy training

Many line managers reported that assembly employees would require continuous training and development programmes in basic computer literacy skills to adapt to and remain relevant in 4IR smart automotive manufacturing. Several line managers indicated that assembly employees would require training in Microsoft Word, Excel, PowerPoint, Outlook and Microsoft Teams.

“I suggest that the training and development programmes focus on computer literacy skills such as Word, Excel, PowerPoint, Outlook, and MS Teams that must be continuous for digital functioning and adaptation into 4IR smart automotive manufacturing.” (P-4)

“We should provide ongoing basic computer literacy skills training with Microsoft Word, Excel, Internet, Outlook, MS Teams and PowerPoint for our assembly employees to operate smart automotive manufacturing systems of 4IR.” (P-1)

Theme 2: Individual development plans

The findings showed that an individual development plan is essential for assembly employees as a talent development strategy to adapt to 4IR smart automotive manufacturing. The individual

development plans act as indicators of talent gaps that need to be addressed and highlight the types of new skills required for the digital automotive manufacturing era of the 4IR.

“I suggest that we grant assembly employees an opportunity for individual development plans as a good talent development strategy for identifying talent gaps, choosing and improving training and development for new capabilities required for 4IR smart automotive manufacturing.” (P-3)

“I think we need to support our assembly employees by initiating the individual development plan programmes to outline the talent shortage and select relevant 4IR training to respond to the high demand and enhance their capabilities in this automotive manufacturing plant.” (P-1)

Theme 3: Social networking

The findings suggest that assembly employees need opportunities to develop social networks through participation in global and local digital automotive manufacturing 4IR indabas, dialogues, workshops and conferences centred on new capabilities. Line managers believed that social networks could help employees share common challenges related to the new skills required by the 4IR. Furthermore, participants indicated that social networks could help assembly employees benchmark the new skills necessary for the 4IR in the South African automotive industry. Additionally, the findings imply that social networks will motivate employees to share innovative ideas, preparing them for 4IR smart automotive manufacturing, including the assembly of hybrid and autonomous vehicles.

“Social networks with local and global automotive manufacturing conferences and webinars on 4IR digital indaba will help our assembly employees to benchmark for new capabilities, interact and connect for sharing innovative ideas and solutions, resolving similar capabilities challenges for the assembly plant.” (P-3)

“...it is crucial that assembly employees get opportunities for 4IR digital automotive manufacturing indaba, dialogues to socially network, interact and connect to share ideas in solving new capabilities issues, benchmark on innovation and new capabilities for assembling modern cars.” (P-6).

Category 7: Support

Line managers were asked what support, if any, assembly employees might need to remain employable over the next five to ten years. The majority of participants indicated that assembly employees could be supported by clearly communicating the 4IR business strategy.

Theme 1: Clear communication of vision and 4IR business strategy

According to the findings, assembly employees need a clear understanding of the 4IR smart automotive manufacturing strategic plan to assemble hybrid and electronic cars. This business strategy should be communicated effectively to help assembly employees understand how 4IR technological innovations will be integrated into their new roles and responsibilities. Supporting assembly employees in understanding the business strategy will give them a clear goal and purpose for transitioning to 4IR digitalisation in a South African automotive manufacturing organisation.

“...4IR automotive manufacturing business strategy must be clearly communicated to assembly employees for understanding, participation and support in talent development programmes to acquire new capabilities for digital assembly roles and responsibilities.” (P-3)

“We need to communicate and share information to our assembly employees to understand purpose of 4IR smart automotive manufacturing business strategy that is aligned with the new roles and functions for smoothly acquiring required capabilities.” (P-2).

DISCUSSION

This section discusses the findings in relation to the specific research objectives for this study.

Outline of findings

Objective 1: Conceptualise talent development, and talent development within the automotive manufacturing industry, according to the literature

Talent has been referred to as both natural abilities and accomplished capabilities within the work environment (Gallardo-Gallardo et al., 2013; Skuza et al., 2022). While talent is also defined as an innate competence that comes easily, expertise is the capability developed through studying, experience and practice (d'Armagnac et al., 2020; Tansley, 2011). In the field of human resources, the term talent refers to top-performing and high-potential employees with capabilities that are beneficial and distinctive to the organisation, varying across environments (Comunian et al., 2021; Vardi & Collings, 2023). The debate among scholars on the nature of talent is summarised in two main approaches: that talent is innate (individuals either possess talent in an area or not) or developable (talent can be cultivated through training), as opposed to the view that talent is either exclusive (only a small number of employees have significant talent and should receive resources) or inclusive (all employees have potential talent and should be given opportunities to develop it) (Sivathanu & Pillai, 2018; Lambert et al., 2020).

The automotive manufacturing industry is undergoing significant change due to rapid digitalisation driven by the 4IR (Feng et al., 2024). Assembly employees in this industry need new capabilities to keep up with technological progress (Carley et al., 2022). It follows then that talent development strategies need to adapt to address the capability needs of these employees (Morris, 2023; Venkat et al., 2023). Talent development approaches in the automotive manufacturing industry are generally driven by the advancements in AI, ML, robotics, IoT and CPPS (Ahmad et al., 2023; Prasomphan et al., 2024). Other capabilities that assembly employees will require include big data analytics (Moeuf et al., 2020; Prasomphan et al., 2024), basic digital and computer literacy, soft skills, problem-solving (Lanham et al., 2020; Uduafemhe et al., 2023), and electronic skills (Ayres et al., 2021; Tzafilkou et al., 2023). To address these required capabilities, individualised talent development plans (Li, 2024; Mukhwa, 2024); employee social networking (Gorski et al., 2023; Mayer, 2024; Purbasari et al., 2023); and clearly communicating the 4IR business strategy to assembly employees (Inyang et al., 2023; Wagh et al., 2023) are proposed as talent development strategies.

Objective 2: Explore the perceptions of line managers regarding the skills and knowledge required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The themes that emerged from the data were basic computer skills and knowledge, electronic skills and knowledge, and skills related to AI, robotics and ML.

The present study found that assembly employees would require basic computer literacy skills and knowledge for 4IR digital operations involving smart machines and robotics in the assembly of smart cars. This finding is supported by Prasomphan et al. (2024) and Uduafemhe et al. (2023), who recommend that assembly employees should have ongoing training in basic digital and computer literacy to support a successful transition to the 4IR era in the automotive manufacturing industry.

Furthermore, assembly employees will need electronic skills and knowledge to integrate electronic and software systems for the assembly of hybrid electric and autonomous vehicles. The research of Ayres et al. (2021), Berisa, (2024) and Tzafilkou et al. (2022) concurs with the findings of the present study, highlighting that electronic skills and knowledge are crucial for integrating electric car hardware components with software and technological applications to assemble hybrid electric and autonomous vehicles.

Line managers identified knowledge and skills related to AI, robotics and ML as crucial 4IR capabilities for assembly employees. These digital technologies are necessary for assembly

employees to adapt to 4IR digitalisation (Moeuf et al., 2020; Prasomphat et al., 2024). Closely related to the aforementioned, the findings of Moeuf et al. (2020) and Prasomphan et al., (2024) further highlight that smart machines, IoT, big data analytics and cyber-physical skills and knowledge are essential 4IR skills in the automotive industry.

Objective 3: Explore the perceptions of line managers regarding the behaviours required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The themes that emerged from the data were positive, proactive behaviours for developing new capabilities required for the 4IR.

The present study revealed that assembly employees would need positive behaviours to support a culture of lifelong learning, thereby enabling talent development programmes to foster the new capabilities necessary for adaptation to 4IR digital automotive manufacturing. These findings are corroborated by Adekanmbi and Ukpere (2022), Nyathi and Oosthuizen (2023) and Oosthuizen (2022), who state that the 4IR has transformed the way people work and live, hence it is essential that employees possess the positive behaviours to acquire new capabilities for smart manufacturing organisations.

This study found that assembly employees required proactive behaviours and open-mindedness to develop their talents to adapt to the ongoing technological innovations of the 4IR. This finding is supported by Adekanmbi and Ukpere (2022), Nyathi and Oosthuizen (2023) and Oosthuizen (2022), who argue that critical proactive behaviours are related to talent development to adapt to 4IR digitalisation within organisations during the era of the 4IR.

Objective 4: Explore the perceptions of line managers regarding the attitudes required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The present study found that assembly employees would require positive attitudes, such as confidence, a commitment to lifelong learning, and a willingness to accept change.

The findings of this study indicate that assembly employees will need confidence in talent development programmes to acquire new skills for quick adaptation to digitalisation. This is supported by Nafukho et al. (2024) and Rocco et al. (2024), who emphasise that digital

transformations require certain attitudes in assembly employees, such as strong confidence and positive perceptions, to develop new capabilities and stay relevant during the digital era of the 4IR.

Most line managers stated that assembly workers would need positive attitudes to foster a culture of lifelong learning, which should help them develop the skills necessary for new human-machine operations in 4IR digital automotive manufacturing. This finding is supported by Mthombeni (2025), Nafukho et al. (2024) and Rocco et al. (2024), who indicate that 4IR technological changes require employees to be prepared with a positive attitude to continuous learning to acquire new capabilities and adapt to the new digital work environment.

Several line managers argued that assembly employees would need the willingness to adopt 4IR digital automotive manufacturing, support ongoing talent development and master the new capabilities required. This finding is supported by Hahm (2018), Nafukho et al. (2024) and Rocco et al. (2024), who indicate that positive attitudes towards the 4IR world of work will strengthen employees' willingness to accept ongoing digital transformations.

Objective 5: Explore the perceptions of line managers regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation

This study found that the automotive manufacturing assembly plant should adopt 4IR digitalisation.

Most line managers in this study expressed the need for the workplace to adapt by incorporating 4IR digital and software tools, along with soft-touch machines. This finding aligns with Berisa (2024) Halder et al. (2020) and Richards (2023), who argue that the move towards 4IR digitalisation necessitates shifting to smart digital assembly plant operations using intelligent tools, laptops and computers.

Objective 6: Explore the perceptions of line managers regarding training and other opportunities required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The themes that emerged from the data were ongoing basic computer literacy training, individual development plans, and social networking opportunities.

The present study found that assembly employees would require ongoing basic computer literacy training to operate digital automotive manufacturing integrated systems and remain employable in the 4IR era. The research of Tzafilkou et al. (2023) and Uduafemhe et al. (2023) support this finding by noting that lifelong learning is required for talent development processes to equip the assembly employees with new capabilities like basic computer literacy.

Another theme that emerged from the data was that individual development plans were required for assembly employees as a strategy for talent development to adapt to 4IR smart automotive manufacturing. Brown et al. (2020), Mayer (2024) and Rana and Rathore (2023) found that individual development plans would ensure a coherent talent development strategy by enabling employees to identify the types of training programmes to be offered.

Furthermore, the current study demonstrated that individual development plans would help assembly employees enhance their capabilities through relevant training to meet the demands of 4IR capabilities. Hewapathirana and Almasri (2021), Li (2024) and Sachdev (2022) agree with this finding, stating that employees must take responsibility for their own development through individual development plans in this era of new capabilities required to adapt to the constantly changing digitalisation of the 4IR. Additionally, employees should be empowered to choose and plan their own goals for talent development to gain new skills (Bauman, 2003; Lejeune et al., 2021; Weinstein, 2020).

The study also found that assembly employees should be given the opportunity and flexibility to identify their talent gaps and acquire the new capabilities required for the 4IR within the South African automotive manufacturing organisation. Various studies concur with this finding and argue that individual talent development will give employees the flexibility to choose relevant adaptive training programmes to acquire the new capabilities required (Bessant, 2014; Brown et al., 2020; Ludwig-Ohm et al., 2023).

Another theme that was identified was social network opportunities. Line managers indicated that assembly employees would require opportunities for social networks such as attending global and local digital automotive manufacturing 4IR indabas, dialogues, workshops and conferences on new capabilities. The findings of the present study are consistent with the assertion that 4IR capabilities for digital manufacturing operations can be facilitated through social networks such as webinars, conferences and dialogues (Strikwerda, 2022). Furthermore, such social networks could assist assembly employees from various automotive manufacturing organisations to share common challenges associated with capabilities required by the 4IR. This finding is congruent with those of Almehairi & Suliman (2025) and Park and Larson (2022), who note that employees in manufacturing

organisations sometimes interact and connect to share similar issues related to new capabilities and try to provide solutions for 4IR digital operations. Furthermore, Almehairi & Suliman (2025), Gorski et al. (2023) and Purbasari et al. (2023) urge manufacturing organisations to afford their employees opportunities to engage in social networking with employees from other manufacturing organisations within the same industry.

Additionally, this study found that social networking could promote innovation in the South African automotive manufacturing organisation. This finding is corroborated by Purbasari et al. (2023), who argue that proper planning and strategies for employees' social networking can encourage and advance innovative digitalisation in manufacturing. Another finding of this study suggests that social networks will assist assembly employees to benchmark which new capabilities will be required for the 4IR in the South African automotive manufacturing industry. This premise is supported by Gorski (2023) and Govender and Adegbite (2022), who found that social networking would help employees benchmark new capabilities and engage management accordingly.

Objective 7: Explore the perceptions of line managers regarding the support required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The theme that emerged from the data was that of clear communication of the vision and 4IR business strategy. Management can support assembly employees by explaining the smart automotive manufacturing strategic business plan to assemble hybrid and electric vehicles. Scholars agree that the transition to 4IR automotive manufacturing will not be successful if employees do not understand their roles and responsibilities inherent in the new business strategy (Ferreira et al., 2021; Inyang et al., 2023). Furthermore, according to this study, understanding the business strategy could give assembly employees clear goals and a sense of purpose regarding the transition to 4IR digitalisation within a South African automotive manufacturing organisation. This finding is supported by Balgobind (2020) and Gomez (2021), who argue that automotive manufacturing organisations should communicate the purpose of 4IR technological change in the context of their business strategy; if employees are uninformed regarding the manufacturing business strategy, it will be difficult for them to support the talent development programmes to acquire new capabilities.

This study also highlights that understanding the automotive manufacturing business strategy will ensure the buy-in, collaboration and inclusion of assembly employees in the transition to 4IR smart automotive manufacturing. The finding is supported by Ferreira et al. (2021) and Wagh et al. (2023), who state that employees' understanding of the 4IR smart automotive manufacturing business

strategy will increase their collaboration, participation and co-creating of innovative ideas and solutions, making them feel included and appreciated.

Furthermore, the present study showed that understanding the automotive manufacturing business strategy would encourage assembly employees to participate in the talent development programmes to acquire the capabilities required by the 4IR. Inyang et al. (2023) and Narsi (2020) found that employees' understanding of the smart automotive manufacturing business strategy would ensure full participation in the talent development programmes to master the capabilities required for the 4IR.

Information sharing was highlighted as a support strategy for assembly employees' understanding of the business strategy of a South African automotive manufacturing organisation. Balgobind (2020) and Gomez (2021) found that sharing information on the smart automotive manufacturing business strategy would motivate employees to support managers in the transition to the 4IR digital production systems.

Objective 8: Make recommendations for future research and practice

This objective is dealt with in the *Limitations and recommendations* section.

Practical implications

South African automotive manufacturing organisations face numerous challenges in assembly plants. These challenges stem from 4IR digitalisation, which demands new skills from assembly employees, resulting in talent development issues and gaps. Addressing these challenges requires innovative talent development strategies, relevant training programmes, and commitment from automotive manufacturing organisations. This study highlighted line managers' perceptions of the capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation. The practical implications of this study are outlined below.

For management, this study sheds light on assembly plant line managers' perceptions of the capabilities required of assembly employees to be successful over the next five to ten years. The observations of the line managers can be viewed as an indication of the readiness of assembly employees for 4IR-driven cyber-physical automotive manufacturing. In addition, this study highlights

the importance of innovative talent management strategies to equip assembly employees with the required 4IR capabilities. With the aforementioned in mind, management can ensure that appropriate policies are formulated to address the critical need for the 4IR-related capability development and talent management of assembly employees. Procedures for AI-inspired automotive manufacturing systems must also be created. The recommendations of this study will have implications for budgetary allocations for learning and development as well as infrastructure development.

For assembly line managers, this study identifies the capabilities and talent development that assembly employees will require to be productive in a 4IR-driven automotive manufacturing environment. Line managers must be upskilled in 4IR technologies to lead and support a team of assembly employees effectively. To fulfil this leadership and support function, line managers' duties will include mentoring for long-term talent development and coaching for short-term capability development. Line managers will be responsible for implementing policies on critical capability development and talent management.

The current study provides insight into the critical capability development required of assembly employees. Learning and development practitioners within the automotive manufacturing organisation can use the study's findings to formulate an integrated learning and development strategy for assembly employees, ensuring 4IR readiness.

For assembly employees, this study sheds light on the capabilities and talent development required of them for the 4IR, as seen from the perspective of assembly plant line managers. The findings of this study, therefore, raise awareness of critical 4IR-required capabilities and can be viewed as a valuable resource for assembly employees.

Limitations and recommendations

This study examined line managers' perceptions of assembly employees' capabilities and talent development necessary for the 4IR within a South African automotive manufacturing organisation. While the study enhanced understanding of the phenomenon, it is important to consider its limitations.

The first limitation is the use of a qualitative research design. Qualitative approaches do not support the generalisation of research findings. However, the purpose of this study was not to generalise the

findings to the broader industry, but to gain a deeper understanding of the capabilities and talent development necessary for the 4IR within a major South African automotive manufacturing organisation. Second, the sample size was limited, but it included all the organisation's assembly line managers who met the study's inclusion criteria, and rich data were collected. Third, the sample involved line managers from only one automotive manufacturing organisation in South Africa. While more automotive manufacturing organisations were approached, only one organisation accepted the invitation to participate. Fourth, individual open-ended semi-structured interviews were conducted to gather the data. This data gathering technique was time-consuming for line managers with critical production responsibilities at the assembly lines. However, the researcher was patient and flexible and interviewed the line managers at a time that suited them. Once the interviews had commenced, the line managers participated fully, and rich data were collected. Fifth, this study explored only line managers' perceptions of the capabilities and talent development required of assembly employees for the 4IR. It could be argued that the perceptions of assembly employees and learning and development practitioners were equally important. However, this study aimed to better understand line managers' perceptions, as they were uniquely positioned to provide expert opinions on the topic.

Future studies could employ a quantitative research design to enhance the generalisability of the findings to the automotive industry. Additionally, the sample size could be increased by including line managers from multiple automotive manufacturing organisations. This would enrich the data by allowing more voices to be heard. Future researchers might consider using qualitative surveys to gather data from line managers, as such surveys can be completed at more convenient times and some participants may prefer textual responses over verbal ones. Future studies may also explore the perceptions of assembly employees regarding the capabilities and talent development needed for the 4IR within a South African automotive manufacturing organisation. The perceptions of learning and development practitioners could also be examined in future scholarly work. The researcher recommends conducting mixed methods research with a larger sample size, encompassing various categories of line managers within a South African automotive manufacturing organisation. This expanded mixed methods approach should include various categories of line managers, such as product, quality assurance, manufacturing engineering, technical support, supply chain management, painting and finishing, and information technology line managers, as well as research and development line managers who create new technologies, materials and processes for new car models. These diverse groups of plant line managers work collaboratively with assembly line operations to ensure that vehicles are designed innovatively, produced efficiently, and manufactured to high standards.

Recommendations for automotive manufacturing organisations

South African automotive manufacturing organisations can utilise the findings of this study to refine and enhance their current talent development strategies, helping assembly employees acquire new skills needed for the 4IR. These findings can also support automotive manufacturing organisations in managing challenges related to new capabilities and talent gaps within the assembly plant. Additionally, a support system should be established that encourages assembly employees to foster positive behaviours towards talent development programmes, enabling them to acquire the new capabilities demanded by the 4IR. Promoting positive behaviours involves encouraging assembly employees to participate in lifelong learning programmes with open minds in order to develop their talents and acquire new capabilities and to adapt effectively to 4IR smart automotive manufacturing.

Another recommendation for South African automotive manufacturing organisations is to encourage assembly employees to adopt a positive attitude towards the 4IR transition to smart automotive manufacturing of hybrid electric and autonomous cars. It is proposed that South African automotive manufacturers support assembly employees in developing a positive attitude when engaging with talent development programmes, such as lifelong learning, to acquire the relevant new skills needed for the 4IR. A positive attitude among assembly employees would boost confidence in developing their talents to remain relevant in 4IR smart automotive manufacturing. Automotive manufacturing organisations should support their assembly employees through the digital transition associated with the 4IR to increase their willingness to embrace change and to continuously learn and acquire new capabilities through talent development programmes.

A notable recommendation in this research article is the need to provide opportunities for assembly employees within the South African automotive manufacturing organisation. For instance, support mechanisms, such as the individual development plan and social networking, were proposed as key talent development strategies to help assembly employees acquire the relevant capabilities required by the 4IR. The individual development plan emerged as a significant recommendation for assembly employees to identify their talent gaps and specify the types of new capabilities needed for talent development programmes to adapt to 4IR smart automotive manufacturing.

Social networking is strongly recommended for South African automotive manufacturing organisations to enable assembly employees to benchmark new capabilities and interact with colleagues from various firms within South Africa. These assembly employees might share similar

capability challenges and develop collective innovative solutions to adapt to 4IR digitalisation. This recommendation aims to address the significant talent gaps in new capabilities that the current research addressed.

Awareness and understanding of 4IR business strategy among assembly employees is a crucial recommendation for supporting automotive manufacturing organisations in South Africa. It is highly advisable for these organisations to clearly communicate the 4IR business strategic plan and objectives to their assembly employees. This will enable employees to commit to, collaborate on, and participate in 4IR digitalisation initiatives for smart automotive manufacturing, helping them see the purpose and importance of acquiring new skills through talent development programmes. Such support would motivate assembly employees to have clear goals and objectives aligned with the 4IR business strategy for automotive manufacturing organisations. This alignment will help them develop goals and plans consistent with the new responsibilities of producing smart vehicles.

Another recommendation for automotive manufacturing organisations is to transition from a physical workplace to digitalisation for a 4IR smart assembly plant to build smart vehicles. The evolution of current automotive manufacturing organisations towards digital systems will be essential as 4IR technologies—AI, robotics, innovative tools and machines, IoT, big data analytics, and more—proliferate across the industry. Leading-edge digital assembly workspaces incorporating technological applications, such as ML, are recommended to enhance the efficiency and quality of modern vehicle production.

Another essential recommendation for automotive manufacturing organisations is to provide assembly employees with relevant equipment, such as smart laptops, computers and self-service touch screens, as fundamental tools during the era of 4IR smart automotive manufacturing. Automotive manufacturing organisations should consider this recommendation, as most assembly plant operations will be digitalised, connected via the IoT, and accessed on smart computers and laptops.

One notable recommendation from this research is the importance of knowledge and skills in adapting to 4IR smart automotive manufacturing. It is crucial for automotive manufacturing organisations to include fundamental computer literacy, electronics, artificial intelligence, smart robotics and machine learning in their talent development programmes. This will allow automotive manufacturing organisations to equip assembly employees with the relevant skills for the new capabilities required by 4IR smart assembly plants.

Automotive manufacturing organisations can utilise the recommended strategies to improve their talent development programmes and provide assembly employees with opportunities for 4IR smart automotive manufacturing. This important recommendation will help the automotive manufacturing industry to address new capability challenges and talent gaps. Applying these key recommendations in the automotive manufacturing environment would also create an adaptable working environment for 4IR smart automotive manufacturing.

Conclusion

The present study titled “Exploring line managers’ perceptions regarding assembly employees’ capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation” presented significant findings concerning the prospective capabilities and talent development challenges in the workplace. This study explored multiple perceptions of the topic, with a deep understanding of line managers’ experiences and the potential implementation of talent development strategies for capability development. It also provided the automotive manufacturing organisation with insights into the types of new capabilities required and talent development strategies for adapting to 4IR smart automotive manufacturing.

In addition, recommendations were made for the development of new capabilities and support for assembly employees. This research article not only sheds light on the new capabilities and talent development challenges of automotive manufacturing in the assembly plant, but also offers employers suggestions to encourage assembly employees to accept 4IR digitalisation and willingly participate in talent development programmes for the new capabilities required in smart automotive manufacturing organisations. This study explored line managers’ perceptions of assembly employees’ capabilities and talent development to ensure smooth adaptation to 4IR smart automotive organisations producing hybrid and autonomous cars.

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CHAPTER 4

RESEARCH ARTICLE 3

DEVELOPING AND EVALUATING A PEOPLE CAPABILITY MATURITY MODEL OF THE FOURTH INDUSTRIAL REVOLUTION CAPABILITIES FOR ASSEMBLY EMPLOYEES IN A SOUTH AFRICAN AUTOMOTIVE MANUFACTURING ORGANISATION

Orientation: The convergence of advanced technological innovations in the automotive manufacturing industry is in high demand and plays a significant role in enhancing the productivity, safety, efficiency, sustainability and quality of smart vehicles through Fourth Industrial Revolution (4IR) technologies. However, there is a lack of literature on frameworks and models developed for the automotive manufacturing industry to continuously improve assembly employees' capability development processes to adapt to 4IR digitalisation. There is also a lack of conceptualisation and evaluation of People Capability Maturity Models (P-CMMs) specifically for the automotive manufacturing industry to improve assembly employees' capability development and keep pace with 4IR digitalisation.

Research purpose: The general objective of this study was to develop and evaluate a P-CMM of the required 4IR capabilities for assembly employees in a South African automotive manufacturing organisation

Motivation for the study: There was a significant need to develop a P-CMM for assembly employees which would enable automotive manufacturing industry line managers to set priorities for the continuous improvement of assembly employees' capabilities and processes, enabling smooth adaptation to the 4IR. Furthermore, it was of the utmost importance to evaluate a P-CMM as a guide for implementation in automotive manufacturing organisations to meet the high demand for new capabilities required by the 4IR.

Research approach/design and method: This study employed a qualitative research design grounded in constructivism. Purposive sampling was utilised during data collection. Data for developing the P-CMM were collected from line managers (N=7) currently employed in an automotive manufacturing organisation in South Africa through face-to-face, semi-structured interviews. Data related to the evaluation of the P-CMM were obtained from a panel of talent development experts and the advisory board in an automotive manufacturing organisation in South Africa (N=9). ATLAS.ti 23 was used to organise and code the data and thematic analysis was employed to analyse it.

Main findings: First, the contextualised P-CMM according to the literature was discussed. Second, essential capabilities for developing a P-CMM for assembly employees to adapt to the 4IR in an automotive manufacturing organisation were identified and discussed. Third, the findings regarding the development of the P-CMM across its five Maturity Levels revealed that assembly employees would require diverse critical capabilities presented under the different categories, such as skills,

knowledge, behaviours, attitudes, equipment, physical workplace change, training opportunities, and support. Last, the evaluation of the P-CMM provided a roadmap for adopting and applying this model across the policy, process, decision-making and recommendations categories.

Practical and managerial implications: For line managers and senior executives in an automotive manufacturing organisation in South Africa, this study, particularly the P-CMM, offers a phased approach to developing the capabilities expected of assembly employees as the organisation progresses towards smart manufacturing. Additionally, the P-CMM provides valuable guidance on the evaluation of technological equipment required and the modifications to assembly lines prompted by the 4IR. Furthermore, the developed P-CMM and evaluations can help align organisational policies and practices with 4IR manufacturing.

Contribution/value add: The findings of this study, using the P-CMM, contribute to the HRM literature by providing insights, knowledge and understanding of the capabilities required for assembly workers to adapt to the 4IR in the automotive manufacturing organisation. This study adds value to the current HRM literature on frameworks and models for assembly employees' capabilities development, specifically in the automotive manufacturing industry.

INTRODUCTION

Currently, automotive manufacturing organisations are subject to stiff competition and significant change with the continual technological innovations associated with the Fourth Industrial Revolution (4IR) (Mona & Nkosi, 2024; Monye et al., 2023; Mqwathi, 2023). The transition from traditional ignition car engines to hybrid electric and autonomous drives has a radical impact on the current capabilities of assembly employees (Hover et al., 2024; Mona & Nkosi, 2024; Smuts et al., 2021). It is essential that automotive manufacturing organisations adopt the 4IR technological innovations to remain competitive and relevant with the manufacturing of smart cars (Mona & Nkosi, 2024; Mqwathi, 2023; Mukhudwana et al., 2025).

Smart automotive manufacturing 4IR technologies include artificial intelligence (AI), additive manufacturing (AM), Internet of Things (IoT), cloud computing, big data analytics, cyber-physical production systems (CPPS), smart robotics and automation (Buyukipekci & Duman, 2025; Monye et al., 2023; Mukhudwana et al., 2025). All these technologies are relevant for smart cars, with a significant impact on the capabilities of assembly employees (Buyukipekci & Duman, 2025; Mukhudwana et al., 2025; Monye et al., 2023). The development of technological innovations driven by the 4IR has now reached a critical period within the automotive manufacturing industry, with a radical impact on the existing Capability Maturity Models (CMMs) (Balli, 2022; Buyukipekci & Duman, 2025; Sezen & Eren-Şenaras, 2022).

In addition, the automotive manufacturing organisations are required to align their CMMs with the current technological trends for the full adoption and implementation of 4IR operating models (Balli, 2022; Buyukipekci & Duman, 2025; Stawiarska et al., 2021). The automotive manufacturing organisations must develop digitalised CMMs to respond to the high demand for building smart autonomous and hybrid electric cars associated with the 4IR (Saari et al., 2024; Salian & Sbeit, 2023; Stawiarska et al., 2021). These 4IR technologies should be incorporated into the capabilities of employees to determine and understand their current people capability maturity level (Hassan & Arshad, 2023; Reboredo & Espadinha-Cruz, 2024; Vance et al., 2023). This will enable automotive manufacturing organisations to identify the employees' capability gaps and the types of new capabilities required by assembly employees (Hassan & Arshad, 2023; Reboredo & Espadinha-Cruz, 2024; Vance et al., 2023). However, there is a lack of literature on People Capability Maturity Models (P-CMMs) that focus on the 4IR within the manufacturing industry and include automotive manufacturing (Hassan & Arshad, 2023; Reboredo & Espadinha-Cruz, 2024; Vance et al., 2023).

The literature revealed that employees in automotive manufacturing organisations are key role players and significantly contribute to the transition towards and adaptation to 4IR digitalisation for smart cars (Elibal & Ozceylan, 2024; Hassan & Arshad, 2023). It is therefore essential for automotive manufacturing organisations to adopt the P-CMM as a framework for the development of employees' new capabilities for 4IR CPPS and human-machine collaboration (Elibal & Ozceylan, 2024; Hover et al., 2024; Vasconcellos et al., 2021). As much as there is an urgent need for automotive manufacturing organisations to adapt to 4IR digitalisation, it is equally important to adopt the P-CMM as a useful guide to address the notable gap in assembly employees' new capabilities required for the 4IR (Hover et al., 2024; Mahdavi et al., 2022).

In addition, there is very limited existing literature that focuses on the evaluation of the P-CMM of the automotive manufacturing industry for the adoption of 4IR digitalisation (Noor & Kumar, 2023; Trevino-Elizondo & Garcia-Reyes, 2023). The opportunity exists for automotive manufacturing organisations to develop a P-CMM as the assessment and evaluation method for 4IR technological incorporation in preparation for 4IR CPPS (Iman et al., 2024; Noor & Kumar, 2023; Trevino-Elizondo & Garcia-Reyes, 2023). It is crucial to evaluate the P-CMM as an implementation guide for automotive manufacturing organisations to develop assembly employees' required capabilities (Iman et al., 2024; Noor & Kumar, 2023; Trevino-Elizondo & Garcia-Reyes, 2023).

Research purpose and objectives

The objective of this study was to develop and evaluate a P-CMM of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation. To reach this general objective, the following specific objectives were articulated:

- To conceptualise a P-CMM according to the literature
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Initial Level: Maturity Level 1
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Managed Level: Maturity Level 2
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Defined Level: Maturity Level 3
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Predictable Level: Maturity Level 4
- To determine the 4IR capabilities for automotive assembly employees at the P-CMM Optimising Level: Maturity Level 5
- To obtain, from a panel of talent development experts, an evaluation of the People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation and recommendations in this regard.
- To make recommendations for future research and practice.

Literature review

The Capability Maturity Model

The CMM was initially developed by the Software Engineering Institute (SEI) in 1987 and funded by the United States Department of Defense (Curtis et al., 2009; Motiso, 2023; Paulk et al., 1993). The CMM comprises five levels, namely, the initial, managed, defined, quantitatively managed and optimising levels (Curtis et al., 2007; Paulk et al., 1993). The CCM aims to describe how software companies could increase their capability by improving the software development process (Curtis et al., 1995; Motiso, 2023; Paulk, 2009). Specifically, the CMM suggests improvements in critical procedure-based practices (Digital Adoption Team, 2022; Paulk et al., 1993). In addition, the CMM determines present capability and maturity levels in an organisation by identifying challenges crucial to quality enhancement (Aguiar et al., 2019; Paulk et al., 1993; Gokalp & Martinez, 2022). This model traces the development from ad hoc movements to defined levels, measured outcomes and standardised and improved processes (Paulk, 1993; Curtis et al., 1995).

Therefore, the benefits of the CMM are related to quality improvement (Gokalp & Martinez, 2022), cost and time reduction and increased customer satisfaction (Curtis et al., 2001; Niazi et al., 2020), identifying gaps in maturity (Hidayati et al., 2018; Gokalp & Martinez, 2022).

The CMM's limitations include the lack of a standard theoretical base. It relies on the experiences of highly skilled experts (Geeksforgeeks, 2024; James, 1994; Pat, 1990). Moreover, the CMM is not appropriate for all organisations and does not account for the security standards of all companies (Digital Adoption Team, 2022; Geeksforgeeks, 2024). It also lacks agility in changing organisational requirements or customer expectations (Geeksforgeeks, 2024).

The People Capability Maturity Model

The People Capability Maturity Model (P-CMM) is a maturity framework developed by the Software Engineering Institute (SEI). However, unlike the CMM, the P-CMM seeks to measure and improve human resource development practices such as employee capabilities (Bakkah, 2024; Chen & Wang, 2018; Lanure et al., 2023). Employee capability is described as the skills, knowledge and functional capacity to accomplish organisational objectives (Curtis et al., 1995; Curtis et al., 2002). The P-CMM comprises five maturity levels for organisational employee development, namely, the initial level, managed level, defined level, predictable level and optimising level (Bakkah, 2024; Chen & Wang, 2018; Curtis et al., 2007; Lanure et al., 2023). Each of the maturity levels is briefly discussed below:

The **Initial level (Level 1)** is characterised by inconsistency or the lack of formal management of employee development practices (Bakkah, 2024; Carnegie Mellon University, 1995; Humphrey, 1989).

The **Managed level (Level 2)** encompasses formalised employee management and development strategies, with an awareness of the required employee capabilities (Bakkah, 2024; Humphrey, 1989; Carnegie Mellon University, 1995). However, practices are still reactive, and there is insufficient alignment among HR employee development practices (Bakkah, 2024; Lanure et al., 2023).

The **Defined level (Level 3)** concerns competency management (Humphrey, 1989; Carnegie Mellon University, 1995). Organisations explain and advance employee capabilities that align with their talent development strategic decisions and goals. HR employee development strategies are outlined and constantly employed within the organisation (Bakkah, 2024; Lanure et al., 2023).

The **Predictable level (Level 4)** involves employee capability management and development (Carnegie Mellon University, 1995; Humphrey, 1989). At this level, creating an information-focused strategy for HR management is crucial. In addition, the transformation demand in employee capabilities is recognised (Bakkah, 2024; Lanure et al., 2023).

The **Optimising level (Level 5)** encompasses change management (Carnegie Mellon University, 1995; Humphrey, 1989). Continuous improvement in people development processes is emphasised. Innovative HR practices are implemented to support and manage the capability challenges in the evolving requirements of the organisation (Bakkah, 2024; Lanure et al., 2023;).

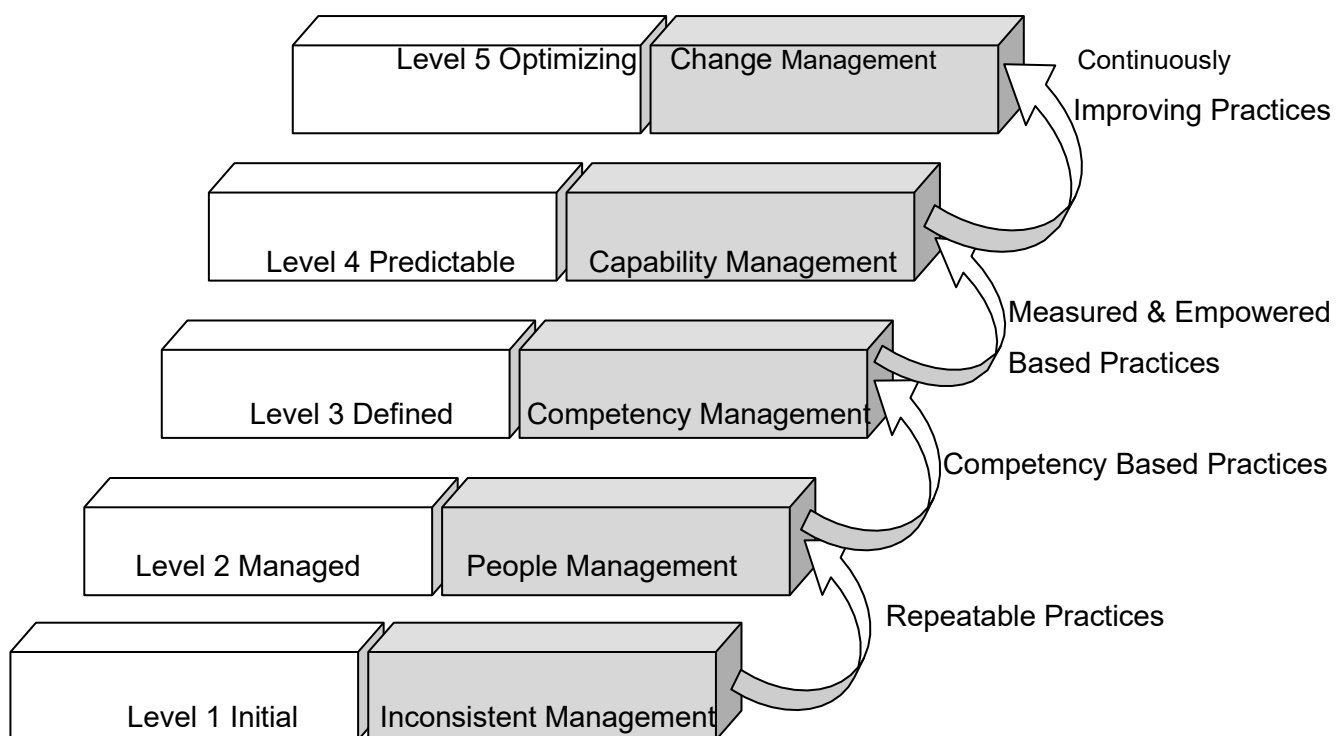


FIGURE 4.1: Levels of the People Capability Maturity Model

Source: Adapted from Humphrey (1989) and Carnegie Mellon University (1995)

This article focuses solely on the progression of capabilities related to skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support. This demarcation aligns with the operational definition of capabilities.

The P-CMM helps organisations determine the current maturity of their employee development strategies for decision-making and create systems for employee development during the change

process (Baradaran & Habibi, 2020; Chen & Wang, 2018; Curtis et al., 2001). With the application of the P-CMM, organisations can create a programme for continuous employee development, set priorities for improvement, integrate employee development with process improvement, and foster a culture of excellence (Baradaran & Habibi, 2020; Widyawati et al., 2025). The P-CMM is highly recommended as an efficient strategy for improving employee capabilities and quality, as well as for gaining a competitive edge during the digital transformation process (Baradaran & Habibi, 2020; Dangmei, 2017; Widyawati et al., 2025). The P-CMM offers organisations a valuable opportunity to enhance employee engagement, development, performance and growth, as well as employee adaptability and retention (Baradaran & Habibi, 2020; Widyawati et al., 2025). The P-CMM also helps organisations align human resource development policy and practices with strategic goals, ensuring that employees focus on organisational objectives (Widyawati et al., 2025). The P-CMM promotes a culture of continual employee development, improvement and cooperation, which leads to positive feedback and an encouraging work environment (Tripathi, 2014; Widyawati et al., 2025).

However, the P-CMM is ineffective for organisations that employ it without a serious commitment to progressing to the next maturity level (Dangmei, 2017; Tripathi, 2014). Some organisations may be satisfied with the current capability maturity level of their employees and fail to recognise the benefits of advanced levels (Dangmei, 2017; Tripathi, 2014). In addition, some organisations apply the P-CMM as a framework for decisions to improve the management of people development but then lose focus and consistency during the process (Kolinger et al. 2024). The P-CMM is process-focused and not goal-focused. The P-CMM, therefore, provides a framework for implementing talent development policy strategies and is not a guide for resolving issues related to its process (Poppelbuß & Roglinger, 2011; Tripathi, 2014). Moreover, implementing a P-CMM can be cost-prohibitive for small organisations (James, 1994; Pat, 1990).

Managers of automotive manufacturing organisations should support employees and provide them with continuous training and development to acquire new capabilities related to 4IR technological applications (Maisiri & Van Dyk, 2021; Macpherson et al., 2023).

Requirements for automotive manufacturing in the Fourth Industrial Revolution

The automotive manufacturing organisations in South Africa face numerous challenges in adopting 4IR advanced technological applications for producing modern automobiles (Griffin & Mary, 2020; Macpherson et al., 2023). The adoption of smart automotive manufacturing for building autonomous and hybrid electric vehicles requires the interaction of human and 4IR technologies (Macpherson et al., 2023; Sharma & Naude, 2021). New capabilities that employees should acquire include software development – amongst others, artificial intelligence (AI), the Internet of Things (IoT), machine learning (ML), smart robotics, smart machines, Python, automation, 3D printing, additive

manufacturing (AM), cloud computing, big data analytics and CPPS (Griffin & Mary, 2020; Macpherson et al., 2023; Schwab, 2016). Training and development should focus on artificial intelligence (AI), the Internet of Things (IoT), machine learning (ML), smart robotics, smart machines, Python, automation, 3D printing, AM, cloud computing, big data analytics and CPPS (Griffin & Mary, 2020; Macpherson et al., 2023; Schwab, 2016). Basic coding and programming language applications, 3D printing, augmented and virtual reality, and system integration are essential technical capabilities for automotive manufacturing organisations and should be considered when developing 4IR continuous training and development programmes (Akyuz, 2023; Karabulut & Popova, 2020).

In addition, automotive manufacturing managers must consider basic computer literacy training as fundamental to the development of new technical capabilities to adapt to the 4IR (Lorenz et al., 2019; Martin, 2022). Employees will require basic computer literacy to perform digital tasks within smart automotive manufacturing organisations (Khumalo, 2020; Lorenz & Kraemer-Mbula, 2021).

Furthermore, basic technical skills, such as electronic and electrical capabilities, will be required in building autonomous and hybrid electric vehicles (Khumalo, 2020; Lorenz et al., 2019; Lorenz & Kraemer-Mbula, 2021).

Employee engagement and commitment to the 4IR

Employee engagement is a crucial strategy for manufacturing organisations to enhance employees' commitment to their production tasks during the adaptive era of the 4IR (Dutta et al., 2023; Gangeni, 2020; Gaur, 2020). Employee engagement can foster employees' acceptable and adaptable behaviours and attitudes through positive communication with regard to 4IR digital manufacturing systems (Gangeni, 2020; Lee et al., 2023). The 4IR technical capabilities are ever-changing (Gaur, 2020; Lee et al., 2023), increasing the demand for employees' capabilities and affecting how managers interact with them (Ganeshan et al., 2022; Mkhize & Parumasur, 2022). Therefore, employees should be engaged to adapt to cyber-physical manufacturing (Ganeshan et al., 2022; Turner, 2022).

In summary, employee engagement should be prioritised within manufacturing to inspire employees and create an interest in acquiring new capabilities in ML, robotics, cybersecurity and 4IR CPPS that utilise AI (Oosthuizen, 2021; Victoria et al., 2021).

Mentorship and coaching programmes for the Fourth Industrial Revolution

The 4IR era is disruptive and will require managers to implement coaching and mentorship programmes for employees to thrive in the automotive manufacturing sector (Gubicza et al., 2024; Kumar, 2020; Reeves, 2023). Employees need motivation and support from management to adapt to the demands of smart automotive manufacturing (Gubicza et al., 2024; Reeves, 2023; Soni, 2019). Mentorship training sessions in change management will help employees understand the purpose of mastering new capabilities and developing their career paths (Festing & Kraus, 2020; Kumar, 2020; Mayer et al., 2024). Usually, team leaders or supervisors are appointed as mentors for employees (Gubicza et al., 2024; Hwa & Hamid, 2022; Reeves, 2023). Such a mentor-mentee relationship will cultivate important knowledge-sharing built on trust and transparent, positive communication, enabling adaptation to 4IR technological innovations (Ali et al., 2020; Hwa & Hamid, 2022; Khalid & Islam, 2020; Okeke & Elegbede, 2024; Osipov et al., 2020; Srimulatsih, 2021).

Mentorship and coaching programmes have been used in digital manufacturing organisations to support continuous learning and development (Buheji & Buheji, 2020; Mang, 2023; Ogbaro et al., 2022). Employees receive guidance from their mentors to align their personal and professional career advancement goals, facilitating their adaptation to 4IR digital manufacturing (Mang, 2023; Zeng et al., 2020).

Continuous learning and development

Manufacturing industries are not fully leveraging the opportunities and benefits of the 4IR due to a lack of employees with relevant new capabilities (Agarwal, 2020; Angevine et al., 2021; Shobha & Johnson, 2022). A clear policy strategy for employee attendance of continuous learning and development programmes is still lacking (Angevine et al., 2021; Shobha & Johnson, 2022). This limitation has compelled many manufacturing organisations to revise their training policies and support employees in acquiring new capabilities (Angevine et al., 2021; Shobha & Johnson, 2022). Therefore, training policies, strategies and guidelines are crucial to ensure compliance with employees' attendance at training and development programmes—including on-the-job, off-the-job, online, and career guidance training—for 4IR digital operations (Bag et al., 2021; ILO, 2018; Kukreja, 2020).

It is essential to invest in lifelong learning as one of the most significant training opportunities for employees to acquire new capabilities in AI, data analytics and IoT for adapting to the 4IR digital transformation within automotive manufacturing organisations (Alexander, 2022; Fanoro et al., 2021; Gorski et al., 2023). The 4IR digital transformation requires managers to invest financially in training and development programmes (Gorski et al., 2023; Mkansi & Landman, 2021; Ogedengbe et al., 2023). Organisations that fail to invest in their employees by offering them opportunities to acquire new capabilities will not thrive in the 4IR (Chung, 2023; Ogedengbe et al., 2023). With AI and IoT

transforming the manufacturing industry, advanced computer capabilities are crucial for continuous training and development (Ganeshan et al., 2022; Govender et al., 2022; Mkhize & Parumasur, 2022; Turner, 2022). Life-long learning within automotive manufacturing can be facilitated through succession planning (Sirayi et al., 2024; Venkat et al., 2023; World Economic Forum & PWC, 2021).

Succession planning for employee empowerment

Several 4IR technological transformations are affecting automotive manufacturing organisations, resulting in a need for succession planning (Fragapane et al., 2022; Jagannathan, 2021; Pavlinek, 2020). Automotive manufacturing organisations are required to support and empower employees through succession planning to master new capabilities, enabling the development of autonomous and hybrid electric vehicles (Fernando & Santhosh Kumar, 2022; Lexe & Lago, 2023; Pavlinek, 2020; Twinomurinzi et al., 2020). South African automotive manufacturing organisations should align their training and development strategies with succession planning to empower employees to acquire the new capabilities for the 4IR (Fernando & Santhosh Kumar, 2022; Lexe & Lago, 2023; Van Den Heever et al., 2021). Successful succession planning will ensure a smooth transition into 4IR automotive manufacturing (Katunga et al., 2024; Venkat et al., 2023).

Positive organisational psychology for acceptance of 4IR change

Technological change associated with the 4IR is inevitable and constitutes an ongoing transformation that organisations must engage in for operational efficiency and competitive edge (Singaram & Mayer, 2022). Managers in manufacturing organisations are encouraged to support their employees in developing positive behaviours and open mindsets to embrace the technological changes brought about by the 4IR (Adekanmbi & Ukpere, 2022; Roberts et al., 2022; Venkatesh, 2020). This can only be achieved through involving employees and sharing information by effectively communicating the need for change and highlighting its benefits for achieving organisational objectives in the digital landscape (Adekanmbi & Ukpere, 2022; Ngobeni et al., 2022; Venkatesh, 2022). Employees should cultivate positive attitudes towards the technological changes associated with the 4IR, recognising the benefits it offers them (Adekanmbi & Ukpere, 2023; Venkatesh, 2022). It is crucial to communicate how these changes will impact employees and how they can master the new capabilities required (Mayer et al., 2024; Ngobeni et al., 2022; Roberts et al., 2022). Managers need to emphasise the importance of self-managed behaviours for capability development strategies, reassuring employees of their relevance and job security in the 4IR digital workplace (Chung & Kim, 2024; Mayer et al., 2024; Suifan et al., 2018).

Furthermore, managers are encouraged to motivate employees to adopt positive attitudes towards 4IR technological changes like digitalisation (Chung & Kim, 2024; Khuzwayo, 2023; Ledwaba, 2022). In today's digital work environment, managers can only depend on employees who are willing to accept technological change rather than resist it (Chung & Kim, 2024; Khuzwayo, 2023; Kruger, 2022). Positive attitudes not only foster acceptance of change but also promote the acquisition of the required skills to stay relevant in the 4IR (Adeyinka, 2023; Ledwaba, 2022; Siddiqui, 2011). Manufacturing smart vehicles, such as hybrid electric cars, requires assembly workers to adapt to 4IR digital changes with a positive attitude and a willingness to learn about CPPS (Adeyinka, 2023; Onyilo et al., 2020; Van der Westhuizen, 2021).

Assembly employees must demonstrate positive behaviours and a willingness to embrace 4IR digital transformation to develop new capabilities that are integrated into the entire process of CPPS (Gräßler et al., 2021; Kruger, 2022; Van der Westhuizen, 2021). Employees with proactive attitudes will excel in automotive manufacturing CPPS, ensuring smart manufacturing efficiency and fostering innovative processes for quality control (Colledani et al., 2018; Gräßler et al., 2021; Onyilo et al., 2020). The new capabilities of assembly employees regarding CPPS will also be vital at the finishing line and testing stages to assess car production functionalities before releasing the smarter hybrid electric vehicles (Colledani et al., 2018; Gräßler et al., 2021; Onyilo et al., 2020).

Automotive manufacturing workplace change

The introduction of 4IR smart technologies has prompted several automotive manufacturing organisations to digitise their plant production systems by integrating smart robotics, intelligent machines and tools aimed at enhancing efficiency, precision and quality (Ahmadi et al., 2023; Devaraj et al., 2025; Roy, 2022). During the 4IR era, automotive manufacturing organisations are expected to employ advanced technologies, including state-of-the-art robotics with AI capabilities; this requires transforming traditional assembly plants into digitalised and innovative structures (Devaraj et al., 2025; Inyang et al., 2023; Monye et al., 2023). To remain competitive in the 4IR era, automotive manufacturing organisations must adopt innovative technological applications both within and beyond their plant processes (Ahmadi et al., 2023; Inyang et al., 2023). The effectiveness of the 4IR in automotive manufacturing facilitates seamless real-time communication, human-machine interaction, and the integration of AI-powered tools, machines and robots through IoT on smart computers and laptops, fostering a digitalised assembly environment (Ahmad et al., 2023; Inyang et al., 2023; Mukhudwana et al., 2025).

Furthermore, automotive manufacturing production systems and facilities should be fully digitalised, with smart computers ensuring effective assembly plant operations through big data analytics and cloud computing services (Hammad et al., 2025; King & Cnop, 2025; Mukhudwana et al., 2025).

Equipment required for an automotive manufacturing organisation

Automotive manufacturing organisations are facing a rapid digital transformation driven by the 4IR, which requires the utilisation of augmented and virtual reality, additive manufacturing and digital equipment for fully integrated smart assembly production systems (Babu, 2025; Prathibha et al., 2024; Winkelhake, 2025). Based on the 4IR, including AI and ML, the application and implementation of programmable logic controllers are essential for ongoing monitoring and control of automotive assembly plant operations (Ojubanire et al., 2025; Osman et al., 2025; Putro et al., 2025). Automotive manufacturing organisations cannot avoid using internet-connected devices such as smart laptops and tablets to adopt 4IR digitalisation with applications of AI, IoT, ML, cloud computing and smart robotics and tools (Alaba, 2024; Hassan et al., 2023; Kallier, 2022).

Additionally, angle sensor detection is a vital piece of smart equipment highly demanded by automotive manufacturing organisations in the era of the 4IR (Alie & Irawan, 2025; Duanaputri et al., 2025; Rangarajan, 2025). Automotive manufacturing relies on autonomous tow motors and variable speed drives to control and manage car speeds accurately, ensuring alignment with specific assembly standards for energy efficiency and performance enhancement (Alie & Irawan, 2025; Duanaputri et al., 2025; Rangarajan et al., 2025). Industrial and collaborative smart robotics are core tools that drive 4IR digitalisation through widespread AI applications for smart automotive manufacturing organisations (Anzolin & Andreoni, 2023; Boyal et al., 2025; Igbal et al., 2025).

RESEARCH METHODOLOGY

Research methodology refers to the procedure that the investigator follows to achieve the study's objectives. This procedure involves selecting the research approach, identifying the study subjects, determining the plan of inquiry to be pursued, and selecting data collection methods and analysis (Babchuk, 2019; Creswell & Báez, 2020). In this section, the researcher outlines the research approach, research paradigm, research designs, research context, participants, procedure, data collection methods, data analysis and trustworthiness.

Research approach

Qualitative research was used in the present study. Qualitative research is conducted in a specific context; depends on the researcher to collect data; utilises various methods; focuses on participants' points of view, meanings and insights; and is considered interpretive (Creswell, 2021; Harrison et al., 2020).

The researcher employed a qualitative research approach to thoroughly explore the perceptions of line managers regarding key elements of a P-CMM for 4IR capabilities among assembly employees in a South African automotive manufacturing organisation.

A disadvantage of using the qualitative research approach is that a study's findings are not impartially verifiable (Kyngäs, 2020; Mayer, 2015; Rahman, 2017). Moreover, qualitative data collection is time-consuming and labour-intensive, involving manual tasks such as transcribing recorded responses from interviews.

Research paradigm

Constructivism was employed as the research paradigm in this study. Constructivism postulates that an individual's reality is socially constructed (Aliyu et al., 2014; Kumatongo & Muzata, 2021).

The ontological assumptions (nature of reality) of constructivism are that many realities exist and that reality is socially constructed (Chilisa & Kawulich, 2012). The researcher gathered data from various line managers when developing the P-CMM in the automotive manufacturing industry in South Africa.

The epistemological assumptions of the constructivism paradigm are listed as follows: (a) knowledge is generated through exploration and understanding of the meanings individuals assign to a phenomenon and their way of interpreting it; (b) investigators build their constructions about the meaning and interpretations generated through individuals they are exploring; (c) interpretation is mainly an inductive procedure, because it requires the exploration of the collected data; (d) a completely unbiased study is not practicable, because the study procedure introduces subjectivity, making it difficult to separate truths from principles; (e) social study is controlled by meaning and individualistic measures and not by the structures of the natural world; (f) it is not possible to encapsulate social reality or analyse it accurately, because broader perspectives and understandings can be dissimilar (Ormston et al., 2014).

The researcher explored the perceptions of line managers in an automotive manufacturing organisation in South Africa regarding their understanding of the five maturity levels of the P-CMM. The meanings that these line managers attached to the five maturity levels and how the maturity

levels relate to the 4-IR capabilities required of assembly employees contributed to the creation of new knowledge.

Research designs

Literature review design

A literature review is a well-organised procedure of reviewing and evaluating the present knowledge about the subject under study (Collins et al., 2014; Guetterman et al., 2019). In Phase 1 of this study, the researcher conducted a complete literature review regarding a P-CMM of 4IR capabilities for assembly employees in a South African automotive organisation. The following keywords were used for the literature review: automotive, assembly, capabilities, talent development, employees, Fourth Industrial Revolution, Industry 4.0, manufacturing, skills, P-CMM, and South Africa.

The following academic sources were consulted to review the literature: Emerald, Google Scholar, EbscoHost, ProQuest, SAE Publications, ScienceDirect, and other relevant databases. The sources comprised published scholarly articles, books, reviews, dissertations and theses, monographs, government and private sector reports, abstracts, surveys, research reports and authentic computerised media information. Moreover, scientific research articles from accredited, double-masked scientific journals were utilised. Examples of such journals include the following: *South African Journal of Human Resource Management (SAJHRM)*, *South African Journal of Information Management (SAJIM)*, *African Journal of Science, Technology, Innovation and Development (AJSTID)*, *International Journal of Human Resource Management (IJHRM)*, *Journal of Strategic Human Resource Management (JSHRM)*, *International Journal of Business and Management (IJBm)*, *Journal of Management Development Review (JMDDR)*, *Journal of People Management (JPM)* and *Journal of Management Studies and Inquiry (JMSI)*. Peer-reviewed research articles published between 2019 and 2025 were mainly used.

Qualitative empirical design

The present study employed a qualitative descriptive design, as it is suitable for research that aims to collect data directly from individuals encountering the phenomenon under exploration, particularly when time and resources are limited (Hu et al., 2020; Neergaard et al., 2009; Siedlecki, 2022). The objective of the qualitative descriptive design is to provide a broad summary of the daily conditions or specific circumstances encountered by people or groups of individuals (Lambert & Lambert, 2012; Siedlecki, 2020). Moreover, the qualitative descriptive design is an inductive procedure that illustrates the phenomenon under exploration, and it can also build on the understanding and perceptions of participants (Saunders et al., 2019; Sullivan-Bolyai et al., 2005). Furthermore, the

qualitative descriptive design is subjective (Goh et al., 2021; Sullivan-Bolyai et al., 2005); in this study, line managers might have different perspectives regarding the five maturity levels of the P-CMM and how they relate to the 4IR capabilities required by assembly employees in an automotive manufacturing organisation in South Africa. In addition, the qualitative descriptive design was found to be suitable for the present study because it could be carried out in the natural setting (Saunders et al., 2019; Siedlecki, 2020; Sullivan-Bolyai et al., 2005) (assembly plants) of an automotive assembly organisation in South Africa.

Research context

The study was conducted at a large automotive manufacturing organisation in South Africa. The province where the automotive assembly organisation's plants are situated will not be revealed, to protect the organisation's anonymity. The organisation has several plants that assemble passenger and commercial vehicles for the local and export markets.

Data were collected at the assembly plants, during the day and in an office where interviews could be conducted confidentially and without interruptions. The privacy provided by the office was conducive to candid discussion, creating an atmosphere in which participants could feel at ease.

Participants

The target population for this study consisted of assembly line operations managers and assembly production and quality manufacturing engineering line managers in an automotive manufacturing organisation in South Africa. The participants had extensive experience in vehicle assembly and managing assembly employees.

Purposive sampling was used to identify a suitable subset of the population. The researcher employed the purposive sampling technique to ensure that participants knowledgeable about the capabilities required for each maturity level of the P-CMM were included in this study (Lamm & Lamm, 2019; Tansey, 2007). To aid in the aforementioned endeavour, inclusion and exclusion criteria were set. These criteria are outlined below.

The inclusion criteria were line managers who:

- Managed automotive vehicle assembly employees
- Had been appointed to the position for at least 12 months
- Were assembly line operations managers
- Were assembly production and quality manufacturing engineering line managers.

The exclusion criteria for participation in this study were line managers who:

- Did not currently manage assembly employees
- Had been appointed to the position for less than 12 months
- Were working in machine and fabrication plants
- Were working in paint and finishing plants.

Seven ($N=7$) line managers participated in the study. The requirements of sufficiency and saturation guided the selection of the sample size. Each of these requirements is briefly discussed below:

Sufficiency

Sufficiency entails adequate numbers to reflect the range of participants and sites. The automotive manufacturing organisation employed twelve line managers; however, five did not fit the inclusion criteria. In addition, the organisation operated four plants, but only two of these were primarily used for vehicle assembly. A sample of seven assembly line managers was, therefore, sufficient to collect data. Moreover, all plants dedicated to vehicle assembly were included in the sample, ensuring an adequate number of sites were represented.

Saturation

When no new themes emerge from the data, and a point of redundancy has been reached, the data are saturated. At the end of the fourth semi-structured interview, the researcher found that no new themes emerged from the data. However, the researcher conducted two additional interviews to confirm data saturation.

TABLE 4.1: Characteristics of line managers ($N=7$)

Item	Category	Frequency	Percentage
Age	31-40	3	43%
	41-50	4	57%
Gender	Male	4	57%
	Female	3	43%
Ethnicity	African	5	71%
	Coloured	1	14%
	Indian	1	14%
Tenure (years of work experience as line manager)	10-14	3	43%
	15-19	2	29%
	20-24	2	29%

Most participants fell within the age range of 41 to 50 years (57%), followed by those aged 31 to 40 years (27,5%) as the second most common category. Regarding gender, 57% were male and 43%

female. Concerning ethnicity, 71% identified as African, while 14% identified as either coloured or Indian. Lastly, in terms of tenure (years of work experience as a line manager), those with 10 to 14 years accounted for the majority at 43%, followed by those with 15 to 19 years and 20 to 24 years, both at 29%.

Procedure

Before data collection, the researcher obtained ethics approval to conduct the study (NWU-00717-23-A4) from the North-West University Economic and Management Sciences Research Ethics Committee (NWU-EMS-REC).

Procedure for line managers

The researcher emailed the decision-making authorities of several South African automotive manufacturing organisations, inviting them to participate in the study. A detailed letter explaining the objectives of the study, inclusion and exclusion criteria for participants, data collection technique, approximate duration per interview, interview questions, data access, how the data would be handled, how and how long data would be stored and the risk level of the research was provided to the invited organisations. Only one organisation accepted the invitation. The researcher then requested permission to conduct research at this organisation. Permission was granted, and the automotive organisation appointed a coordinator who identified possible participants and arranged interview dates and times on behalf of the researcher to collect the data.

Before conducting interviews, the researcher explained the ethical considerations to the participants and gave them the opportunity to ask questions. Interviews were recorded with the participants' permission, as outlined in the consent form. The interview questions were provided to the participants in advance, allowing them sufficient time to prepare for the interview.

Procedure for talent development experts and advisory board

The researcher asked the automotive organisation, which had agreed to participate in the study, for volunteers from the management team and talent development experts to evaluate the developed P-CMM. Additionally, the researcher and his promoter used their networks to request talent development experts outside the automotive organisation to evaluate the model. A consent form outlining the purpose of the study, including inclusion and exclusion criteria for participants as well as other relevant information related to voluntary participation, confidentiality and protection of personal information, was shared. Therefore, participants could decide whether they wanted to participate in the research. Upon receiving consent from the volunteers, the researcher proceeded

to forward them the developed P-CMM and qualitative survey. The participants completed the survey and emailed it back to the researcher or his promoter.

The researcher fulfilled various roles during this study. Firstly, the researcher developed a comprehensive plan to implement the study. As a data collector, the researcher conducted semi-structured interviews and used qualitative surveys to collect data from the line managers, talent management experts and advisory board who fulfilled the respective inclusion criteria and had volunteered to participate in the research study. The researcher then adopted the role of a data analyst by organising the data into themes. The researcher made use of a co-coder to assist with the data analysis. Lastly, the researcher reported on the findings of the study.

Data collection methods

Data collection of line managers

In-person, open-ended, semi-structured interviews were employed to enable participants to express new thoughts, perceptions and beliefs throughout the interview process (Seabi et al., 2021). Semi-structured interviews are defined as a data-gathering technique that involves asking questions within a prearranged thematic structure, where an interplay between two individuals occurs on a specific topic as the interviewer poses questions to the interviewee (George et al., 2025; Ruslin et al., 2022). The duration of each interview ranged from 40 to 60 minutes. Line managers were also requested to provide their demographic information during the semi-structured interviews. No inferences were drawn from the demographic data in the study, as it was only used to describe the characteristics of the sample population. The demographic information included age, gender, ethnicity and tenure. It should be noted that the designations for ethnicity are used in line with the terminology of the Employment Equity Act, 55 of 1998, for designated and non-designated groups. No offence is intended.

The semi-structured interviews were based on six preselected questions using an interview guide. However, the interview structure did allow for probing and exploration to gather thick and rich data (Rugg & Petre, 2007; Seabi et al., 2021). The interview guide is outlined below.

Interview guide for line managers

The researcher introduced the interview sessions by saying: “Thank you for providing me with this opportunity to ask you a few questions. Before each question, I will read a short statement. Please think about this statement before answering the question”.

Statements for line managers

Introductory statement: The P-CMM comprises five maturity levels: Initial, Managed, Defined, Predictable and Optimising.

Statement for the Initial Level: Maturity Level 1

Level 1 is characterised by a talent shortage where neither employees nor managers take responsibility for skills development.

Interview question 1

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the Initial Level (Level 1) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

Statement for the Managed Level: Maturity Level 2

At Level 2, the organisation frequently fails at widespread improvement initiatives. Managers often lack the skills required to execute complex practices.

Interview question 2

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the Managed Level (Level 2) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

Statement for the Defined Level: Maturity Level 3

Level 3 is characterised by missed opportunities to standardise workforce practices, primarily because mutual knowledge and skills required for business activities are not identified. However, an organisation-wide competency framework is being built for the workforce.

Interview question 3

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the Defined Level (Level 3) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

Statement for the Predictable Level: Maturity Level 4

At Level 4, the organisation manages and utilises the capability established by the workforce capability framework. In addition, the competencies that are most critical for organisational success are measured quantitatively. Moreover, baselines are established for critical competency-based processes.

Interview question 4

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the Predictable Level (Level 4) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

Statement for the Optimising Level: Maturity Level 5

Maturity Level 5 denotes a collective focus on constant organisational improvement. Such improvements are made to the capabilities of individuals and work groups' competency-based processes. At Level 5, change management is viewed as a standard business process that should be performed systematically and consistently.

Interview question 5

What capabilities (skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support) would describe the Optimising Level (Level 5) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?

Data collection of talent development experts and the advisory board

Data were collected through qualitative surveys incorporating open-ended questions, allowing talent development experts and the advisory board to provide detailed and nuanced responses in their evaluation of the developed P-CMM. The data were collected from nine (9) panel members (N=9) of the talent development experts and advisory board from a South African automotive manufacturing organisation. The panel of talent development experts and advisory board were selected based on their field of specialisation in capabilities development. A qualitative survey is a data collection method that uses open-ended questions to collect detailed, written responses from participants (Braun et al., 2021). The benefits of qualitative surveys are that they provide participants with the opportunity to express their opinions thoughtfully, reducing the possibility of interviewer influence or answer bias (McCombie et al., 2024; Povee & Roberts, 2014).

Talent development experts and the advisory board were also requested to provide their demographic information during the survey. No extrapolations were made from the demographic data in the study. It was merely used to describe the sample population. The demographic information included age, gender, ethnicity and tenure. It should be noted that the designations for ethnicity are used in line with the terminology of the Employment Equity Act, 55 of 1998, for designated and non-designated groups. No offence is intended.

Qualitative survey questions for talent development experts and the advisory board

The following questions were posed in the qualitative survey:

1. What recommendations can you make regarding a People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation?
2. What observations can you make about a People Capability Maturity Model regarding its potential to impact policy in a South African automotive organisation? Please motivate your answer.
3. What observations can you make about a People Capability Maturity Model regarding its potential to impact processes in a South African automotive organisation? Please motivate your answer.
4. What observations can you make about a People Capability Maturity Model regarding its potential to impact decision-making in a South African automotive organisation? Please motivate your answer.

Data analysis

Qualitative data analysis involves organising and transcribing collected information into content transcripts for critical review and categorising it through processing and assigning codes (Babchuck, 2019). Creswell (2021) agrees with Babchuck (2019) that data analysis in a qualitative study includes organising and preparing the collected data for analysis, then coding it into themes, and ultimately interpreting and reporting it in terms of frameworks, structures or exploration.

Thematic analysis was employed to categorise the raw data into codes and then condense it into semantic themes. Boyatzis (1998) describes thematic analysis as a method that identifies, analyses and reports themes and also interprets various characteristics of the phenomenon under investigation. Thematic analysis differs from other analytical techniques that aim to report patterns across qualitative data, as it is not restricted by theory (Smith et al., 1999; Smith & Osborn, 2009). In the present study, the researcher did not intend to generalise the findings but rather to ensure that they reflected the perspectives of the participants.

Thematic analysis is a method for identifying and evaluating the themes that emerge from the data, as well as interpreting the contrasting characteristics of the phenomenon being explored (Braun & Clarke, 2016). This thematic analysis procedure allows investigators to retain participants' unaltered responses throughout the data analysis process. The data are thus not divided into contrasting segments to select theoretical features (as suggested by Guest et al., 2013).

In the present study, the investigator adopted the following data analysis process as recommended by Creswell (2014):

Step 1. Organising, categorising and preparing data for analysis. This step involved transcribing the recorded individual open-ended, semi-structured interviews verbatim. Thereafter, the data were classified in accordance with the research objectives of the articles.

Step 2. Reading the entire dataset, familiarising oneself with the data to gain a sense of familiarity, and reflecting on its broader meaning. The investigator repeatedly scrutinised and reviewed the entire dataset to familiarise himself with the contents and meaning of what had been said.

Step 3. Coding and analysing the whole dataset by first determining codes. In this study, the investigator organised the data into segments of words before linking meaning to the data. A catalogue of classifications was created to serve as quotations during the data analysis phase of the current research.

Step 4. Describing and identifying themes. Descriptions were generated of themes obtained from the classifications. The themes represented the range of perspectives of participants supported by verbatim quotations.

Step 5. Representing and presenting findings on data analysis. In the present study, narratives were used to convey the findings across all study stages. The narratives comprised rigorous explanations of various themes and sub-themes, as well as diverse perspectives of participants and supporting quotations. Tables were used to summarise the findings.

Step 6. Interpreting the meaning of the data. In this study, the investigator was guided by the research question: What are the perceptions of line managers regarding the capabilities required of assembly employees for the 4th Industrial Revolution (4IR) in the South African automotive manufacturing industry?

ATLAS.ti 23 was used to code and analyse the data. The data analysis was conducted in conjunction with the promoter.

Given the study's purpose, the recommendation by Saunders et al. (2016) to use an inductive approach to data analysis was adopted. This approach ensured that diverse themes emerging from the data were evaluated as the data were collected. The thematic analysis was also data-driven, as this approach involved gathering data specifically for the study's objectives (Braun & Clarke, 2016). The identified themes might not necessarily correspond to the questions asked of the study participants (Braun & Clarke, 2016).

Open coding was utilised to categorise the data that had shared meaning and connections (Saunders et al., 2016). Coding was performed by discerning feasible patterns, recognising pertinent codes, and deciding which data represented the codes. Once this had been done, the codes were classified into feasible themes (Braun & Clarke, 2016). The themes and the fashion in which they related were assessed; this entailed arranging codes under themes and determining their connection to one another.

Trustworthiness

Credibility means adhering to the trustworthiness standard through the method of credibility, which comprises ensuring that findings are reliable and trustworthy from the perspective of the research participants. As qualitative research explores people's ideas, experiences, views, affections and assumptions, research participants are the ideal individuals to determine whether the research findings appropriately reflect their beliefs and feelings (Kumar, 2014). The investigator demonstrated the credibility of this study by describing the context in which the research was conducted – for example, the procedures used and the methods for data collection. Additionally, by utilising data triangulation, which involves the use of different data sources in a single research study, credibility was established. The data were, therefore, transcribed verbatim after having been gathered from various research participants. Additionally, the investigator utilised a co-coder to enhance credibility.

Transferability concerns the validity of a research study (Leedy & Ormrod, 2015). In qualitative studies, findings are context-sensitive and predicated on that; qualitative investigators do not set out the course of action or wish to generalise their data conclusions (Yin, 2015). The qualitative investigator is responsible for providing broad explanations of the study to ensure its transferability. In this study, the researcher collected rich and illustrative data within the context of the South African automotive manufacturing industry, which can be compared to other available contexts in which transferability may be considered. According to Guba (1981), rich and expressive data should be collected based on the researcher's judgment to align with the standards of other available contexts, as this is essential for transferability. In addition, the transferability of the findings in this study was enhanced by using purposive sampling to gather in-depth data from research participants who had a broad understanding of the research topic (Maxwell, 2013).

Dependability is concerned with whether other investigators can arrive at comparable findings of a study if analogous processes are duplicated (Trochim et al., 2016). The investigator enhanced the dependability of the study by providing a detailed description of the methodology employed. Furthermore, the study's objectives were clear and aligned with the research methodology. Moreover, the researcher augmented the reliability of the research by providing clear descriptions of

participants' responses and documenting the decisions made throughout the study (Creswell, 2021; Leedy & Ormrod, 2015).

Confirmability is the extent to which other investigators can confirm the findings (Kumar, 2014). Confirmability is also described as the process by which the data reflect the focal point of the exploration rather than the investigator's biases (Lincoln et al., 2017). This confirmability procedure is regarded as an audit trail (Petty et al., 2012; Lincoln et al., 2017), which involves a reliable investigator reading the findings to establish the confirmability of the study's results. The audit trail documents the stages from the beginning of the study through the development and presentation of the findings (Lincoln et al. 2017). The confirmability audit trail approach confirms that the data underpin each analysis and that the analysis is consistent with the accessible data (Akkerman et al., 2008; Carcary, 2020). The confirmability audit trail in this study is reflected in the record of how the research was conducted and how the investigator arrived at the conclusions (Carcary, 2020; Given et al. 2023). The researcher ensured confirmability by remaining objective during the study and avoiding the influence of his opinions or values on the results or processes. To this end, the researcher employed a co-coder to validate the findings. In addition, the researcher scheduled regular meetings with his promoter to ensure that the data were analysed correctly and consistently.

Ethical considerations and the protection of personal information

Ethical considerations in research involve principles and rules that ensure the study is conducted responsibly, protects participants and maintains methodological integrity (Busby, 2025; Muskaan et al., 2025). They essentially constitute a combination of principles guiding the selection of research designs and practices (Busby, 2025; Muskaan et al., 2025). It is crucial that all research studies fully adhere to ethical procedures when collecting data or conducting studies involving humans (Almusaed et al., 2025; Tsungmey et al., 2023). The aim of human studies is often to understand real-life situations by exploring specific perspectives, behaviours and beliefs, which requires strict ethical procedures (Almusaed et al., 2025; Tsungmey et al., 2023). Furthermore, ethical considerations ensure that individuals' rights are recognised (Almusaed et al., 2025; Tsungmey et al., 2023).

The core principles of ethical considerations include obtaining informed consent, safeguarding participants' anonymity and confidentiality, allowing voluntary participation, ensuring the fair selection of participants, and maintaining ethical standards throughout the research by being transparent, presenting data honestly, and avoiding conflicts of interest (Kaczmarek et al., 2025; Rodrigues et al., 2024). Ethical conduct involves adhering to standards that protect participants,

ensuring moral soundness and fostering trust through practices such as informed consent, confidentiality, harm reduction, and upholding integrity and fairness throughout the research process (Kaczmarek et al., 2025).

The researcher must also stay objective during data collection and ensure that the data are protected (Marlina et al., 2025). To maintain anonymity, the researcher safeguarded participants' confidentiality by using pseudonyms.

The researcher further ensured the anonymity of the information collected from participants by not gathering or storing any identifying details of individual subjects (e.g., name, address, ethnicity, email address, etc.). The data were stored using pseudonyms and reported as group data. The researcher did not link the individual responses to the participants' identities.

The Protection of Personal Information Act (POPIA) (Act 4 of 2013) grants South African research participants specific rights over their personal data, including the right to consent to its handling, the right to understand how the data will be used, and the right to withdraw consent at any time (Adams et al., 2021; Sema et al., 2025). In this study, the researcher followed the principles of POPIA by obtaining full consent, especially for sensitive data, implementing strict data security measures, and clearly informing participants about their control over their information (Adams et al., 2021; Sema et al., 2025).

This study complied with the ethical requirements of the North-West University Research Ethics Committee, which entailed the following:

- Participants had to complete the consent forms to voluntarily participate in the study and return them to the researcher.
- Participants were informed that the information was strictly confidential and solely for use in the present study.
- Participants were informed that participation in this study was voluntary.
- Participants were informed that the withdrawal of participation in this study was allowed.
- The research study would not cause harm to those involved or have a negative impact on participants or the organisation.
- Participants were assured of adherence to the Protection of Personal Information Act (Act 4 of 2013).
- Participants were guaranteed confidentiality and anonymity.
- Participants were all treated equally with full attention, dignity and respect.

- Participants were informed regarding the objectives and purpose of the present study.
- The Ethics Clearance Certificate and approval for the study were obtained from North-West University before the commencement of data collection.
- The researcher was granted permission to conduct the study by the South African automotive manufacturing organisation, with approval from the General Manager through the Human Resource Division.

FINDINGS

This section reports on the findings, related firstly to the development of a P-CMM of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation, and secondly to the evaluation of the developed model.

Findings from the line managers on the development of a P-CMM

Table 4.2 outlines the descriptives of the line managers.

TABLE 4.2: Descriptives of line managers (*N*=7)

Participant number	Age	Gender	Ethnicity	Tenure
1	31-40	Female	African	10-14
2	31-40	Male	African	10-14
3	41-50	Female	African	15-19
4	41-50	Male	African	15-19
5	41-50	Female	Coloured	20-24
6	41-50	Male	Indian	20-24
7	31-40	Male	African	10-14

Table 4.3 provides a summary of the developed P-CMM.

TABLE 4.3: A P-CMM of 4IR capabilities for assembly employees in an automotive manufacturing organisation

Type of capability	Initial Level: Maturity Level 1	Managed Level: Maturity Level 2	Defined Level: Maturity Level 3	Predictable Level: Maturity Level 4	Optimising Level: Maturity Level 5
Skills	Basic computer skills	Advanced computer skills Artificial intelligence skills	Artificial intelligence skills Internet of Things skills	Basic programming to communicate with robots and smart machines	Cyber-physical production skills Cybersecurity skills Robotics skills

		Internet of Things skills Critical thinking	Python skills Automation skills Digital skills Electronic and electrical skills Machine-learning skills Cloud computing skills Big data analytics Quantum computing Robotics skills	System integration skills Augmented reality and virtual reality skills Python skills Complex software-solving skills	Machine-learning skills
Knowledge	Basic computer knowledge	Artificial intelligence knowledge Internet of Things knowledge	Understanding the link between electronic and software devices, i.e., Bluetooth, car sound, navigation, car sensors, cameras and wipers	Communicating with robots and smart machines System integration Augmented reality and virtual reality Python knowledge	Cyber-physical production knowledge Cybersecurity knowledge Robotics knowledge Machine-learning knowledge
Behaviours	Attend briefings and/or training and development workshops Honesty Proactive behaviours towards acquiring new capabilities Problem-solving behaviours Assertiveness	Compliance with continuous training and development programmes and policy Demonstrating willingness to accept change Accept responsibility for continued learning	Proactive behaviours such as assertiveness, creativity, innovation, adaptability and being disciplined	Compliance behaviours such as honesty and integrity, consistency and transparency Self-management behaviours such as confidence, openness, patience, resilience, adaptability and acceptance	Adaptability behaviours / Agency Positive communication
Attitudes	Commitment to change Confidence Positivity Willingness to accept change	Career agility Career adaptability Proactive attitudes Commitment to quality	Positive attitude Willingness to accept change	Positive attitude towards learning and development Willingness to use every opportunity for life-long learning	Positive attitude towards learning and development\ Positive attitude towards change
Equipment	Laptops or tablets Internet connectivity devices	Programmable logic controllers Internet connectivity	Variable speed drives Autonomous tow motors and tow trucks	Angle sensor detection	Industrial and collaborative robots Augmented and virtual reality Additive manufacturing/3 D printing

Physical workplace	Change to digitisation Introduction of robots and smart machines	Change to digital and innovative building structure Alter workplace for AI set-ups	Smart buildings, both inside and outside	Smart computers	Reflect the intersection of the IoT, AI and robotics
Training opportunities	Basic computer literacy	Artificial intelligence skills training Data analytics training Internet of Things skills training Simulation skills training	Robotics operation training, including automation Artificial intelligence training, including Internet of Things, machine learning, cloud computing, big data analytics, and quantum computing	Coding and programming System integration Augmented reality and virtual reality Python	Cyber-physical production Cyber security Change management Robotics Machine-learning
Support	Information sharing Involvement in the transformation process Communication of vision and strategy	Investment in training and development Strategic planning and alignment of training and development Promote engagement of assembly employees Culture of employee empowerment Commitment from line managers	Talent development policy amendment Compliance with training and development strategy	Promote succession planning Availability of critical positions	Mentorship for support and motivation Coaching for continuous learning and development

Category 1: 4IR capabilities for automotive assembly employees: P-CMM Initial Level: Maturity Level 1

Theme 1: Basic computer literacy skills and knowledge

Note to the reader: Since the required skills and knowledge are interrelated, these findings are discussed together.

Line managers were asked to describe the skills and knowledge, if any, that assembly employees would need in the next five to ten years. Various line managers indicated that at Level 1 of the P-CMM, assembly employees lacked the technological skills and knowledge, such as basic computer literacy skills, to adapt to the 4IR smart automotive manufacturing of hybrid and autonomous cars. The line managers argued that such skills were fundamental to human-machine interaction during the digital era.

“The new capabilities that the assembly employees require to have are the basic computer literacy skills like Word, Excel, PowerPoint, Outlook, internet and MS Teams.” (P-1)

“What I can emphasise is that Microsoft skills such as Word, Excel, Outlook, PowerPoint, internet and MS Teams are crucial skills for adaptation and first implementation stages of the 4IR smart manufacturing.” (P-5).

Theme 2: Positive behaviours

Line managers were asked to describe the behaviours, if any, that assembly employees would need in the next five to ten years. Many line managers maintained that at Level 1 of the P-CMM, assembly employees required positive behaviours such as compliance, honesty, proactivity and problem-solving. Line managers insisted that these positive behaviours were important for swift adaptation to 4IR digital automotive manufacturing and assembling smart cars.

Subtheme 2.1: Attend briefings and/or training and development workshops

Participants indicated that positive behaviours of assembly employees, which ensured compliance with training and development expectations, would be crucial.

“Acceptable and positive behaviours will enable employees to continuously comply with the attendance of the briefings and training and development workshops to acquire new capabilities required for 4IR.” (P-2)

“The assembly employees need to commit to and comply to the culture of continuous attendance to the training and development to acquire new capabilities required for 4IR digital assembly production.” (P-6)

Subtheme 2.2: Honesty

Line managers stated that honesty related to the expressed behaviours of assembly employees would be essential at Level 1 of the P-CMM.

“... honestly, transparency ... will be crucial for 4IR.” (P-1)

“Our assembly employees have to be open-minded [and have] honesty ... as the 4IR is now with us in the automotive manufacturing.” (P-3)

Subtheme 2.3: Proactive behaviours towards acquiring new capabilities

Many participants stressed the importance of proactive behaviours of assembly employees concerning acquiring new 4IR capabilities.

“Our assembly employees have to be ... proactive ... as the 4IR is now with us in the automotive manufacturing.” (P-3)

“...willing to continuously attend the talent development training to acquire new capabilities required for 4IR.” (P-1)

Subtheme 2.4: Problem-solving behaviours

Many participants indicated that problem-solving behaviours would be crucial at Level 1 of the P-CMM.

“...problem-solving oriented ... as the 4IR is now with us in the automotive manufacturing.” (P-3)

“These kinds of behaviours will enable employees to attend ... training and development workshops to acquire new capabilities for solving 4IR cyber-physical problems.” (P-2)

Subtheme 2.5: Assertiveness

Many line managers stated that assembly employees needed to be assertive to adapt to the 4IR at Maturity Level 1 of the P-CMM.

“I think our assembly employees must be assertive and have positive behaviours to adapt to 4IR digital transformations within this assembly plant.” (P6)

“...assertiveness ... will be crucial for 4IR.” (P-1)

Theme 3: Positive attitudes

Line managers were asked to describe the attitudes, if any, that assembly employees would need in the next five to ten years. Several line managers asserted that at Level 1 of the P-CMM, assembly employees required positive attitudes such as commitment, confidence, positivity, and willingness to accept change. Some line managers argued that these positive attitudes were crucial and relevant for their assembly employees to adapt to 4IR digital change within the South African automotive manufacturing organisation.

Subtheme 3.1: Commitment to change

The majority of the participants stated that assembly employees would need positive attitudes, including a willingness to accept the changes brought about by the 4IR and a commitment to them.

“...commitment and willingness to accept change will be crucial for 4IR.” (P-1)

“...willing to continuously attend the talent development training to acquire new capabilities required for 4IR.” (P-1)

Subtheme 3.2: Confidence

Line managers believed that assembly employees needed to be confident in their ability to succeed in the 4IR.

“Our assembly employees have to be ... confident ... as the 4IR is now with us in the automotive manufacturing.” (P-3)

“I think enough confidence would be required from our assembly employees for 4IR.” (P-6)

Subtheme 3.3: Positivity

Many participants highlighted the importance of positivity and openness in acquiring new capabilities suitable for the 4IR at Level 1.

“Assembly employees' positivity, openness ... will be crucial for 4IR.” (P-1)

“I assume that the assembly employees should have a positive attitude to positively communicate with the line managers to obtain the new capabilities needed for 4IR human-machine interface.” (P-6)

Subtheme 3.4: Willingness to accept change

Most of the line managers stressed that the willingness to accept change brought about by the 4IR would be critical.

“...willingness to accept change will be crucial for 4IR.” (P-1)

“...willing to accept the technological transformational [change] as the 4IR is now with us in ... the automotive manufacturing.” (P-3)

Theme 4: Equipment

Line managers were asked to indicate what equipment (tools, machines, computers, etc.), if any, assembly employees would need in the next five to ten years. Assorted line managers argued that at Level 1 of the P-CMM, there was a high demand for assembly employees to use smart laptops and computers in the automotive manufacturing organisation. Diverse line managers contended that smart computer equipment was a fundamental step in the transition to the 4IR new world of manufacturing of smart cars. Several line managers argued that internet connectivity for devices

such as laptops and tablets should be accessible to assembly employees to enable them to operate digital assembly lines.

Subtheme 4.1: Laptops or tablets

Most of the participants indicated that smart computers in the form of laptops and tablets would be required at Level 1.

“...at this maturity level, assembly employees will first need the smart computers as the fundamental of 4IR equipment or smart tablets to move around with...” (P-3)

“Digital equipment, such as the smartest computers to ensure swift and smooth smart 4IR automotive assembly operations.” (P-1)

Subtheme 4.2: Internet connectivity devices

Many line managers argued that internet connectivity devices would be essential at Level 1 of the P-CMM.

“...internet connectivity, server and Internet of Things resources will be necessary for the 4IR automation in this assembly plant.” (P-4)

“...internet connectivity with the Internet of Things will be the best move and start to embark on the digital journey of manufacturing modern cars.” (P-5)

Theme 5: Physical workspace

Line managers were asked if the physical workplace needed to change over the next five to ten years to enable assembly employees to perform their jobs effectively. In addition, line managers were asked to motivate their answers. Many line managers reported that at Level 1 of the P-CMM, the current assembly lines should be transformed into digital assembly points. In these new settings, assembly employees would utilise 4IR smart tools and interact with smart robots and machines. Many line managers argued that the physical workplace should reflect the advancements in artificial intelligence, such as smart robots, machine learning, and the Internet of Things, to support 4IR digital automotive manufacturing and the assembly of modern cars.

Subtheme 5.1: Change to digitisation

Most of the line managers stressed that the physical workplace should change to accommodate digital manufacturing and assembly processes.

“...new world of work in this automotive manufacturing organisation must change to digitalisation.” (P-1)

"The physical workplace will change because the assembly employees must see the digital world in real life and see how machine learning, the Internet of Things, and artificial intelligence are practically applied in the modern assembly line." (P-4)

Subtheme 5.2: Introduction of robots and smart machines

Many participants indicated that the physical workplace would include 4IR technologies such as robots and smart machines.

"The physical workplace for this automotive assembly plant will be designed to represent the 4IR assembly operations with robots and smart machines as part of the artificial intelligence and machine learning." (P-5)

"...physical workplace must change to accommodate the robotics and smart machines, Internet of Things and simulation processes." (P-6)

Theme 6: Basic computer literacy

Line managers were asked what training, if any, assembly employees would require to remain employable in the next five to ten years. Several line managers argued that at Level 1 of the P-CMM, assembly employees would need basic computer literacy training as a fundamental new capability for 4IR automotive smart manufacturing systems. Many line managers asserted that ongoing basic computer literacy training in Word, Excel, PowerPoint, Outlook, the Internet and MS Teams was crucial for assembly lines.

"We need to start providing our assembly employees with the training and development programmes for the basic computer literacy skills like Word, Excel, PowerPoint, Outlook, internet and MS Teams." (P-1)

"The ongoing training and development must look at the basic computer literacy skills for the transition from traditional systems to digitalisation of smart automotive manufacturing." (P-6)

Theme 7: Communication support

Line managers were asked what support, if any, assembly employees would require to remain employable in the next five to ten years. Several line managers argued that at Level 1 of the P-CMM, assembly employees would need to understand the impact, purpose, benefits and overall vision for implementing 4IR smart automotive manufacturing to build modern cars. Line managers indicated that assembly employees should be involved and engaged in their talent development. Moreover, line managers advised that sharing information with assembly employees was necessary to convey the importance of acquiring new capabilities in their roles to adapt to 4IR digitalisation within a smart automotive assembly plant.

Subtheme 7.1: Information sharing

Many participants indicated that sharing 4IR-related information with assembly employees would be essential at Level 1 of the P-CMM.

“I think the important support that we can give our assembly employees is to engage them by sharing information about 4IR smart automotive manufacturing and how they will be affected by digital change.” (P-4)

“I think proper engagement, consultation and information sessions with the assembly employees regarding the 4IR strategic investment planning is crucial.” (P-3)

Subtheme 7.2: Involvement in the transformation process

Participants stressed the importance of involving and engaging assembly employees in the 4IR transformation process.

“I think the employees will only buy into the 4IR technological transformation if they feel engaged, involved and provided with the opportunities for training and development for integration with the smart robotics and machines, etc.” (P-2)

“I think we need to continuously involve and engage employees to understand the importance of smart automotive production of the 4IR, what is expected from them and what it is all about.” (P-5)

Subtheme 7.3: Communication of vision and strategy

Most of the line managers opined that clearly communicating the vision and strategy for 4IR capability development to assembly employees would be crucial.

“...assembly employees in this automotive assembly plant will only commit to training for new capabilities required for 4IR only if we clearly communicate to them to understand the benefits and purpose of this technological transformation.” (P-2)

“I think it is very important to support our assembly employees by communicating a clear vision for fundamental strategic talent development ideas and innovative technological plans.” (P-1)

Category 2: 4IR capabilities for automotive assembly employees: P-CMM Managed Level: Maturity Level 2

Theme 1: Technological application skills and knowledge

Line managers were asked to describe the skills and knowledge, if any, that assembly employees would need in the next five to ten years. Many line managers indicated that at Level 2 of the P-CMM,

assembly employees would require new technical and technological applications skills, such as the Internet of Things and artificial intelligence. Line managers argued that artificial intelligence and the Internet of Things were central to the new world of 4IR smart automotive manufacturing.

Subtheme 1.1: Artificial intelligence skills and knowledge

Most of the line managers emphasised the importance of AI skills and knowledge at Level 2 of the P-CMM.

“I think the technical skills such as artificial intelligence ... are very important for our assembly employees at this level.” (P-2)

“From my point of view, the artificial intelligence knowledge will be the driver of the 4IR in this automotive assembly plant.” (P-4)

Subtheme 1.2: Internet of Things skills and knowledge

Many participants stressed the importance of skills and knowledge related to the Internet of Things.

“I can recommend that the assembly employees have the Internet of Things skills, machine learning skills...” (P-1)

“I think amongst the other things, the knowledge that we must focus on for our assembly employees is the Internet of Things in this automotive manufacturing assembly plant.” (P-3)

Subtheme 1.3: Critical thinking

Various line managers strongly emphasised that assembly employees would need soft skills, such as critical thinking, for collaboration and interaction within the 4IR digital assembly plant.

“I think at the end of the day, the assembly employees would be required to have the soft skills like critical thinking to be able to quickly solve the assembly plant issues.” (P-7)

“I also believe that the human-machine collaboration and cyber-physical production systems will need our assembly employees to have think critically out of the box to adapt swiftly to the 4IR challenges.” (P-4)

Subtheme 1.4: Advanced computer skills and knowledge

Many line managers emphasised that advanced computer literacy skills would be essential for assembly employees in digital assembly plant operations during the era of the 4IR.

“I strongly believe that our assembly employees would need to be more advanced on basic computer literacy skills and knowledge to function in a computer for 4IR digital assembly plant.” (P-7)

“Most of the organisations frequently fail at widespread improvement initiatives due to lack of these crucial skills and knowledge on the advanced basic computer literacy to effectively and efficiently implement the 4IR smart automotive manufacturing.” (P-2)

Theme 2: Positive behaviours

Line managers were asked to describe any behaviours that assembly employees would need in the next five to ten years. Several line managers maintained that at Level 2 of the P-CMM, assembly employees would require positive behaviours to transition into the 4IR. Compliance with training and development policies and making use of training and development opportunities were positive behaviours. Some line managers mentioned that taking responsibility for mastering the new capabilities required for the 4IR digital change would be essential.

Subtheme 2.1: Compliance with continuous training and development programmes and policy

The majority of the line managers agreed that assembly employees should comply with continuous training and development programmes and policy instructions at Level 2 of the P-CMM.

“In my opinion, assembly employees must behave in an acceptable and ethical manner to comply with all the policy instructions for 4IR training and development programmes.” (P-6)

“As far as I know, the assembly employees’ compliance towards the continuous learning and development programmes will be the good behaviours required for 4IR.” (P-3)

Subtheme 2.2: Accept responsibility for own learning

Participants stressed that it would be crucial for assembly employees to take personal responsibility for continuous learning related to 4IR technologies.

“Assembly employees should also act with integrity and accept the responsibility of acquiring new capabilities required for 4IR technological innovations.” (P-2)

“If the assembly employees are not taking the responsibility of attending the capabilities development training programmes to continuously learn about 4IR technological applications, then they will be redundant with outdated capabilities.” (P-3)

Subtheme 2.3: Demonstrating willingness to accept change

Participants indicated that assembly employees should demonstrate a willingness to accept change regarding new capability development.

"I am sure that the acceptable behaviour from our assembly employees will allow us as managers to properly plan and provide new capabilities training to standardise assembly production practices." (P-4)

"I think the behaviour to accept change is basic, and it will open doors for assembly employees to obtain new capabilities for human-machine interaction in this automotive assembly plant." (P-1)

Theme 3: Positive attitudes

Line managers were asked to describe what attitudes, if any, assembly employees would need in the next five to ten years. Several line managers contended that at Level 2 of the P-CMM, positive attitudes to 4IR digital change would be required. Career agility regarding training and development, and career adaptability related to human-machine interaction, were examples of positive attitudes. Some line managers argued that assembly employees required positive attitudes with open-minded, proactive behaviours to prepare themselves to master new capabilities to thrive in 4IR smart automotive manufacturing. Some line managers maintained that assembly employees should approach the 4IR with a positive attitude.

Subtheme 3.1: Career agility

Most of the line managers pointed out that assembly employees would need an adaptive readiness for the changes associated with the 4IR automotive assembly plant.

"For me, assembly employees must have a positive attitude to commit to the culture of continuous training and development programmes to have the new capabilities for 4IR in this automotive assembly plant." (P-6)

"I think the behaviour to accept change is basic, and it will open doors for assembly employees to obtain new capabilities for human-machine interaction in this automotive assembly plant." (P-1)

Subtheme 3.2: Career adaptability

Many participants emphasised the importance of utilising psycho-social resources to adapt to the changing employment context.

"I think the positive attitude is the way to go for assembly employees in order to survive the digital transition of the 4IR for the new world of work in this automotive assembly plant." (P-1)

"I guess our assembly employees should commit to the high standards of personal honesty and exemplary character to adapt to 4IR in this automotive assembly plant." (P-2)

Subtheme 3.3: Proactive attitudes

Line managers believed that a proactive approach to developing new capabilities would be crucial at Level 2 of the P-CMM.

"I think that a positive attitude will help our assembly employees to think out of the box and be under the mentorship and coaching programmes for acquiring new capabilities required for 4IR in this automotive assembly plant." (P-5)

Subtheme 3.4: Commitment to quality

Most of the line managers opined that a commitment to quality through creativity, innovation and problem-solving to improve efficiency, safety and performance would be crucial.

"...technological change for 4IR in this automotive manufacturing organisation is to ensure the efficiency, safety and high performance of the cars with modern cars like hybrid electric and autonomous cars." (P-4)

"Instead, the assembly employees must use their exceptional soft skills such as creativity, innovation, critical thinking, complex problem solving, and active learning skills to integrate well during the 4IR human-machine interaction." (P-3).

Theme 4: Equipment

Line managers were asked to indicate which equipment (tools, machines, computers, etc.) assembly employees would need in the next five to ten years, if any. Different line managers stated that at Level 2 of the P-CMM, assembly employees would need programmable logic controllers to manage smart machines and robots and integrate software devices for 4IR smart automotive manufacturing. Line managers argued that assembly employees would also require internet connectivity as a fundamental step in smart automotive manufacturing processes.

Subtheme 4.1: Programmable logic controllers for automation

Most of the line managers agreed that programmable logic controllers, including autonomous tow motors and tow trucks, would be essential for the automation of assembly systems.

"Programmable logic controllers, autonomous tow motors, and tow trucks are important for 4IR." (P-5)

"I think the programmable logic controllers in this assembly plant to automate several electronic and mechanical systems will be the basic equipment for transition into 4IR." (P-4)

Subtheme 4.2: Internet connectivity

Participants emphasised the importance of internet connectivity for servers and the Internet of Things.

“...internet connectivity, server and internet of things resources will be necessary for the 4IR automation in this assembly plant.” (P-4)

“...internet connectivity with the internet of things will be the best move and start to embark on the digital journey of manufacturing modern cars.” (P-5)

Theme 5: Physical workplace

Line managers were asked if the physical workplace would need to change over the next five to ten years to enable assembly employees to perform their jobs effectively. Line managers were also asked to provide motivation for their answers. Different line managers argued that at Level 2 of P-CMM, the physical workspace should be digitalised to accommodate the artificial intelligence and smart robots connected through the Internet of Things. Some line managers insisted that the current physical workplace could not remain the same, as they needed to keep pace with the mass technological evolution associated with the 4IR shift towards building smart cars.

Subtheme 5.1: Change to digital and innovative building structure

Most of the line managers agreed that Level 2 of the P-CMM would see a change to a digital and innovative building structure.

“4IR preparation for smart automotive production must start with transforming the current workplace to digital and innovative building structure inside the automotive manufacturing organisation.” (P-1)

“I think the physical workplace will definitely have to be altered completely for new artificial intelligence set-ups.” (P-6)

“There is no way that the current physical workplace will remain the same; it will have to be digital with the mass artificial intelligence, smart robotics and Internet of Things interacting with assembly employees.” (P-5)

Theme 6: Training opportunities

Line managers were asked what training, if any, assembly employees would require to remain employable in the next five to ten years. Several line managers argued that at Level 2 of P-CMM, assembly employees would need training and development in new capabilities related to artificial intelligence and the Internet of Things for a smooth transition into 4IR smart automotive manufacturing. Line managers highlighted the importance of artificial intelligence and Internet of Things training for assembly employees for transition into 4IR smart production systems.

Subtheme 6.1: Artificial intelligence training

Participants stressed the importance of AI training for assembly employees.

"Our innovative training and development programmes must be based on the artificial intelligence skills..." (P-6)

"...artificial intelligence, data analytics, etc., will be very important for the smooth transition into the 4IR smart automotive production systems." (P-3)

Subtheme 6.2: Internet of Things training

The majority of the line managers emphasised the significance of continuous training programmes on the Internet of Things.

"The continuous training programmes on the technological applications such as Internet of Things..." (P-3)

"...simulation skills and Internet of Things as the important skills to have for a 4IR smart automotive assembly plant." (P-6)

Theme 7: Employee support

Line managers were asked what support, if any, assembly employees would require to remain employable in the next five to ten years. Many line managers argued that at Level 2 of the P-CMM, assembly employees would require support for swift adaptation to 4IR smart automotive manufacturing of smart cars. Various line managers contended that strategic investment and planning for training and development were called for to meet the high demand for assembly employees' new capabilities in the 4IR era. Some line managers stated that employee engagement, empowerment and commitment would make assembly employees feel they belong and help them accept the 4IR digital changes within the automotive manufacturing organisation.

Subtheme 7.1: Investment in training and development

Many participants argued that investing in the training and development of assembly employees would be essential.

"I also think the investment for continuous training and development for assembly employees' new capabilities will help us to thrive in 4IR, which is affecting the automotive manufacturing." (P-6)

"So, with a good financial investment, we will easily keep up with the ongoing training and development programmes without the obstacles and financial challenges." (P-2)

Subtheme 7.2: Strategic planning and alignment of training and development

Line managers stressed the importance of strategic planning and of aligning training and development programmes at Level 2.

“We also need to strategically plan, align and invest in the training and development programmes.” (P-4)

“Therefore, no one can ignore the strategy of investing in the employees’ capabilities development” (P-1)

Subtheme 7.3: Proactive engagement of assembly employees

The participants emphasised the importance of engaging assembly employees proactively.

“The engaged employees will support the widespread organisational improvement initiatives while caring about their jobs, objectives and goals of this automotive manufacturing organisation.” (P-4)

“I think the employee engagement is a good strategy that we must use to measure the level of buy-in for 4IR so that we can improve our approach and initiatives for technological transformation.” (P-1)

Subtheme 7.4: Culture of employee empowerment

Many participants stated that a culture of empowering assembly employees would be vital.

“I honestly feel that employee empowerment can also make a difference during the 4IR smart production.” (P-4)

“I think we need to encourage and build the culture of employee empowerment for our assembly employees to be adaptable.” (P-5)

Subtheme 7.5: Commitment from line managers

Many participants believed that commitment from line managers to support assembly employees would be crucial.

“Employee engagement as a human resources component can determine the level of enthusiasm and commitment for our assembly employees and to what extent they feel about the 4IR technological change.” (P-1)

“I think we must provide support as managers to assembly employees by involving them as part of commitment throughout the 4IR implementation plan and strategy process to support and buy-in the digital change.” (P-2)

Category 3: 4IR capabilities for automotive assembly employees: P-CMM Defined Level: Maturity Level 3

Theme 1: Advanced technological application skills and knowledge

Line managers were asked to describe what skills and knowledge, if any, assembly employees would need in the next five to ten years. Several line managers argued that at Level 3 of the P-CCM, assembly employees would require advanced technical and technological skills and knowledge to operate 4IR digital systems for building autonomous and hybrid electric cars. Different line managers contended that the technical and technological skills and knowledge would include electronic and electrical skills to support the interconnection between software and electronic devices of smart cars. Some line managers highlighted the importance of big data analytics, quantum computing, robotics operation, machine learning skills and knowledge for assembly employees' adaptation to the 4IR smart automotive assembly plant.

Subtheme 1.1: Artificial Intelligence skills and knowledge

Many participants emphasised the importance of AI skills and knowledge at Level 3 of the P-CMM.

"The technical skills include artificial intelligence skills, Internet of Things skills, Python skills, automation skills, digital skills, electronic skills, machine learning skills, cloud computing skills, and data analytics skills." (P-2)

"I believe technical skills are essential as we are moving towards building the hybrid cars, electric cars and autonomous cars, which is part of the 4IR, the driverless, and driver assisted cars." (P-1)

Subtheme 1.2: Internet of Things skills and knowledge

Many of the participants pointed out that assembly employees would require IoT skills and knowledge for 4IR digital operations.

"...assembly employees will need to have various new sets of skills and knowledge, such as the Internet of Things, to operate all the 4IR technological applications that are interconnected through the Internet of Things." (P-7)

"I think as line managers, we need to provide our assembly employees with the Internet of Things skills and knowledge in preparation for 4IR technological innovations." (P-2)

Subtheme 1.3: Python skills and knowledge

Various line managers emphasised Python skills and knowledge for Maturity Level 3 of the P-CMM of assembly employees within the automotive manufacturing assembly plant.

"I think at this maturity level, the Python skills for our assembly employees would be necessary for human-machine operation in the 4IR new world of manufacturing assembly plant." (P-7)

“The demand for new capabilities is real and will need to be addressed through ... Python skills and knowledge to adapt to 4IR smart automotive assembly plant.” (P-5)

Subtheme 1.4: Cloud computing skills and knowledge

Many of the participants highlighted the importance of cloud computing skills and knowledge for assembly employees to operate the cyber-physical production systems associated with 4IR technological innovations.

“I believe cloud computing skills and knowledge would be required for 4IR to assist our assembly employees in the cyber-physical production systems for manufacturing smart cars...” (P-7)

“I strongly do not have a doubt that the cloud computing will be the most important skills and knowledge to drive the 4IR digital transformation.” (P-6)

Subtheme 1.5: Electronic and electrical skills and knowledge

Line managers indicated that electronic and electrical innovations brought continuous change, making up-to-date skills and knowledge essential.

“...electronics and electrical knowledge in this ever-changing technological innovation of the 4IR are essential as electronic applications in the vehicle are advancing at a very high rate to interact with the computerised systems.” (P-1)

“I think knowledge sharing on ... electronics for the link between electronic and software devices in the car, for example, the car sound, Bluetooth, navigation, car sensors, cameras, wipers, etc.” (P-4)

Subtheme 1.6: Big data analytics

Some participants pointed to the relevance of big data analytics at Level 3 of the P-CMM.

“I think ... quantum computing and big data analytics will be relevant for our assembly employees in the era of 4IR.” (P-3)

“I think automation skills, artificial intelligence skills, machine learning skills, Internet of Things ... quantum computing and big data analytics will be required for 4IR.” (P-3)

Subtheme 1.7: Quantum computing skills and knowledge

Some line managers emphasised that assembly employees should have skills and knowledge related to quantum computing to adapt to a 4IR digital assembly plant.

“I am on the view that the quantum computing skills and knowledge will be crucial for our assembly employees to adapt to 4IR digitalisation within the assembly plant.” (P-7)

"I guess the quantum skills are crucial and fundamental knowledge required for assembly employees when we embrace the 4IR smart production systems in this automotive manufacturing organisation."
(P-3)

Subtheme 1.8: Robotic operations skills and knowledge

Most of the line managers believed that skills and knowledge related to robotics operations would be critical.

"...system integration skills, robotics operation skills, machine learning skills ... will be the most important technical skills for 4IR." (P-6)

"It is very important that our assembly employees gain more knowledge on the technical field such as electronic knowledge and robotic operations knowledge and understanding." (P-2)

Subtheme 1.9: Machine learning skills and knowledge

Some participants highlighted the importance of machine learning skills and knowledge at Level 3.

"I think the assembly employees of this automotive assembly plant must have sufficient knowledge on automation operating systems, artificial intelligence, machine learning..." (P-3)

"I am of the view that the machine learning skills, Internet of Things skills, Python skills ... will be relevant for 4IR." (P-3)

Theme 2: Proactive behaviours

Line managers were asked to describe the behaviours, if any, that assembly employees would need in the next five to ten years. Diverse line managers mentioned that at Level 3 of the P-CCM, assembly employees would require proactive behaviours for training to keep pace with 4IR smart automotive manufacturing trends in assembling smart cars.

"Assembly employees must be positive, assertive, proactive, creative, innovative, patient, focused and disciplined, punctual and adaptable to change as we are heading towards 4IR technological change..."
(P-3)

"I guess the assembly employees' positive behaviour to support the culture of training attendance must be performed systematically and consistently to move with the technological trends of the 4IR digital change in this automotive assembly plant." (P-4)

Theme 3: Positive attitudes

Line managers were asked to describe the attitudes, if any, that assembly employees would need in the next five to ten years. Various line managers stated that at Level 3 of the P-CMM, assembly

employees should have positive attitudes to accept 4IR digital changes and take responsibility for acquiring new capabilities.

Subtheme 3.1: Positivity towards technological operations

Many participants opined that a positive attitude towards technological operations would be essential.

"I personally feel that the positive attitude is the best thing to show for our assembly employees as part of the responsibility for their own capabilities development for robot assistance in this automotive assembly plant." (P-6)

"Positive attitude and a good approach towards the technological operations will be necessary for our assembly employees into the 4IR." (P-4)

Subtheme 3.2: Willingness to accept change

Most of the line managers emphasised the importance of embracing the changes introduced by 4IR automotive production.

"Our assembly employees need to be more focused, get out of the comfort zone and think out of the box by accepting the transformational change of 4IR to acquire new capabilities required for 4IR." (P-2)

"I think our assembly employees must just accept that the 4IR smart automotive production is real, and they must show a great commitment for acquiring the new capabilities to remain employable." (P-6)

Theme 4: Equipment

Line managers were asked to indicate what equipment (tools, machines, computers, etc.), if any, assembly employees would need in the next five to ten years. Different line managers argued that at Level 3 of the P-CMM, assembly employees would need variable speed drives to adapt to 4IR smart digital operations in the automotive assembly plant to adjust the hybrid electric vehicles' input frequency and voltage. Many line managers pointed to a need for autonomous tow motors and trucks to promptly and effectively collect and deliver car parts across the automotive assembly plant.

Subtheme 4.1: Variable speed drives

Many participants indicated that variable speed drives would be essential equipment at Level 3 of the P-CMM.

"I believe the variable speed drives will be the relevant tools for 4IR digital systems of automotive manufacturing." (P-4)

"I think variable speed drives ... will be the important equipment for survival into the 4IR world of the automotive assembly plant." (P-6)

Subtheme 4.2: Autonomous tow motors and tow trucks

The majority of the line managers stressed the importance of autonomous tow motors and tow trucks as part of the assembly line at Level 3.

"Assembly employees will need to utilise the autonomous tow motors and autonomous tow trucks to collect car parts and deliver them to the assembly lines." (P-3)

"I guess autonomous tow motor will be sent to several assembly lines to deliver parts, which is part of the 4IR smart production when building autonomous vehicles." (P-4)

Theme 5: Physical workplace

Line managers were asked if the physical workplace would need to change over the next five to ten years to enable assembly employees to perform their jobs effectively. They were also asked to motivate their answers. Several line managers indicated that at Level 3 of the P-CMM, the workspace had to become smarter, digital and innovative to accommodate the 4IR automotive manufacturing of smart cars.

"I strongly feel that technological transformation and the appearance of 4IR smart machines will inspire our assembly employees to realise that they also need to upskill and reskill themselves as the physical workplace is evolving." (P-5)

"I do not think it will make sense that we are in the 4IR digital automotive manufacturing assembly plant, but the building inside and outside, with the operations not looking innovative and smarter." (P-6)

Theme 6: Training opportunities

Line managers were asked what training, if any, assembly employees would require to remain employable in the next five to ten years. Several line managers contended that at Level 3 of the P-CCM, training and development programmes on operating smart robotics for the 4IR smart automotive manufacturing of smart cars should be prioritised.

Subtheme 6.1: Robotics operation training

Most of the participants stressed the importance of training assembly employees to operate robots, including automation.

“It is important for our assembly employees to get training and know how smart robotics operate, how artificial intelligence is applied in this automotive manufacturing plant to advance vehicle performance and safety.” (P-2)

“I believe training and development on robotics operation must be given sufficient attention for the 4IR implementation plan in this automotive manufacturing.” (P-6)

Subtheme 6.2: Artificial intelligence training

Many participants opined that training in AI, including the IoT, ML, cloud computing, big data analytics and quantum computing, would be essential.

“...assembly employees will need training opportunities for new capabilities on smart robotics, automation, artificial intelligence, Internet of Things, cloud computing, big data analytics, and quantum computing.” (P-7)

“I think our strategic planning for training and development programmes must focus on the Internet of Things skills, big data analytics, machine-learning skills and artificial intelligence skills.” (P-2).

Theme 7: Support

Line managers were asked what support, if any, assembly employees would require to remain employable in the next five to ten years. Several line managers argued that at Level 3 of the P-CMM, assembly employees would require support with compliance policy amendment and a strategic planning framework for ongoing training and development to keep pace with the 4IR smart digital era.

Subtheme 7.1: Talent development policy amendment

Most of the line managers indicated that an amendment to talent development policies would be required at Level 3 of the P-CMM.

“We must amend our talent development compliance policies and strategies to be aligned to the 4IR smart automotive manufacturing era to ensure continuous improvement processes for assembly employees’ new capabilities.” (P-2)

“It is crucial that we have an adjustment on our talent development compliance policy to be in line with the 4IR digital automotive manufacturing.” (P-6)

Subtheme 7.2: Compliance with training and development strategy

“...I guess this ongoing training and development should get first preference in the strategic planning for digital compliance policy for guidance to manage training attendance for assembly employees.” (P-6)

“Our assembly employees need to be supported towards 4IR to comply with the strategically planned new capabilities training and development framework.” (P-1)

Category 4: 4IR capabilities for automotive assembly employees: P-CMM Predictable Level: Maturity Level 4

Theme 1: Software development skills and knowledge

Line managers were asked to describe the skills that assembly employees would need in the next five to ten years. Referring to Level 4 of the P-CMM, some line managers indicated that assembly employees would require software development technical skills and knowledge for 4IR cyber-physical production systems within this automotive manufacturing organisation. Various line managers argued that software technical skills and knowledge should include programming language, coding, Python, and augmented and virtual reality for understanding robotics and smart machines in 4IR digital automotive manufacturing and interacting and communicating with them. Different line managers insisted that at Level 4 of the P-CMM, assembly employees would require these software technical skills and knowledge for swift software problem-solving and improvement processes for the 4IR digital assembly plant.

Subtheme 1.1: Programming language

The majority of the participants indicated that skills and knowledge in the programming language Python would be crucial to communicate with robots and smart machines.

“Our assembly employees will need to have basic programming language skills to communicate with the robotics and smart machines.” (P-1)

“I think the programming language understanding and ... skills are the future of the automotive manufacturing industry.” (P-2)

“In my view, Python knowledge will help our assembly employees in this automotive assembly plant to understand how to interact with the smart robots.” (P-1)

Subtheme 1.2: Coding skills and knowledge

Many line managers stressed the importance of coding knowledge for assembly employees at Level 4.

“...assembly employees will need coding knowledge to translate instructions from our language to the computerised language, such as the smart machine and robotics language, which is written in binary terms.” (P-2)

“I think the basic coding skills ... and system integration skills are crucial for our subordinates in this automotive assembly plant.” (P-3)

Subtheme 1.3: Augmented and virtual reality skills and knowledge

Some participants opined that assembly employees would require AR and VR skills and knowledge at Level 4.

“Augmented reality skills, virtual reality skills, and digital twins ... will be the skills required for our assembly employees at this maturity level four.” (P-6)

“I feel like the assembly employees are required to have better knowledge on augmented reality, virtual reality for interaction and adaptation with 4IR digital automotive manufacturing.” (P-6)

Subtheme 1.4: Complex software solving skills and knowledge

Several line managers indicated that assembly employees would need skills and knowledge of various software solutions to resolve complex problems quickly.

“...alignment and focus knowledge should be on the programming languages like Python because it is a straightforward and efficient programming language to solve complex software problems in a short period.” (P-2)

“I believe smart robotics will be operating through machine learning; big data will be analysed to predict future expectations, better car improvements and software complex solutions.” (P-4)

Theme 2: Positive behaviours

Line managers were asked to describe the behaviours, if any, that assembly employees would need in the next five to ten years. Many line managers argued that at Level 4 of the P-CMM, assembly employees should have positive behaviour characteristics to adapt to 4IR smart automotive production systems. Several line managers stated that positive behaviour characteristics comprised confidence, honesty, openness, consistency, patience, high integrity, resiliency and self-management.

Subtheme 2.1: Compliance behaviours

Many participants indicated that compliance behaviours, such as honesty, integrity, ethical behaviour, consistency and transparency, would be required of assembly employees at Level 4.

“Confidence, honesty, openness, consistency, patience, good integrity, self-management, good ethical behaviour, and positivity will be types of behaviours that assembly employees will need to have for 4IR digital production in this automotive assembly plant.” (P-4)

“Positivity, confidence, compliance, resiliency, acceptance, and transparency will be very important for assembly employees to gain new capabilities required for 4IR smart production in this automotive assembly plant.” (P-3)

Subtheme 2.2: Self-management behaviours

Most of the line managers stressed the importance of self-management behaviours, such as confidence, openness, patience, resilience, adaptability and acceptance, for assembly employees at Level 4.

“Confidence, honesty, openness, consistency, patience, good integrity, self-management, good ethical behaviour, and positivity will be types of behaviours that assembly employees will need to have for 4IR digital production in this automotive assembly plant.” (P-4)

“Positivity, confidence, compliance, resiliency, acceptance, and transparency will be very important for assembly employees to gain new capabilities required for 4IR smart production in this automotive assembly plant.” (P-3)

Theme 3: Positive attitudes

Line managers were asked to describe the attitudes, if any, that assembly employees would need in the next five to ten years. Various line managers observed that at Level 4 of the P-CMM, assembly employees should be willing to learn about cyber-physical production systems and should realise the necessity of lifelong acquisition of new capabilities. Some line managers emphasised the importance of assembly employees' willingness to participate and their commitment to learning, which would enable them to acquire new capabilities through training and to benefit from 4IR succession planning and promotions.

Subtheme 3.1: Positive attitude towards training and development

The majority of the line managers agreed that a positive attitude towards training and development among assembly employees would be crucial.

“4IR also requires assembly employees to have a good attitude and to understand the combination or interface between technological applications and software devices for collaboration.” (P-5)

“Acceptance of 4IR will enable employee commitment for 4IR participation as well as acquiring the new capabilities that are in high demand in this automotive manufacturing assembly plant.” (P-6)

Subtheme 3.2: Willingness to use every opportunity for lifelong learning

Many participants indicated that assembly employees would have to be willing to make use of every opportunity for lifelong learning.

“I think the willingness to use every opportunity for life-long learning for our assembly employees is the way to go and the way to win the talent development war for required new capabilities for 4IR.” (P-1)

“...4IR ... requires our assembly employees to always have positive willingness for lifelong learning to acquire new capabilities to operate the smart tools, robots for human-machine collaboration in this automotive assembly plant.” (P-7)

Theme 4: Angle sensor detection equipment

Line managers were asked what equipment (tools, machines, computers, etc.), if any, assembly employees would need in the next five to ten years. Various line managers stated that at Level 4 of the P-CMM, assembly employees would need to use angle position sensor detection to identify the rotational evolution in assembling smart car parts.

“It is advisable that the assembly employees use the inductive and magnetic sensors for assembling and fitting of the car accelerator and steering angle detection.” (P-1)

“I strongly feel that the angle detection sensors ... are very important for our assembly employees to assemble modern cars such as hybrid electric cars and autonomous cars.” (P-4)

Theme 5: Physical workplace comprising smart computers

Many participants opined that the physical workspace would be digitalised, with reliance on smart computers, at Level 4.

“I strongly believe that we move towards the digitalised automotive manufacturing plant with smart computerised operation systems to meet the requirements of 4IR technological innovations.” (P-7)

“I think we need a digital workspace that relies on the smart computers for application of big data analytics, cloud computing as required by 4IR smart operations on the assembly lines.” (P-4)

Theme 6: Training opportunities

Line managers were asked what training, if any, assembly employees would require to remain employable in the next five to ten years. Many line managers contended that at Level 4 of the P-CMM, assembly employees should be provided with training and development to understand coding and programming software development systems for 4IR smart automotive manufacturing.

Subtheme 6.1: Coding and programming training opportunities

Many line managers indicated that assembly employees should receive training in programming and coding.

“I recommend that the focus for training and development at this maturity level must focus on coding, programming ... skills and knowledge for our assembly employees.” (P-3)

“I think the training that must be considered for assembly employees should include programming, coding...” (P-2)

Subtheme 6.2: Augmented and virtual reality training

Some participants indicated that assembly employees would require augmented and virtual reality training to adapt to the 4IR technological transformation within the assembly plant.

“I propose that we give our assembly employees new capabilities training on ... virtual reality, augmented reality, digital twins, quantum computing ... to adapt to 4IR technological transformations.” (P-7)

“I think the ongoing on-the-job training and development for learning these 4IR crucial skills like artificial intelligence, augmented and virtual reality must be the priority for capabilities trainings for our assembly employees.” (P-4)

Theme 7: Support

Line managers were asked what support, if any, assembly employees would require to remain employable in the next five to ten years. According to a number of line managers, at Level 4 of the P-CMM assembly employees should be empowered and motivated through proactive succession planning. Line managers emphasised the importance of communicating the purpose and role of succession planning to assembly employees, enabling them to acquire new capabilities relevant to vacant critical positions. Various line managers also highlighted that succession planning should be aligned with 4IR strategic planning to prepare assembly employees for new, critical technical positions that would become available in smart automotive manufacturing.

Subtheme 7.1: Promote succession planning

Most of the line managers emphasised the importance of succession planning in relation to 4IR capabilities.

“...alignment of succession planning with the 4IR strategic planning can be a good initiative ever to succeed with the talent war for the high demand of the new capabilities for our assembly employees in this automotive assembly plant.” (P-1)

“Besides the advantage of insourcing our employees into available critical positions with relevant new technological capabilities, we will also be playing a key role in aligning new digital succession planning with 4IR in this automotive assembly plant.” (P-2)

Subtheme 7.2: Availability of critical positions

Line managers reiterated that at Level 4 of the P-CMM, there would be critical positions available for assembly employees to fill if they had the required 4IR capabilities.

“We must also support and encourage our assembly employees that there is no doubt that there will be critical available positions in this automotive manufacturing organisation for the 4IR digital world.” (P-3)

“It is very important that we clearly communicate the purpose and role of succession planning to our assembly employees to understand that there will be critical positions and how they will be filled in this automotive assembly plant.” (P-5)

Category 5: 4IR capabilities for automotive assembly employees: P-CMM Optimising Level: Maturity Level 5

Theme 1: Cyber skills and knowledge

Line managers were asked to describe the skills, if any, that assembly employees would need in the next five to ten years. Several line managers maintained that at Level 5 of the P-CMM, assembly employees would still be required to possess advanced technological skills and knowledge of cyber-physical production systems to interact with smart machines and robots. Various line managers also argued that assembly employees would need cybersecurity skills to ensure trustworthiness and address data privacy and cybersecurity challenges.

Subtheme 1.1 Cyber-physical production skills and knowledge

Most of the participants stressed the importance of cyber-physical skills and knowledge, including robotics and ML, at Level 5.

“To be honest, another important technological skill that is in high demand for our assembly employees to adapt to the 4IR in this automotive manufacturing includes cyber-physical production skills.” (P-1)

“So, there is no doubt that our assembly employees will need the new knowledge, particularly on cyber-physical production, to interact well with the smart machines and robots.” (P-2)

Subtheme 1.2: Cybersecurity skills and knowledge

The majority of the line managers indicated that cybersecurity skills and knowledge would be essential for assembly employees.

“In my perspective, the cybersecurity skills will be essential, as they will help our assembly employees to ensure the trustworthiness of the connected cars, electric cars and autonomous cars.” (P-2)

“I assume that the cyber security skills ... robotics and machine learning skills will dominate the future of automotive manufacturing in the 4IR digital era.” (P-5)

Theme 2: Self-management behaviours

Line managers were asked to describe the behaviours, if any, that assembly employees would need in the next five to ten years. Different line managers insisted that at Level 5 of the P-CMM, assembly employees should have self-management behaviours to acquire the new capabilities required for the 4IR through training and development. These self-management behaviours would include adaptability behaviours, agency and proactive communication.

“In my view, assembly employees must give positive perspectives regarding training and development programmes ... of this automotive manufacturing organisation for new capabilities required for 4IR.” (P-4)

“I guess the assembly employees at this improved maturity level will need to express their own perspectives and readiness for technological change through positive communication approach...” (P-3)

Theme 3: Positive attitudes

Line managers were asked to describe the positive attitudes, if any, that assembly employees would need in the next five to ten years. Various line managers insisted that at Level 5 of the P-CMM, assembly employees should have a positive attitude in order to communicate positively with the line manager. Some line managers indicated that a positive attitude towards learning would help assembly employees interact with smart robots and tools for cyber-physical systems in 4IR smart automotive manufacturing. Some line managers also highlighted the importance of maintaining a positive attitude towards change while participating in the transition process, along with positive relationships to support adaptation to the 4IR.

Subtheme 3.1: Positive attitude towards learning and development

Many participants stressed that assembly employees should have a positive attitude towards learning and development at Level 5.

“I assume that the assembly employees should have a positive attitude to positively communicate with the line managers to obtain the new capabilities needed for 4IR human-machine interface.” (P-6)

"Assembly employees must continue with positive ... attitude with a strong willingness to learn how to interact with smart robotics and utilise smart tools for smart 4IR manufacturing of the smart cars." (P-3)

Subtheme 3.2: Positive attitude towards change

Line managers indicated that assembly employees should have a positive attitude towards change to remain engaged.

"During this maturity level, we expect our assembly employees to build change capacity for readiness to adapt while feeling involved and engaged throughout the processes." (P-2)

"...assembly employees will need to create positive relationships and participate in the change initiative process to gain momentum." (P-3).

Theme 4: Equipment

Line managers were asked to specify which equipment (tools, machines, computers, etc.), if any, assembly employees would need in the next five to ten years. Many line managers revealed that at Level 5 of the P-CMM, assembly employees would require industrial and collaborative robots within the automotive manufacturing plant. Several line managers also indicated that assembly employees would need augmented and virtual reality, additive manufacturing, and 3D printing equipment to understand the integration of various software and digital devices for Industry 4.0 smart automotive manufacturing.

Subtheme 4.1: Industrial and collaborative robots

Many line managers stressed that at Maturity Level 5, assembly employees would need industrial and collaborative robots for digital assembly plant systems and operations in the era of the 4IR.

"I think at this maturity level 5, the assembly employees would require advanced digital equipment that comprises smart collaborative robots, smart machines, large industrial robotics with high-speed for a 4IR automated assembly plant." (P-7).

"I guess the smart manufacturing robots and synergetic robots will be at the heart of the 4IR smart automotive manufacturing of modern cars." (P-6)

Subtheme 4.2: Augmented and virtual reality

Many participants indicated that augmented and virtual reality would be crucial for the 4IR digital automotive assembly plant at Level 5 of the P-CMM.

"From my perspective, I think the augmented and virtual reality equipment will be important to enhance our assembly employees' real-world view for a digitalised automotive assembly plant." (P-7)

"In my opinion, the assembly employees will require augmented and virtual reality within the assembly plant for a 4IR computer-generated systems environment." (3)

Subtheme 4.3: Additive manufacturing/3D printing

Some line managers stressed that at Maturity Level 5, the automotive manufacturing organisation should provide assembly employees with additive manufacturing/3D printing equipment for 4IR digital operations.

"It seems to me that the assembly employees will need the additive manufacturing, which is also referred to as 3D printing, for layering and computer control for digital operations to assemble smart cars effectively in the era of 4IR." (P7)

"I suppose the advanced technological equipment should include the 3D printers to be part of the essential equipment needed for effective transition into the 4IR smart automotive manufacturing of building modern cars.

Theme 5: Physical workplace to reflect the intersection of the Internet of Things, artificial intelligence and robotics

Line managers were asked if the physical workplace would need to change over the next five to ten years to enable assembly employees to perform their jobs effectively. Line managers were also asked to motivate their answers. Diverse line managers insisted that at Level 5 of the P-CMM, the physical workplace should transition to a digital environment for assembly employees to experience how AI is interconnected through the IoT within a smart automotive assembly plant.

"...physical workplace for 4IR technological trends must just be digital that is all I can say, and that will be a necessity." (P-2)

"At this maturity level, our automotive manufacturing assembly plant needs to change to digital observability so that our assembly employees can see the practical interconnection of the Internet of Things, artificial intelligence, and robotics." (P-1)

Theme 6: Training

Line managers were asked what training, if any, assembly employees would require to remain employable in the next five to ten years. Several line managers opined that at Level 5 of the P-CMM, ongoing training and development on cyber-physical production systems would be important for assembly employees to adapt to the 4IR digital automotive assembly plant. Various line managers also argued that assembly employees would need ongoing change management training to know the purpose and benefits of the 4IR digital changes for smart automotive manufacturing.

Subtheme 6.1: Cyber-physical production training opportunities

Many line managers indicated that assembly employees would require cyber-physical training opportunities.

"I trust that the continuous training and development programmes on 4IR cyber-physical production systems will be important for our assembly employees in this automotive assembly plant." (P-6)

"In my view, the ... cyber-physical production requires the continuous training and development programmes to close new capabilities gap." (P-3)

Subtheme 6.2: Cybersecurity training opportunities

Various line managers strongly emphasised the importance of prioritising cybersecurity training opportunities for assembly employees to work effectively with cybersecurity systems.

"We need to prioritise the cybersecurity training opportunities for our assembly employees to adapt to 4IR technological transformations." (P-7)

"Assembly employees are required to have basic training on how to handle the cybersecurity systems for big data analytics due to the heavy reliance on the software systems for 4IR smart automotive manufacturing." (P-5)

Subtheme 6.3: Change management training opportunities

Many line managers emphasised the importance of change management training opportunities for assembly employees to adapt to the 4th Industrial Revolution (4IR).

"I think an ongoing change management training on digital change is important for the benefits of our assembly employees for the 4IR digital era within the assembly plant." (P-2)

"I strongly believe that frequent change management training on positivity for acceptance of 4IR, which increases the buy-in from our assembly employees." (P-4).

Subtheme 6.4: Robotics training

Many of the line managers emphasised that assembly employees would need training on smart robotics systems to operate effectively in the 4IR digital automotive assembly plant.

"I recommend that our assembly employees be trained on the smart robotics for adaptation into a 4IR digitalised assembly plant." (P7)

"I think we also need to put efforts and provide the assembly employees with the continuous training programmes on the smart robotics that are associated with 4IR." (P-3)

Subtheme 6.5: Machine learning training

Various line managers mentioned that ML was crucial for the training programme of assembly employees within the 4IR automotive assembly plant.

“I can tell you that the training on machine learning is crucial for our assembly employees as part of the branch of artificial intelligence.” (P-7)

“It is essential that our assembly employees get training on the basic understanding of machine learning for the 4IR smart automotive manufacturing assembly plant.” (P-1)

Theme 7: Support

Line managers were asked to describe what support, if any, assembly employees would require to remain employable in the next five to ten years. Diverse line managers stated that at Level 5 of the P-CMM, assembly employees would need mentorship for support and motivation, while coaching programmes would facilitate rapid adjustment to 4IR smart automotive manufacturing. Many line managers argued that the line managers of assembly employees should first be trained to become experienced mentors and coaches for assembly employees to adapt to 4IR smart automotive manufacturing. Several line managers also indicated that the mentorship and coaching programmes would influence, guide, encourage, inspire, support and motivate assembly employees for lifelong learning to master the new capabilities required by the 4IR.

Subtheme 7.1: Mentorship for support and motivation

Line managers stressed the importance of mentorship to assembly employees at Level 5.

“I strongly believe that the line managers will be good assembly mentors to influence, encourage, support, motivate and guide assembly employees as their mentees to see the necessity of 4IR digital automotive manufacturing.” (P-1)

“I think the pilot test experiment and initial phases of the 4IR digital manufacturing must be done with the team leaders and group leaders to become adequately experienced mentors and coaches.” (P-6)

Subtheme 7.2: Coaching for continuous learning and development

Many participants emphasised that coaching for continuous learning and development would be crucial.

“In my opinion, assembly employees will need 4IR coaching for encouragement on ongoing training and development programmes using support, influence and motivate them to adjust well with 4IR automation systems in the plant.” (P-4)

“I believe that through mentorship and coaching programmes, our assembly employees will be inspired for life-long learning with a clear 4IR understanding and support for acquiring new capabilities for digital automotive manufacturing.” (P-2)

Findings from experts in talent development and the advisory board regarding the evaluation of a P-CMM

Table 2 presents the descriptives of the panel of talent development experts and the advisory board of the automotive manufacturing organisation who participated in the study.

TABLE 4.4: Descriptives of the panel of talent development experts ($N=9$)

Participant number	Age	Gender	Ethnicity	Tenure
1	31-40	Male	African	5-9
2	31-40	Female	Indian	5-9
3	31-40	Male	African	10-14
4	41-50	Female	African	15-19
5	41-50	Male	Coloured	10-14
6	41-50	Male	African	15-19
7	50 +	Male	African	20-24
6	50 +	Female	Indian	15-19
9	50 +	Female	Coloured	15-19

Data were gathered from a panel of 9 members ($N=9$) talent development experts and the advisory board (hereafter referred to as the panel) within an automotive manufacturing organisation in South Africa. The objective was to assess the five levels of a P-CMM for a South African automotive manufacturing organisation. Figure 2 displays the categories and themes derived from the analysed evaluation data.

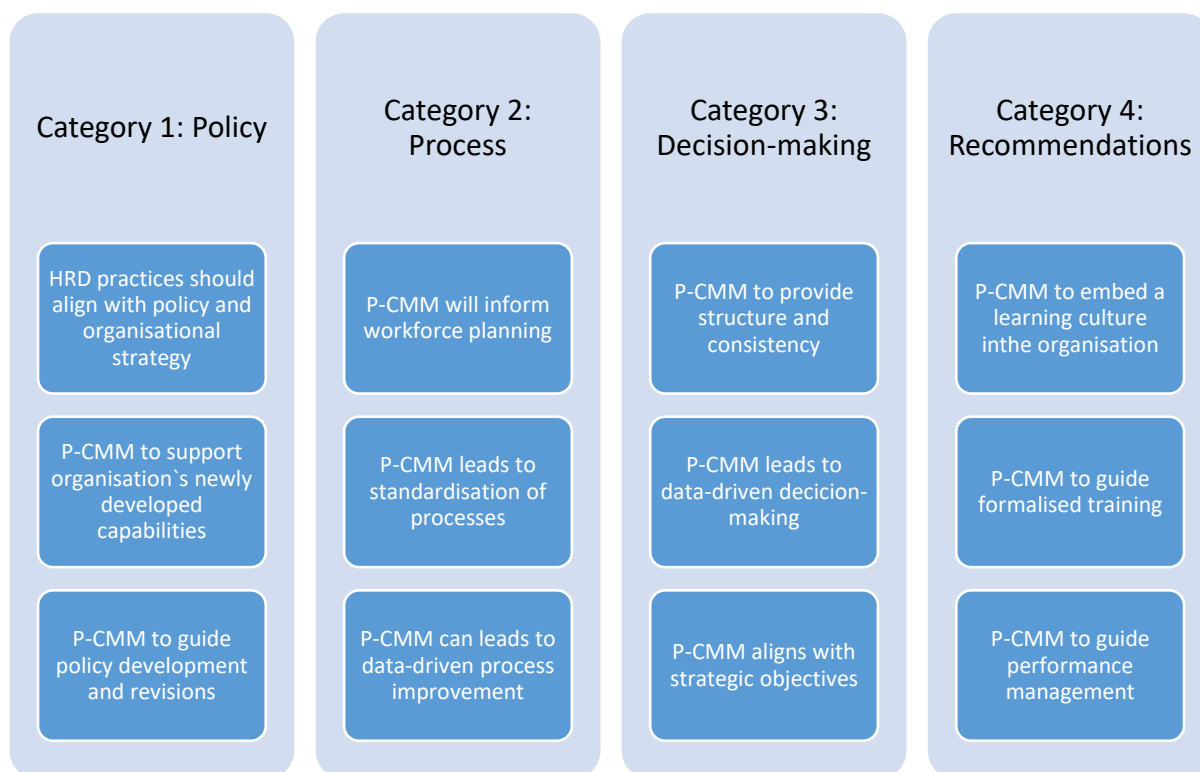


FIGURE 4.2: Overview of categories and themes – participant data

Category 1: Policy

The panel members were asked to share their observations on the P-CMM's potential to influence policy in a South African automotive organisation and to support their responses. Many participants suggested that human resource development (HRD) practices should align with policy and organisational strategy and support the organisation's newly developed capabilities; the P-CMM could guide policy development and revision to adapt to 4IR smart automotive manufacturing.

Theme 1: HRD practices should align with policy and organisational strategy

Several members of the panel advised that HRD practices should align with policy and organisational strategy for the automotive manufacturing organisation to adopt the P-CMM, operate digitally, and keep pace with 4IR technologies to assemble smart cars, such as hybrid and autonomous models.

“HRD alignment with Broader Strategy to ensure that the P-CMM goals are fully integrated into South Africa's automotive manufacturing broader business strategy.” (P-2)

“An Organisational Development (OD) Strategy (including Change Management as well as Leadership Development) in alignment with HRD policy should drive the P-CMM development process to ensure organisational practices support newly developed capabilities.” (P-1)

Theme 2: Organisational support of newly developed capabilities

Various panel members stated that the P-CMM was crucial for organisational support of newly developed capabilities to keep pace with the 4IR in smart automotive manufacturing, which involves digital systems used in assembling smart cars, such as hybrid electric and autonomous vehicles.

“Thus, for the success of the development of capabilities, the buy-in from top management is crucial. Without adoption of P-CMM and top management support, driving a culture of learning, the capability initiative will not succeed.” (P-1)

“As far as I can tell, I recommend the P-CMM with positive impact on our talent development policies’ review as we are required to support and equip our assembly employees with new capabilities to keep up with the 4IR digital systems.” (P-7).

Theme 3: P-CMM guides policy development and revision

Many members of the panel expressed that the P-CMM should guide policy development and the revision of talent development policies to continuously improve the capabilities of assembly employees in adapting to 4IR digital automotive manufacturing.

“I recommend PCMM as a framework to guide us to redesign and align our training policies for continuous improvement of employees’ talent development processes to acquire new capabilities to adapt to 4IR.” (P-5)

“I would highly recommend that the PCMM will serve as a guidance for amendment of the talent development policies that will continuously improve the capabilities of the assembly employees for 4IR.” (P-9)

Category 2: Process

The panel members were asked to share their observations regarding the P-CMM’s potential to influence processes in a South African automotive organisation, along with their reasons for their answers. Different participants highlighted that the P-CMM would assist in workforce planning, lead to the standardisation of processes, and help drive data-driven process improvements for integration into 4IR smart automotive manufacturing.

Theme 1: P-CMM will inform workforce planning

Panel participants stated that the P-CMM would guide workforce planning to improve talent development practices for employees’ new capabilities, which is the most essential step in adapting to a 4IR digital automotive assembly plant.

“In my opinion, I am recommending this model to be our framework for the determination of our capability maturity level for measuring, planning and improving the processes for developing talent practices for employees’ new capabilities.” (P-6)

“I advise that the P-CMM will determine our current capability maturity level to be improved with talent development processes and planning for our assembly employees to acquire new capabilities for 4IR.” (P-7)

Theme 2: P-CMM can lead to the standardisation of processes

Different members of the panel conveyed that the P-CMM should lead to the standardisation of HR talent development and operational processes for continuous talent development for 4IR capabilities for smart automotive manufacturing.

“The P-CMM would force organisations to standardise their HR and operational processes. Instead of each department or team handling tasks like hiring, onboarding, or performance reviews differently, the PCMM's focus on repeatable practices ensures that a single, documented process is used across the entire organisation.” (P-2)

“I strongly recommend this model to identify our current assembly employees’ capability maturity level for standardising and continuously improving our talent development process for 4IR new capabilities in this automotive assembly plant.” (P-5)

Theme 3: P-CMM can lead to data-driven process improvement

Various panellists stated that the P-CMM could facilitate data-driven process improvement for the ongoing enhancement of talent development processes in the 4IR digitalisation of assembling smart cars.

“At the highest levels of the PCMM, all processes are quantitatively managed, meaning they are measured, analysed, and continuously improved based on data. This moves the organisation beyond simply following a process to actively refining it.” (P-2)

“I suggest that we apply the PCMM model for the identification of our current people capability maturity model data for continuous improvement of our talent development processes for 4IR digitalisation of assembling smart cars.” (P-9)

Category 3: Decision-making

The panel participants were asked to make observations on the P-CMM's potential to influence decision-making in a South African automotive organisation, and to account for their responses. Various participants observed that the P-CMM would provide structure and consistency, lead data-driven decision-making, and align decisions with strategic objectives to support the adoption of 4IR digital automotive manufacturing.

Theme 1: P-CMM to provide structure and consistency

Many participants from the panel argued that the P-CMM was essential for providing the structure and consistency needed for decision-making and alignment with strategic goals, from the recruitment to the development of assembly employees for 4IR automotive manufacturing.

“P-CMM will provide structure and consistency when making decisions, when aligned with strategic goals, from recruitment to the development of staff.” (P-1)

“By formalising and standardising processes, the P-CMM creates a foundation for consistent and fair decision-making. Decisions are made based on a predefined set of criteria structure rather than on individual discretion.” (P-2)

Theme 2: P-CMM leads to data-driven decision-making

Several members of the panel observed that the P-CMM would facilitate data-driven rather than ad hoc decision-making to mitigate strategic and operational risks, thereby enhancing capabilities development processes for inclusivity and compliance in 4IR smart automotive manufacturing.

“The P-CMM moves an organisation from making ad-hoc decisions to making data-driven decisions. At higher maturity levels, the model requires the collection and analysis of workforce capabilities development data to understand the effectiveness of HR practices.” (P-2)

“...data-driven decision-making will reduce strategic and operational risks and, in turn improve capabilities development processes for inclusivity and compliance.” (P-4)

Theme 3: P-CMM aligns decisions with strategic objectives

Many participants from the panel observed that the P-CMM would assist in aligning the talent development decision-making processes of assembly employees with the strategic objectives during the digital era of 4IR smart automotive manufacturing.

“The P-CMM ensures that all people-related decisions are aligned with the organisation's strategic objectives. Decisions are no longer isolated but are integrated into a broader plan for developing a capable workforce.” (P-2)

“...P-CMM for providing us with our current capability maturity level for alignment of our employees' talent development decision-making processes with the strategic objectives.” (P-6)

Category 4: Recommendations

The panel was asked for recommendations regarding the P-CMM of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation. Several participants suggested that the P-CMM be integrated into the organisation's learning culture, guide formalised training programmes, and direct performance management to support the adoption of 4IR technologies in automotive manufacturing.

Theme 1: P-CMM to embed a learning culture in the organisation

Most panel participants recommended that the P-CMM should foster a learning culture where assembly employees are willing to acquire new capabilities to adapt to the evolving 4IR technologies within the automotive manufacturing plant.

“I would recommend the adoption of P-CMM to embed a learning culture into the organisation.” (P-4)

“Foster an environment where learning is a continuous process, not a one-time event. P-CMM is recommended for embedding a culture of lifelong learning programmes and micro-credentialed skills systems to help employees adapt to evolving technologies.” (P-2)

Theme 2: P-CMM to guide formalised training programmes

Various members of the panel recommended the P-CMM as a framework for guiding formalised training programmes to assess and enhance the talent development of assembly employees, enabling them to acquire new capabilities to thrive in the 4IR digital world of work.

“P-CMM is recommended for guiding formalised training programmes to move away from ad hoc training. Establish a structured training framework with clear learning paths for different roles. These programmes are recommended to be practical, hands-on, and accessible to all assembly workers, focusing on the identified skill gaps.” (P-5)

“It is crucial that I recommend the application of P-CMM as a framework for assessing and improving the talent development of our assembly employees to acquire new capabilities to thrive in the 4IR digital world of work.” (P-9)

Theme 3: P-CMM to guide performance management

Different panel participants recommended that the P-CMM guide performance management systems and training outcomes, enabling continuous evaluation of the effectiveness of human resource practices. According to the participants, these practices include new 4IR-relevant key performance indicators (KPIs), such as adaptability to new technologies, problem-solving for automated systems, and effective use of digital tools.

“I would recommend the use of the P-CMM to guide performance management systems and training outcomes to continuously evaluate the effectiveness of HR practices. For example, analyse data to see if training on new robotic systems leads to a measurable decrease in production errors or cycle time.” (P-3)

“I highly recommend the implementation of a consistent and fair performance management system guided by the P-CMM. This system should not only measure traditional metrics but also include new 4IR-relevant KPIs, such as adaptability to new technologies, problem-solving on automated systems, and effective use of digital tools.” (P-8)

DISCUSSION

Outline of the findings

This section presents the findings for each specific objective. It also discusses how these findings add to the existing body of knowledge.

Objective 1: To conceptualise a People Capability Maturity Model according to the literature

The P-CMM is a maturity framework developed by the Software Engineering Institute (SEI) at Carnegie Mellon University. However, unlike the CMM, the P-CMM seeks to measure and improve human resource development practices such as employee capabilities (Bakkah, 2024; Chen & Wang, 2018; Lanure et al., 2023). Employee capability is described as the skills, knowledge, and functional capacity to accomplish organisational objectives (Curtis et al., 1995; Curtis et al., 2002). The P-CMM comprises five maturity levels for organisational employee development, namely, the initial level, managed level, defined level, predictable level, and optimising level (Bakkah, 2024; Chen & Wang, 2018; Curtis et al., 2007; Lanure et al., 2023). Each of the maturity levels is briefly discussed below.

The **Initial Level (Level 1)** is characterised by inconsistency or the lack of formal management of employee development practices (Bakkah, 2024; Carnegie Mellon University, 1995; Humphrey, 1989).

The **Managed Level (Level 2)** encompasses formalised employee management and development strategies, with an awareness of the required employee capabilities (Bakkah, 2024; Humphrey, 1989; Carnegie Mellon University, 1995). However, practices are still reactive, and there is insufficient alignment among HR employee development practices (Bakkah, 2024; Lanure et al., 2023).

The **Defined Level (Level 3)** concerns competency management (Humphrey, 1989; Carnegie Mellon University, 1995). Organisations explain and advance employee capabilities that align with their talent development strategic decisions and goals. HR employee development strategies are outlined and constantly employed within the organisation (Bakkah, 2024; Lanure et al., 2023).

The **Predictable Level (Level 4)** involves employee capability management and development (Carnegie Mellon University, 1995; Humphrey, 1989). At this level, creating an information-focused

strategy for HR management is crucial. In addition, the transformation demand in employee capabilities is recognised (Bakkah, 2024; Lanure et al., 2023).

The **Optimising Level (Level 5)** encompasses change management (Carnegie Mellon University, 1995; Humphrey, 1989). Continuous improvement in people development processes is emphasised. Innovative HR practices are implemented to support and manage the capability challenges in the evolving requirements of the organisation (Bakkah, 2024; Lanure et al., 2023;).

The P-CMM helps organisations determine the current maturity of their employees' development strategies for decision-making and create systems for employee development during the change process (Baradaran & Habibi, 2020; Chen & Wang, 2018; Curtis et al., 2001). With the application of the P-CMM, organisations can create a programme for continuous employee development, set priorities for improvement, integrate employee development with process improvement, and foster a culture of excellence (Baradaran & Habibi, 2020; Widyawati et al., 2025). The P-CMM is highly recommended as an efficient strategy for improving employee capabilities and quality, as well as for gaining a competitive edge during the digital transformation process (Baradaran & Habibi, 2020; Dangmei, 2017; Widyawati et al., 2025). The P-CMM offers organisations a valuable opportunity to enhance employee engagement, development, performance and growth, as well as employee adaptability and retention (Baradaran & Habibi, 2020; Widyawati et al., 2025).

Objective 2: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Initial Level: Maturity Level 1

The themes that emerged from the data included basic computer skills and knowledge, positive behaviours and attitudes, internet connectivity devices, equipment such as laptops and tablets, physical workplace changes towards digitalisation with the introduction of robotics and smart machines, basic computer literacy training, information sharing, and support for involvement and communication.

Line managers reported that basic computer skills and knowledge would be essential at Level 1 of the P-CMM. This finding is corroborated by Khumalo (2020) and Lorenz et al. (2019), who report that basic computer literacy will be required to adapt to the 4IR and operate many digital jobs within smart automotive manufacturing organisations.

The participants indicated that assembly employees would need positive behaviours at the P-CMM Initial Level. Onyilo et al. (2020) state that employees with positive behaviours will thrive in

automotive manufacturing CPPS, thereby ensuring the efficiency of smart manufacturing and innovative quality-control processes.

Additionally, the line managers reported that positive attitudes would be essential at Level 1 of the P-CMM. This finding is supported by Adeyinka (2023), who argues that the manufacturing of smart vehicles, such as hybrid electric cars, requires assembly employees to adapt to 4IR digital change with a positive attitude and willingness to learn about CPPS.

The participants reported that computer equipment, such as laptops, tablets and internet connectivity devices, would be a fundamental step in transitioning into the 4IR world of manufacturing smart cars. This finding is supported by Alaba (2024), Hassan et al. (2023) and Kallier (2022), who point out that the automotive manufacturing organisations cannot avoid the use of internet connectivity devices, such as smart laptops and tablets equipped with AI, IoT, ML, cloud computing, smart robotics and tools, when adopting 4IR digitalisation.

Line managers indicated that the current assembly lines would have to be transformed into digital assembly points with the introduction of robotics and smart machines at Level 1 of the P-CMM. This finding is corroborated by Ahmadi et al. (2023), Devaraj et al. (2025) and Roy (2022), who report that the introduction of 4IR smart technologies forced several automotive manufacturing organisations to digitalise their plant production systems with the incorporation of smart robotics, smart machines and tools demanded for increased efficiency, precision and quality.

Regarding training, the line managers emphasised the importance of basic computer literacy for assembly employees. Martin (2022) and Lorenz et al. (2019) confirm that automotive manufacturing managers consider basic computer literacy training as the foundational stage in developing employees' technical capabilities to adapt to the 4IR.

Several line managers argued that at Level 1 of the P-CMM, assembly employees would need effective communication to understand the impact, purpose, benefits and overall vision for implementing 4IR smart automotive manufacturing to build modern cars. Moreover, line managers advised that involvement and information sharing with assembly employees would be crucial for acquiring new capabilities to adapt to 4IR digitalisation in a smart automotive assembly plant. The overall theme of support related to communication with assembly employees is affirmed by Adekanmbi and Ukpere (2022), Ngoben et al. (2022) and Venkatesh (2022), who argue that the transition to 4IR can only be achieved by involving employees and sharing information, positively

communicating the need for change and the likely benefits for employees in terms of achieving organisational objectives in the digital world.

Objective 3: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Managed Level: Maturity Level 2

For Level 2, the following themes emerged from the data: technological application skills and knowledge, positive behaviours, positive attitudes, programmable logic controllers and internet connectivity equipment, physical workplace change to digital and innovative building structures, AI, IoT and data analytics training opportunities, and employee support through investment in training, engagement, commitment and empowerment.

The line managers noted that technological application skills and knowledge, such as AI, IoT and advanced computing capabilities, would be essential for assembly employees at P-CMM Maturity Level 2. This finding is supported by Ganeshan et al. (2022), Govender et al. (2022), Mkhize and Parumasur (2022) and Turner (2022), who argue that, with AI and IoT transforming the manufacturing industry, advanced computer skills are vital for ongoing training and development.

Many participants noted that positive behaviours of assembly employees were essential at Level 2 of the P-CMM. This finding is supported by Gräßler et al. (2021), Kruger (2022) and Van der Westhuizen (2021), who state that assembly employees need to exhibit positive behaviours and a willingness to accept 4IR digital change to develop new capabilities for integration into the entire process of cyber-physical production systems.

Many participants indicated that positive attitudes of assembly employees would be necessary at the P-CMM Managed Level. This finding is supported by Adekanmbi and Ukpere (2023) and Venkatesh (2022), who maintain that employees should adopt positive attitudes to 4IR technological change, as it will benefit them.

Several line managers suggested that programmable logic controllers and internet connectivity digital equipment would be essential at Level 2 of the P-CMM. This finding is supported by Ojubanire et al. (2025), Osman et al. (2025) and Putro et al. (2025), who state that, in the context of 4IR technologies like AI and ML, the application and implementation of programmable logic controllers are essential for ongoing monitoring and control of automotive assembly plant operations.

Different participants conveyed that the current physical workplace should transition to digital and innovative building structures at Level 2 of the P-CMM. This finding is supported by Devaraj et al. (2025), Inyang et al. (2023) and Monye et al. (2023), who posit that during the 4IR, automotive manufacturing organisations are required to use advanced technologies such as cutting-edge robotics, including AI applications, which necessitate transforming traditional assembly plants into digitalised and innovative structures.

Regarding training, diverse participants emphasised that training opportunities in AI, IoT and data analytics would be significant at the P-CMM Managed Level. Investing in lifelong learning is one of the most valuable avenues for employees to develop new skills in AI, data analytics and IoT to adapt to the 4IR digital transformation in automotive manufacturing organisations (Alexander, 2022; Gorski et al., 2023; Fanoro et al., 2021).

Various line managers indicated that employee support—such as investing in training and development, aligning training initiatives, and promoting employee engagement, commitment and empowerment—would be necessary at Level 2 of the P-CMM. This finding is supported by Gorski et al. (2023), Mkansi and Landman (2021) and Ogedengbe et al. (2023), who argue that the 4IR digital transformation requires managers to invest financially in training and development programmes. This is further supported by Fernando and Santhosh Kumar (2022), Lexe and Lago (2023) and Van Den Heever et al. (2021), who propose that South African automotive manufacturing organisations should align their training and development strategies with succession planning to empower employees to acquire the new capabilities needed for the 4IR. Additionally, this finding is reinforced by Dutta et al. (2023), Gangeni (2020) and Gaur (2020), who maintain that employee engagement is a vital strategy for manufacturing organisations to increase employees' commitment to their production tasks during the adaptive phase of the 4IR.

Objective 4: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Defined Level: Maturity Level 3

For Level 3, the themes that emerged from this category included advanced technological application skills and knowledge; proactive behaviours; positive attitudes; variable speed drives and autonomous tow motors and tow trucks; physical workplace changes to smart buildings, both inside and outside; robotics operation; automation; and AI, ML, cloud computing, big data analytics and quantum computing training opportunities supported through talent development policy amendments and adherence to training and development strategies.

Many line managers indicated that advanced technological skills and knowledge, such as AI; IoT; Python; automation; digital, electronic and electrical systems; ML; cloud computing; and big data analytics, would be essential for assembly employees at Level 3 of the P-CMM. This finding is supported by Griffin and Mary (2020), Macpherson et al. (2023) and Schwab (2016), who state that the new capabilities that employees should acquire include software development, AI, the IoT, ML, smart robotics, smart machines, Python, automation, 3D printing, AM, cloud computing, big data analytics and CPPS.

Different participants reported that proactive behaviours of assembly employees would be needed at the P-CMM Defined Level. This finding is supported by Colledani et al. (2018), Gräßler et al. (2021) and Onyilo et al. (2020), who maintain that employees with proactive behaviours will thrive in automotive manufacturing CPPS, thereby ensuring the efficiency of smart manufacturing and innovative quality-control processes.

Most participants indicated that positive attitudes of assembly employees would be needed at Level 3 of the P-CMM. This finding is supported by Chung and Kim (2024), Khuzwayo (2023) and Ledwaba (2022), who urge managers to encourage employees to adopt positive attitudes towards 4IR technological change as one of the important required capabilities and a good approach to the transition to digitalisation.

Several line managers suggested that variable-speed drives, autonomous tow motors, autonomous tow trucks, and digital equipment would be essential at the P-CMM Defined Level. This finding is corroborated by Alie and Irawan (2025), Duanaputri et al. (2025) and Rangarajan et al., (2025), who explain that automotive manufacturing requires autonomous tow motors and variable-speed drives to enable precise control of vehicle speed, ensuring alignment with specific assembly production standards for energy efficiency and performance enhancement.

Most participants stated that the current physical workplace should be replaced with smart buildings, both inside and outside the assembly plant structures, at Level 3 of the P-CMM. This finding is confirmed by Ahmadi et al. (2023) and Inyang et al. (2023), who state that, to adapt and maintain a competitive advantage in the era of 4IR, automotive manufacturing organisations need to implement innovative technological applications both within and beyond plant processes.

Many participants stated that training in robotics operation, automation, AI, ML, cloud computing, big data analytics and quantum computing would be important at the P-CMM Defined Level. This finding is supported by Griffin and Mary (2020), Macpherson et al. (2023) and Schwab (2016), who maintain that it is important for training and development to focus on AI, IoT, ML, smart robotics, smart machines, Python, automation, 3D printing, AM, cloud computing, big data analytics, and CPPS.

The line managers suggested that employee support through amendments to the talent development policy and adherence to the training and development strategy would be necessary at Level 3 of the P-CMM. This finding is supported by Angevine et al. (2021) and Shobha and Johnson (2022), who highlight the continued absence of a clear policy strategy for employee participation in ongoing learning and development programmes. This limitation has led many manufacturing organisations to revise their training policies and assist employees in acquiring new skills (Angevine et al., 2021; Shobha & Johnson, 2022).

Objective 5: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Predictable Level: Maturity Level 4

At Predictable Level 4 of the P-CMM, the identified themes include software development skills and knowledge, positive behaviours, positive attitudes, angle sensor detection equipment, a physical workplace with smart computers, coding and programming, system integration, augmented and virtual reality, Python training opportunities, and support through succession planning and the availability of critical positions.

Several line managers indicated that software development skills and knowledge, such as basic programming, augmented and virtual reality, system integration and complex software problem-solving, would be essential for assembly employees at the P-CMM Predictable Level. This finding is supported by Popova (2020) and Karabulut and Akyuz (2023), who maintain that basic coding and programming language applications, 3D printing, augmented and virtual reality, and system integration are essential technical capabilities for automotive manufacturing organisations and should be considered when developing 4IR continuous training and development programmes.

Various participants reported that assembly employees should demonstrate positive behaviours at Level 4 of the P-CMM. Managers in manufacturing organisations are urged to support their employees in adopting positive behaviours and open minds to embrace 4IR technological changes (Adekanbi & Ukpere, 2022; Roberts et al., 2022; Venkatesh, 2020).

Several participants emphasised that a positive attitude among assembly employees would be essential at the P-CMM Predictable Level. This view is corroborated by Adeyinka (2023), Ledwaba (2022) and Siddiqui (2011), who assert that positive attitudes not only facilitate acceptance of change but also foster ongoing learning to develop the capabilities necessary to remain competitive in the era of the 4IR.

Many line managers suggested that angle sensor detection equipment would be essential at the P-CMM Predictable Level. This finding is corroborated by Alie and Irawan (2025), Duanaputri et al. (2025) and Rangarajan et al., (2025), who explain that angle detection sensors are crucial smart equipment often required by automotive manufacturing organisations in the era of the 4IR.

Different participants indicated that at Level 4 of the P-CMM, current physical workplaces should be modified to include smart computers. This finding is supported by Hammad et al. (2025), King and Cnop (2025) and Mukhudwana et al. (2025), who state that automotive manufacturing production systems and facilities should transition to full digitalisation, emphasising the role of smart computers for efficient assembly plant operations with big data analytics and cloud computing services.

Many participants argued that coding and programming, system integration, augmented and virtual reality, and Python training opportunities would be crucial at the P-CMM Predictable Level. These findings are corroborated by Popova (2020) and Karabulut and Akyuz (2023), who explain that basic coding and programming language applications, 3D printing, augmented and virtual reality, and system integration are essential technical capabilities for automotive manufacturing organisations and should be considered when developing 4IR continuous training and development programmes.

Several line managers indicated that employee support through succession planning and the availability of critical positions would be needed at Level 4 of the P-CMM. Fernando and Santhosh Kumar (2022), Lexe and Lago (2023), Pavlinek (2020) and Twinomurinzi et al. (2020) confirm that automotive manufacturing organisations should support and empower employees through succession planning to acquire new capabilities, enabling the development of autonomous and hybrid electric vehicles.

Objective 6: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Optimising Level: Maturity Level 5

For Level 5, the themes that emerged included cyber skills and knowledge, self-management behaviours, positive attitudes, industrial and collaborative robots, additive manufacturing, virtual and augmented reality equipment, the physical workplace reflecting the interaction of the IoT, AI and robotics, CPPS, cyber security, change management training opportunities, and employee mentorship and coaching support.

Most line managers indicated that cyber-physical production, cybersecurity, robotics and ML skills and knowledge would be essential for assembly employees at the P-CMM Optimising Level. This finding is supported by Oosthuizen (2021) and Victoria et al. (2021), who argue that employee engagement should be prioritised in manufacturing to inspire and foster interest in acquiring new capabilities in ML, robotics and cybersecurity when adopting 4IR CPPS that utilise AI.

Many line managers reported that assembly employees should demonstrate self-managed behaviours at Level 5 of the P-CMM. This finding is supported by Chung and Kim (2024), Mayer et al. (2024) and Suifan et al. (2018), who state that managers should inform employees of the need for self-managed behaviours to ensure relevance and job security in the 4IR digital world of work.

Different participants indicated that assembly employees would need positive attitudes at the P-CMM Optimising Level. This finding is supported by Adeyinka (2023), Onyilo et al. (2020) and Van der Westhuizen (2021), who argue that the manufacturing of smart vehicles, such as hybrid electric cars, requires assembly employees to adapt to 4IR digital change with a positive attitude and the willingness to master the cyber-physical systems.

Several line managers suggested that industrial and collaborative robots, additive manufacturing, and virtual and augmented reality equipment would be essential at Level 5 of the P-CMM. This finding is corroborated by Anzolin and Andreoni (2023), Boyal and Aigbavboa (2025) and Igbal et al. (2025), who insist that industrial and collaborative smart robotics are the core equipment driving 4IR digitalisation, with mass AI applications in smart automotive manufacturing organisations. Babu (2025) also supports this finding. Prathibha et al. (2024) and Winkelhake (2025) assert that automotive manufacturing organisations are facing a drastic 4IR digital transformation, which demands the utilisation of augmented and virtual reality, additive manufacturing, and digital equipment to fully achieve smart, integrated assembly production systems.

Various participants emphasised that current physical workplaces should be modified to reflect the interaction of the IoT, AI and robotics at Level 5 of the P-CMM. This finding is supported by Ahmadi et al. (2023), Inyang et al. (2023) and Mukhudwana et al. (2025), who maintain that the 4IR enables

seamless real-time communication, connectivity between humans, and the integration of AI smart tools, machines and robots through the IoT on smart computers and laptops for a digitised assembly environment.

Regarding training, many participants highlighted the opportunities in cyber-physical production, cyber security, and change management at the P-CMM Optimisation Level. This finding is supported by Adeyinka (2023), Onyilo et al. (2020) and Van der Westhuizen (2021), who maintain that manufacturing smart vehicles, such as hybrid electric cars, requires assembly employees to adapt to 4IR digital changes with a positive attitude and willingness to learn cyber-physical systems. This is further confirmed by Festing and Kraus (2020), Kumar (2020) and Mayer et al. (2024), who state that mentorship training in change management will help employees understand the purpose of acquiring new skills and developing their career paths.

Various line managers indicated that employee mentorship and coaching support would be necessary at Level 5 of the P-CMM. This finding is supported by Gubicza et al. (2024), Kumar (2020) and Reeves (2023), who argue that the 4IR era is disruptive and will require managers to implement coaching and mentorship programmes to help employees thrive in the automotive manufacturing sector. Furthermore, Buheji and Buheji (2020), Mang (2023) and Ogbaro et al. (2022) report that mentorship and coaching programmes have been utilised in digital manufacturing organisations to support employees in continuous learning and development.

Objective 7: To obtain, from a panel of talent development experts, an evaluation of the People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation and recommendations in this regard

The themes that emerged from the evaluation of the P-CMM regarding its potential to influence policy were the alignment of HRD practices with policy and organisational strategy; organisational support for newly developed capabilities; and the P-CMM being guided by policy development and revision.

The panel outlined that HRD practices should align with the automotive manufacturing organisation's policy and organisational strategy. This alignment will help the organisation adopt the P-CMM, operate digitally, and keep pace with 4IR technologies to assemble smart vehicles, such as hybrid and autonomous models. This finding is supported by Widyawati et al. (2025), who point out that the P-CMM helps organisations align human resource development policies and practices with strategic goals, ensuring that employees focus on organisational objectives.

Participants indicated that the P-CMM was essential for organisational support of newly developed capabilities to keep pace with 4IR smart automotive manufacturing, which uses digital systems in the assembly of smart vehicles, such as hybrid electric and autonomous models. This finding is supported by Maisiri and Van Dyk (2021) and Macpherson et al. (2023), who contend that managers in automotive manufacturing organisations should endorse ongoing training and development for employees to gain new skills in 4IR technological applications.

Furthermore, the participants stated that the P-CMM should guide policy development and the revision of talent development policies, ensuring the continuous improvement of assembly employees' ability to adapt to 4IR digital automotive manufacturing. This finding is confirmed by Poppelbuß and Roglinger (2011) and Tripathi (2014), who point out that the P-CMM provides a framework for implementing talent development policy strategies.

The themes that emerged from the evaluation of the P-CMM regarding its potential to influence organisational processes were that the P-CMM would inform workforce planning, lead to the standardisation of processes, and contribute to data-driven process improvement.

The panel believed that the P-CMM would inform workforce planning and talent practices to build employees' new capabilities, as the most fundamental step in adapting to a 4IR digital automotive assembly plant. This finding is supported by Bakkah (2024), Chen and Wang (2018) and Lanure et al. (2020), who argue that the P-CMM seeks to measure and improve human resource development practices such as employee capabilities.

Panel members noted that the P-CMM should lead to the standardisation of HR talent development and operational processes to continuously enhance talent development for 4IR capabilities in this assembly plant specialising in smart automotive production. This finding is supported by Paulk (1993) and Curtis et al. (1995), who explain that this model traces the progression from ad hoc activities to defined levels, measurable outcomes and standardised and improved processes.

Furthermore, participants noted that the P-CMM could facilitate data-driven process improvements to talent development for the 4IR digitalisation of assembling smart vehicles. This finding is supported by Bakkah (2024) and Lanure et al. (2023), who state that at Level 5 Optimisation, the continual improvement of people development processes is emphasised.

The themes that emerged from the evaluation of the P-CMM regarding its potential to influence decision-making in the organisation were providing structure and consistency; data-driven decision-making; and aligning decisions with strategic objectives.

The panel reported that the P-CMM was key to the structure and consistency of decision-making and alignment with strategic goals, from recruitment to the development of assembly employees for 4IR automotive manufacturing. This finding is corroborated by Kolinger et al. (2024), who cautions that some organisations use the P-CMM as a decision-making framework to improve people development management but then lose focus and consistency during the process.

Participants indicated that the P-CMM would lead to data-driven rather than ad hoc decision-making, reducing strategic and operational risks and thereby enhancing the capabilities development processes for inclusivity and compliance in 4IR smart automotive manufacturing. This finding is supported by the fact that the P-CMM helps organisations assess their employees' current decision-making maturity levels and establish systems for employee development during the change process (Baradaran & Habibi, 2020; Chen & Wang, 2018; Curtis et al., 2001).

Furthermore, the participants observed that the P-CMM would aid in aligning assembly employees' talent development decision-making processes with strategic objectives during the digital era of 4IR smart automotive manufacturing. This finding is supported by Bakkah (2024) and Lanure et al. (2023), who highlight that at Managed Level 2, practices remain reactive and there is insufficient alignment among HR employee development activities. Additionally, Bakkah (2024) and Lanure et al. (2023) argue that at Defined Level 3, organisations explain and develop employee capabilities that align with their talent development strategies and goals.

The themes that emerged regarding the recommendations of the P-CMM were: embedding a learning culture in the organisation, guiding formalised training programmes, and guiding performance management.

The panel recommended that the P-CMM embed a learning culture that requires assembly employees to be willing to master new capabilities to adapt to the 4IR evolving technologies within the automotive manufacturing plant. This finding is corroborated by Tripathi (2014) and Widyawati et al. (2025), who maintain that the P-CMM can help organisations implement a culture of continual employee development, improvement and cooperation, which leads to positive feedback and an encouraging work environment.

Participants recommended that the P-CMM guide the organisation's formalised training programmes as a framework for assessing and improving the talent development of its assembly employees,

equipping them with new capabilities to thrive in the 4IR digital world of work. This finding is supported by Bakkah (2024), Carnegie Mellon University (1995), Humphrey (1989) and Lanure et al. (2023), who state that Managed Level 2 encompasses formalised employee management and development strategies, with an awareness of the required employee capabilities.

Furthermore, the panellists recommended that the P-CMM guide performance management systems and training outcomes to continually evaluate the effectiveness of HR practices. This finding is confirmed by Baradaran and Habibi (2020) and Widyawati et al. (2025), who state that the P-CMM offers organisations a valuable opportunity to enhance employee engagement, development, performance and growth, as well as employee adaptability and retention.

Objective 8: To make recommendations for future research and practice

The recommendations for future research and practice are outlined in the section below titled *Limitations and recommendations*.

Practical implications

The automotive manufacturing industry is currently experiencing extreme challenges in adapting to technological innovations. Cyber-physical manufacturing and digitalisation in the automotive industry require new capabilities from employees. The 4IR technological innovations, characterised by production systems that include technological connectivity, the IoT, AI and robotics, have a significant impact on current assembly employees' capabilities in the automotive manufacturing industry. To overcome these challenges, exploring new capabilities—such as skills, knowledge, behaviours, attitudes, equipment, physical workspace, training opportunities and support from South African automotive manufacturing organisations—is vital. This study sheds light on the new types of capabilities required for assembly employees. It provides a South African automotive manufacturing organisation with a roadmap for the capabilities required at each level of the P-CMM.

A key implication of this study is the development of a bespoke P-CMM to guide assembly employees, line managers, human resource practitioners, talent development specialists and senior management in understanding the capabilities required for assembly staff as they transition into the 4IR and beyond.

This study provides assembly employees with insights into the vital skills, knowledge, behaviours and attitudes needed to stay employable in the 4IR. Assembly employees can evaluate their current capability level using the P-CMM and strategically plan their career development to progress to the next stage of capability maturity.

For line managers and senior executives within an automotive manufacturing organisation in South Africa, this study, particularly the P-CMM, presents a phased approach to the capabilities expected of assembly employees as the organisation advances towards smart manufacturing. Additionally, valuable guidance is provided on the technological equipment required and the modifications to assembly lines prompted by the 4IR. Furthermore, the developed P-CMM can assist in aligning organisational policies and practices with 4IR manufacturing.

The implications for human resource management practitioners include the ability to tailor recruitment and selection processes to the capabilities specified at each level of the P-CMM. For talent development specialists, the P-CMM offers a checklist of training needs identified by both assembly employees and their line managers. Existing learning and development programmes can therefore be adapted or enhanced with these findings in mind.

For policymakers in a South African automotive manufacturing organisation, this research provides a capabilities development framework through the creation of a P-CMM to ensure the development of relevant and sufficient talent. Furthermore, the findings can support policy development related to financial planning, infrastructure enhancement and supply chain management, all aimed at preparing for 4IR smart manufacturing processes.

Finally, the developed P-CMM was evaluated by a panel of internal and external talent development experts, specifically assessing the model's impact on organisational policies, processes and decision-making. The panel supported the P-CMM created for the South African automotive organisation (see the findings) and provided recommendations for practice, which will be detailed in the following section.

Limitations and recommendations

This study developed and evaluated a P-CMM of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation. While this study makes a notable contribution, it also

has limitations which will be outlined below, together with recommendations for future research and practice.

The primary limitation is that the results of this qualitative study are not generalisable to the entire automotive manufacturing industry. However, the researcher aimed to gain a detailed understanding of what a P-CMM would look like for an automotive manufacturing organisation in South Africa, and therefore, the chosen research approach was deemed suitable.

Additionally, the researcher provided thorough descriptions of the research process, participants and findings to improve the transferability of the results to similar contexts. Secondly, numerous interview questions were posed to the line managers. The P-CMM comprises five maturity levels, each of which was covered by eight questions. Consequently, the line managers were asked 40 questions, leading to lengthy interviews. Nevertheless, the line managers regarded the study as important and were dedicated to the data collection, taking breaks when needed.

Thirdly, the sample size for the line managers was small ($N=7$) – while the organisation had 12 line managers in total, five did not meet the inclusion criteria. The researcher, therefore, collected data from all qualifying line managers.

Fourthly, only one organisation accepted the invitation to participate in the study. Therefore, the identified required capabilities of assembly employees for the 4IR may not be complete or may not represent the perceptions of other automotive manufacturing organisations in South Africa.

Fifthly, the researcher selected the P-CMM as the theoretical framework for the study, although this model is predominantly applied within the information technology sector and is not typically associated with the automotive manufacturing industry. However, since the 4IR emphasises technological capabilities, the researcher decided to adopt the P-CMM within the automotive manufacturing organisation. Lastly, this study focused on developing and evaluating a P-CMM specifically for assembly employees. However, assembly employees do not operate in isolation; they are part of a larger system. The researcher nonetheless decided to keep the study focused and therefore did not opt for a broader perspective. In light of these limitations, recommendations for future research and practice are offered.

The first recommendation is that future researchers employ a quantitative research approach to investigate the required capabilities for 4IR assembly employees in the automotive manufacturing sector of South Africa. By applying a quantitative approach across multiple organisations in South Africa, the findings can be generalised to the target population. Secondly, a survey based on the findings of this study can be developed and used as a data collection tool to validate the results. Thirdly, the sample size of line managers can be increased by including more automotive manufacturing organisations in South Africa in future qualitative studies. By increasing the sample size, and especially the number of participating organisations, more diverse perspectives can be included. Fourthly, future studies can utilise other theoretical frameworks, such as the job demands-resources (JD-R) model or career construction theory, to explore the required capabilities of assembly employees in a South African automotive manufacturing organisation for the 4IR. Lastly, future studies can develop and evaluate a P-CMM for line managers, as these employees should be at the forefront of the technological advancements required by future automotive production systems.

Various recommendations can be made for practice regarding skills and knowledge, behaviours and attitudes, equipment, the physical workspace, and support for assembly employees at the five levels of the P-CMM. These recommendations are outlined below.

Skills and knowledge

At Level 1 of the P-CMM, assembly employees should receive basic computer literacy. At Level 2 of the P-CMM, it is recommended that assembly employees develop knowledge and skills in AI and IoT. Regarding Level 3 of the P-CMM, it is strongly advised that assembly employees have access to ongoing training in electronics, electrical systems, ML, cloud and quantum computing, big data analytics, and robotics operation skills and knowledge. At Levels 4 and 5 of the P-CMM, it is recommended that assembly employees acquire 4IR software development skills and knowledge, such as cyber-physical production systems, coding, Python, complex software problem-solving, and augmented and virtual reality. Furthermore, it is recommended that continuous training and development focus on these 4IR software development capabilities to understand the interconnectedness within a digital automotive assembly plant.

Behaviours

Positive and proactive behaviours are encouraged among assembly employees at all five P-CMM levels. Lifelong learning, honesty and diligent participation in training programmes will be essential for developing the new capabilities needed for 4IR innovative automotive production.

Attitudes

Positive attitudes, such as commitment and confidence, and the willingness to accept change and to continually learn and master the capabilities required by 4IR smart automotive manufacturing are highly recommended at all five levels of the P-CMM.

Equipment

At Level 1 of the P-CMM, it is recommended that assembly employees have access to smart laptops, tablets and computers to operate smart machines and tools, all connected via the IoT. They should also manage big data analytics and cloud services using a smart computer or laptop. At Level 2 of the P-CMM, it is advised that assembly employees have access to programmable logic controllers for controlling smart machines and robotics, and for interacting with various software devices for 4IR smart automotive manufacturing, specifically for building hybrid electric and autonomous cars. Internet connectivity is also recommended as a fundamental requirement for 4IR digital automotive manufacturing assembly plant operations. At Level 3 of the P-CMM, assembly employees will need variable-speed drives to adjust the input frequency and voltage of hybrid electric vehicles. Furthermore, autonomous tow motors and tow trucks will be required to effectively collect and deliver automotive parts across the plant to their respective assembly lines. At Levels 4 and 5 of the P-CMM, it is recommended that assembly employees use angle-detection sensors.

Physical workspace

It is advised that current assembly plants adapt to support widespread digitisation of operational systems for human-machine collaboration. Throughout all stages of the P-CMM, the workspace will increasingly incorporate strands of AI such as ML, robotics, and innovative tools and machines interconnected via the IoT.

Support

At Level 1 of the P-CMM, it is highly recommended that line managers share information with assembly employees. This sharing of information will lead to the involvement of assembly employees in the 4IR transformation process. Related to this is the clear communication of the automotive manufacturing organisation's vision and strategy for 4IR smart manufacturing. At Level 2 of the P-CMM, continued engagement of assembly employees is recommended. Furthermore, a clear investment in training and development of assembly employees that aligns with the organisation's strategic planning is essential. Fostering a culture of employee development is advised and will require management's commitment. At Level 3 of the P-CMM, the talent development policy should be amended to ensure compliance with the training and development strategy. At Level 4, succession planning for assembly employees is advised. Additionally, it is recommended that critical assembly-line positions be filled with employees who possess the requisite 4IR capabilities. Mentorship for support and motivation, as well as coaching for continuous learning and development of assembly employees, are recommended at Level 5 of the P-CMM.

Conclusion

The present study, titled "Developing a People Capability Maturity Model of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation", concluded with significant findings regarding the new capabilities required by assembly employees in a 4IR smart automotive manufacturing organisation. This research developed and assessed an important P-CMM framework and guidelines for an automotive manufacturing organisation to adopt and adapt to the new capabilities demanded by 4IR digitalisation. The study not only shed light on the types of new capabilities needed for 4IR digitalisation in smart automotive manufacturing but also provided guidance on essential training opportunities, support strategies, and avenues for improvement. Practical implications of the research were outlined, along with detailed recommendations for future research and practice.

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CHAPTER 5

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

The purpose of this chapter is to present the conclusions based on the general and specific objectives of the current research project. Following this, the limitations of the study are discussed. The chapter concludes with recommendations for future research and practice.

5.1 Conclusions

The general objectives of the current research project were threefold: first, to explore the perceptions of assembly employees regarding the capabilities required for the Fourth Industrial Revolution (4IR) in a South African automotive manufacturing organisation; second, to explore line managers' perceptions regarding assembly employees' capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation; and third, to develop and evaluate a People Capability Maturity Model (P-CMM) of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation.

Research article 1: Exploring the perceptions of assembly employees regarding the capabilities required for the 4IR in a South African automotive manufacturing organisation

The initial general objective of this study had eight specific objectives. The conclusions drawn from the findings of these specific objectives are outlined below.

Specific objective 1: To conceptualise capabilities, the 4IR, and capabilities required for the 4IR, in the automotive manufacturing industry according to literature

A comprehensive literature review was conducted on capabilities, the 4IR, and capabilities required for the 4IR in the automotive manufacturing industry. The purpose was to achieve a clearer conceptualisation of these phenomena in the automotive manufacturing industry. The conceptualisations are summarised below.

Capabilities

The capability approach (CA), introduced by Sen, consists of three main elements: functionings, capabilities, and freedom (Sen, 1993). Functionings refer to the different aspects of what a person can do or be to lead a fulfilling life (Sen, 1993), and values are essential (Van der Klink et al., 2016). Capabilities describe the combination of functionings that individuals can achieve or choose from (Sen, 1993). Freedom has a dual meaning because it relates to both the opportunity to shape one's life and environment (process) and the possibility of achieving valued goals (opportunity) (Sen,

2009). The CA provides a framework where values complement work and employability functionings (Sen, 1983). Central to the concept of capability is the idea that individuals can realise the doings and beings they value (Sen, 1980). According to Sen (2005), capabilities are defined as the real freedom individuals have or the opportunities and options available to them.

Additionally, capabilities are described as the things individuals can do and the states they may achieve if they wish; their opportunities to act or be, such as being healthy, being educated, securing employment, having a marital status, being, or travelling, are capabilities already attained (Sen, 2004). Capabilities encompass all personal resources (i.e., skills, knowledge, behaviours and attitudes), material resources (such as tools, machines and computers), physical resources (appropriate workplaces), and social environment resources (e.g., training and support) (Sen, 1980; Van der Klink et al., 2016). Therefore, the core of the capability concept is (a) being able to, (b) having opportunities, and (c) being facilitated and enabled to (Van der Klink et al., 2016).

In this study, the researcher defines capabilities as a combination of organisational procedures, skills, knowledge, behaviours, attitudes, manufacturing structures, workspace, equipment, and technology training (Gama & Magistretti, 2025; Hirvonen & Majuri, 2020; Jagadisen et al., 2022). Capabilities also refer to the factors and abilities that enable organisations to produce products and services, adapt to changing customer expectations, and maintain a competitive edge (Gama & Magistretti, 2025; Jagadisen et al., 2022; Rotjanakorn et al., 2020). For manufacturing organisations with mass production systems, the focus may be broader, emphasising the technical capabilities of equipment to boost productivity (Hirvonen & Majuri, 2020; Jagadisen et al., 2022; Modgil et al., 2025). Alternatively, capabilities can also relate to human resources, including the skills, knowledge, behaviours, attitudes, technological applications, and processes that organisations can utilise to achieve their goals (Gama & Magistretti, 2025; Jagadisen et al., 2022; Modgil et al., 2025).

The Fourth Industrial Revolution

The 4IR was introduced by Klaus Schwab in 2016 during the World Economic Forum as a concept representing rapid technological advances in the 21st century (Kruger & Steyn, 2025; Schwab, 2017). It is defined as the fastest phase of technological development, driven by digital trends such as AI and the IoTs that is transforming individuals' lifestyles and work methods (Kayembe & Nel, 2019; Khoza, 2025; Opesemowo et al., 2025). The 4IR guides individuals and organisations into a highly digitalised world through modern technological innovations (Kademeteme & Twinomurinzi, 2019; Matlala, 2025; Parra-Sanchez, 2025). However, research on its application and benefits has faced some challenges, particularly regarding organisational restructuring to align with current 4IR trends (Matlala, 2025; Padeli et al., 2025; Parra-Sanchez, 2025). The 4IR has introduced advanced

technological innovations that enable manufacturing equipment to become smarter and more efficient, making them highly attractive for various manufacturing environments (Kruger & Steyn, 2025; Matlala, 2025; Parra-Sanchez, 2025).

The automotive manufacturing industry is undergoing a major digital transformation driven by 4IR innovations and trends. This shift aims to boost competitiveness amid the growth of smart vehicle technologies, such as hybrid electric and autonomous vehicles (Gorcun et al., 2024; Nayan, 2025; Niyaz et al., 2025). Key 4IR smart technologies impacting this industry include AI, IoT, cybersecurity, additive manufacturing, software-defined vehicle production, cyber-physical systems, big data analytics, cloud computing, smart robotics, Python, and programming (Gorcun et al., 2024; Nayan, 2025; Niyaz et al., 2025). Additionally, many other technological applications are employed globally to improve vehicle efficiency, quality, performance and productivity, as well as to support modern manufacturing models, systems, monitoring, and control mechanisms (Gorcun et al., 2024; Llopis-Albert et al., 2024; Nayan, 2025).

Capabilities required for the Fourth Industrial Revolution in the automotive manufacturing industry

In the automotive manufacturing industry digital capabilities are essential for growing a worldwide competitive advantage in designing and producing modern vehicles (Naidoo & Pretorius, 2025; Rotjanakorn et al., 2020; Zheng et al., 2025). The digital capabilities for 4IR automotive manufacturing include data analytics, cloud computing, quantum computing, machine learning (ML), Python, robotics, cyber-physical production, smart machines and tools, augmented and virtual reality, additive manufacturing, AI, soft skills and the IoT (Andriiuk, 2024; Baiyere et al., 2025; Naidoo & Pretorius, 2025), as well as a basic understanding of coding, programming languages, cybersecurity, electronics and electrical engineering, and automation and systems integration for the integration of software and electronic application devices in smart vehicles (Dakic et al., 2024; Gupta, 2024; Zheng et al., 2025).

The automotive manufacturing industry worldwide faces the challenge of keeping pace with the constantly changing digital trends of the 4IR to remain fully operational (Dakic et al., 2024; European Parliament, 2024; Zheng et al., 2025). The 4IR technological changes in automotive manufacturing have uncovered a significant capabilities gap, with a recent survey indicating that 85% of automotive organisations are struggling to recruit employees with the necessary digital skills (Rapf, 2023). The same survey also showed that only 34% of employees in automotive manufacturing had the new

digital capabilities required by the 4IR to produce smart vehicles with advanced technologies (Rapl, 2023).

Specific objective 2: To explore the perceptions of assembly employees regarding the skills and knowledge required for the 4IR in a South African automotive manufacturing organisation

This study highlights that assembly employees in an automotive manufacturing organisation need to acquire new skills and knowledge in computer literacy, AI, ML, IoT, cloud computing, cyber-physical production, big data analytics and robotics to operate digital automotive manufacturing systems for the production of smart vehicles. The findings are supported by Bhatia and Kumar (2020), Cronin et al. (2019), Demlehner et al. (2021), Kumar et al. (2024), Krommuang and Suwunnamek (2022), Sehgal (2020) and Szajna et al., (2021).

Interestingly, the assembly employees also indicated that they would require soft skills such as creativity and innovation, critical thinking, complex problem-solving and decision-making, as well as active listening and communication skills, during the 4IR automotive manufacturing transition process (Mabe & Bwalya, 2022; Schmidt et al., 2021).

Specific objective 3: To explore the perceptions of assembly employees regarding the behaviours required for the 4IR in a South African automotive manufacturing organisation

This study found that assembly employees from the automotive manufacturing organisation needed adaptive behaviours, the ability to demonstrate confidence, innovation to stay relevant, behaviours focused on acquiring new capabilities, and behaviours aimed at fostering positive communication. These findings are supported by Bosch and Rossouw (2021), Faulk (2023) and Gianolli (2020).

Specific objective 4: To explore the perceptions of assembly employees regarding the attitudes required for the 4IR in a South African automotive manufacturing organisation

Assembly employees emphasised the importance of a willingness to learn and develop new skills to continuously adapt to 4IR technological advancements in the automotive manufacturing organisation (Holman & Švejdárová, 2023; Martiskova, 2022; Verma & Venkatesan, 2023). They also highlighted the need to build confidence, as their work identity might be impacted by automation and technological changes (Faulk, 2023; Luckow et al., 2018). Additionally, employees stressed that maintaining a positive attitude and embracing the 4IR digital transformation, rather than resisting it, were crucial (Schwab, 2016; World Economic Forum, 2020).

Specific objective 5: To explore the perceptions of assembly employees regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation

This study found that the automotive manufacturing organisation should be automated to meet the standards and requirements of the 4IR digitalised assembly work environment. This finding is echoed by Mashilo (2025), Rammai et al., (2025) and Roy (2022).

Specific objective 6: To explore the perceptions of assembly employees regarding training and other opportunities required for the 4IR in a South African automotive manufacturing organisation

Assembly employees indicated that the rapid growth of AI in the automotive manufacturing industry in recent years necessitated employees' willingness and dedication to acquiring new knowledge and skills through training (Felser & Wynn, 2023; King & Cnop, 2025; Zhu, 2021). This study also found that organisations should build employees' capabilities through training and development opportunities related to IoT and big data analytics and provide adequate support structures and advanced equipment (Dobrovnik et al., 2025; Joussem et al., 2025; Rincon-Guio et al., 2025). According to the assembly employees, the automotive manufacturing organisation should provide adequate training on cyber-physical production systems and human-machine interaction processes (Llopis-Albert et al., 2024; Piromalis et al., 2022).

The study found that implementing 4IR human-machine interaction in automotive manufacturing required continuous learning for employees in fundamental skills such as basic computer literacy, AI, robotics and ML (Kumar et al., 2024; Sehgal, 2020; Szajna et al., 2021). Furthermore, assembly employees argued that lifelong learning was crucial for automotive workers due to the rapid development of 4IR technologies, including AI, robotics, the IoT, cloud computing, and CPPSs (Ali & Abd Latif, 2023; Cotterman et al., 2022; Fatol et al., 2020).

Specific objective 7: To explore the perceptions of assembly employees regarding the support required for the 4IR in a South African automotive manufacturing organisation

This study found that assembly employees in the automotive manufacturing organisation expected full support, including information sharing, new knowledge management, and fostering positive communication, to accept the 4IR digital transformation. These findings are supported by Ruostela et al. (2015) and Schmidt et al. (2021).

Specific objective 8: To make recommendations for future research and practice

(Recommendations for future research and practice are presented in the recommendations section of this chapter.)

Research article 2: Exploring line managers' perceptions regarding assembly employees' capabilities and talent development required for the 4IR in a South African automotive manufacturing organisation

The second general objective of the research project included eight specific objectives. The conclusions established from the findings of these specific objectives are outlined below.

Specific objective 1: To conceptualise talent development, and talent development within the South African automotive manufacturing industry, according to the literature

A comprehensive literature review was conducted on talent development in general and in the automotive manufacturing industry in particular. The purpose was to achieve a clearer conceptualisation of this phenomenon in the automotive manufacturing industry. The outcomes are summarised below.

Several elements identified in the literature inform the conceptualisation of talent development, particularly within the South African automotive manufacturing sector. Management research literature stresses the significance of the underlying philosophies of talent, or the core assumptions and beliefs about the development and value of talent (Jayaraman et al., 2018; Meyers & van Woerkom, 2014). According to Abid (2025), Jayaraman et al. (2018), Meyers and van Woerkom (2014), the dominant philosophy about cultivating individual talent presumes that talent is innate and develops naturally, meaning it is gradual and predetermined (Abid, 2025; Jayaraman et al., 2018; Meyers & van Woerkom, 2014). This perspective is supported by the belief that individuals will always be who they are, and nothing can change that (Dries, 2013). Authors endorsing the inborn concept of talent generally assert that talent is limited and associated with exceptional brilliance (Abid, 2025; Dries, 2013; Jayaraman et al., 2018; Meyers & van Woerkom, 2014).

Conversely, the developable talent strategy offers many benefits for organisations and has attracted significant attention and respect (Axiak, 2025; Garavan et al., 2023; Meyers & van Woerkom, 2014). It assumes that ongoing effective training leads to high productivity and success in manufacturing industries (Bjorkman et al., 2007; Meyers & van Woerkom, 2014). When talent is viewed as a

developable asset, managers should focus on enhancing workforce capabilities through training programmes, mentorship and coaching, according to Dries (2013), Garavan et al., (2023), and Mabaso and Ontong (2025). The developable talent strategy is also considered important and reliable in helping employees adapt to the ongoing technological changes associated with the 4IR (Garavan et al., 2023; Mabaso & Ontong, 2025; Pantouvakis & Karakasnaki, 2018). This can be achieved by consistently implementing and evaluating talent development strategies to keep pace with the latest technological innovations (Mabaso & Ontong, 2025; Pantouvakis & Karakasnaki, 2018; Tsaousiotis et al., 2025).

Talent is developable, especially from existing skills and understanding of traditional manufacturing operations and procedures towards the skills and understanding associated with the 4IR digital world of work (Anshari & de Pablos, 2025; Naidoo & Pretorius, 2025; Schumacher et al., 2016). Managers in manufacturing industries need to cultivate talent to develop the required new capabilities (Anshari & de Pablos, 2025; Naidoo & Pretorius, 2025; Sivathanu & Pillai, 2018).

Talent development within the automotive manufacturing industry

The automotive manufacturing industry is undergoing rapid change due to 4IR digitalisation, requiring the optimisation of talent development models to meet the rising demand for new skills among assembly workers (Carley et al., 2022; Feng et al., 2024; Venkat et al., 2023). Enhancing talent development is essential for assembly workers to gain the new skills needed in 4IR digital automotive manufacturing, particularly for assembling smart cars like hybrid electric and autonomous models (Carley et al., 2022; Cotterman et al., 2022; Feng et al., 2024; Padovan, 2020). It is argued that the automotive manufacturing industry should create innovative talent development strategies for assembly workers to adapt to the ongoing technological advances driven by 4IR digitalisation (Carley et al., 2022; Feng et al., 2024; Morris et al., 2023).

Moreover, authors argue that to meet the demands of the 4IR for new capabilities among assembly employees (Morris et al., 2023; Padovan, 2020; Venkat et al., 2023), developing talent strategies aligned with 4IR technological applications in the automotive manufacturing industry is essential. The traditional talent development approaches in automotive organisations are influenced by the 4IR transformation enabled by AI (Moretti et al., 2021; Venkat et al., 2023). This influence arises from AI's effectiveness in deploying robotics, ML, the IoT, and innovative tools and machines to produce smart cars (Ahmad et al., 2023; Moretti et al., 2021; Prasomphan et al., 2024).

Specific objective 2: To explore the perceptions of line managers regarding the skills and knowledge required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The line managers confirmed that assembly employees would require basic digital and computer literacy for a successful transition to the 4IR era in the automotive manufacturing industry (Prasomphan et al., 2024; Uduafemhe et al., 2023). In addition, the study found that assembly employees would need electronic skills and knowledge to integrate the electric car hardware parts with the software and technological applications in assembling hybrid electric and autonomous vehicles (Ayres et al., 2021; Berisa, 2024; Tzafilkou et al., 2022). Furthermore, the line managers indicated that assembly employees would need skills and knowledge in smart machines, IoT, big data analytics and CPPSs (Moeuf et al., 2020; Prasomphan et al., 2024).

Specific objective 3: To explore the perceptions of line managers regarding the behaviours required by assembly employees for the 4IR in a South African automotive manufacturing organisation

This study highlighted that it was essential for employees to possess positive behaviours to acquire new capabilities in smart manufacturing organisations (Adekanmbi & Ukpere, 2022; Nyathi & Oosthuizen, 2023; Oosthuizen, 2022). The findings of this study confirmed that proactive behaviours for talent development to adapt to 4IR digitalisation within organisations during the era of 4IR were crucial (Adekanmbi & Ukpere, 2022; Nyathi & Oosthuizen, 2022; Oosthuizen, 2022).

Specific objective 4: To explore the perceptions of line managers regarding the attitudes required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The line managers of assembly employees confirmed that digital transformation called for certain attitudes, such as strong confidence and positive perceptions, among assembly employees, to acquire new capabilities and remain relevant in the 4IR era (Nafukho et al., 2024; Rocco et al., 2024). The findings of this study corroborated the notion that 4IR technological transformations required employees to adopt positive attitudes towards continuous learning to master new capabilities and adapt to the new digital world of work (Mthombeni, 2025; Nafukho et al., 2024; Rocco et al., 2024). Furthermore, line managers of assembly employees in the automotive manufacturing organisation supported the view that positive attitudes towards the 4IR world of work would increase employees' willingness to accept the ongoing digital transformations (Hahm, 2018; Nafukho et al., 2024; Rocco et al., 2024).

Specific objective 5: To explore the perceptions of line managers regarding the physical workplace changes required for the 4IR in a South African automotive manufacturing organisation

The line managers in this study argued that the shift towards 4IR digitalisation required the automotive manufacturing organisation to transition to smart digital assembly plant operations using smart tools, laptops and computers. This aligns with the recommendations of Berisa (2024), and Halder et al. (2020), and Richards (2023).

Specific objective 6: To explore the perceptions of line managers regarding training and other opportunities required by assembly employees for the 4IR in a South African automotive manufacturing organisation

This study recommends that assembly employees engage in lifelong learning to support talent development and equip them with new capabilities, such as basic computer literacy (Tzafilkou et al., 2022; Uduafemhe et al., 2023). The line managers agreed that individual development plans were an integral part of the talent development strategy and would assist in identifying, with employees, the types of training programmes to be offered (Brown et al., 2020; Mayer, 2024; Rana & Rathore, 2023). They argued that individual talent development plans enabled employees to select relevant adaptive training programmes to master the new capabilities required for the 4IR (Bessant, 2014; Brown et al., 2020; Ludwig-Ohm et al., 2023).

Furthermore, the line managers indicated that assembly employees needed opportunities to develop 4IR capabilities for digital manufacturing operations through the use of social networks such as webinars, conferences and dialogues (Richards, 2023; Strikwerda, 2022).

Specific objective 7: To explore the perceptions of line managers regarding the support required by assembly employees for the 4IR in a South African automotive manufacturing organisation

The line managers of the assembly employees agreed that the transition to 4IR automotive manufacturing would not be successful if employees did not understand their roles and responsibilities detailed in the new business strategy (Ferreira et al., 2021; Inyang et al., 2023). Furthermore, the line managers of the assembly employees supported the view that automotive manufacturing organisations should communicate the purpose of 4IR technological change in alignment with their business strategy; if employees were uninformed about the manufacturing

business strategy, it would be difficult for them to support talent development programmes aimed at acquiring new capabilities (Balgobind, 2020; Gomez-Trujillo et al., 2021).

In relation to this, the line managers in this study confirmed that employees' understanding of the 4IR smart automotive manufacturing business strategy would enhance collaboration and the co-creation of innovative ideas and solutions, fostering a sense of inclusion and appreciation (Ferreira et al., 2021; Wagh et al., 2023). The line managers agreed that sharing information about the smart automotive manufacturing business strategy would positively influence employees to support managers in transitioning to the 4IR digital production systems (Balgobind, 2020; Gomez-Trujillo et al., 2021).

Specific objective 8: To make recommendations for future research and practice

(Recommendations for future research and practice are presented in the recommendations section of this chapter.)

Research article 3: Developing and evaluating a people capability maturity model of 4IR capabilities for assembly employees in a South African automotive manufacturing organisation

The third general objective of the current research study encompassed eight specific objectives. The conclusions flowing from the findings of these specific objectives are interpreted below.

Specific objective 1: To conceptualise a P-CMM according to the literature

A comprehensive literature review of the P-CMM was conducted. The aim was to develop a clearer understanding of this model. The outcomes are summarised below.

Several elements were identified in the literature that conceptualise a People Capability Maturity Model. The P-CMM is a maturity framework developed by the Software Engineering Institute (SEI). However, unlike the Capability Maturity Model (CMM), the P-CMM seeks to measure and improve human resource development practices, including employee capabilities (Bakkah, 2024; Chen & Wang, 2018; Lanure et al., 2023). Employee capability is described as the skills, knowledge and functional capacity to accomplish organisational objectives (Curtis et al., 1995; Curtis et al., 2002). The P-CMM comprises five maturity levels for organisational employee development, namely, the initial level, managed level, defined level, predictable level and optimising level (Bakkah, 2024; Chen

& Wang, 2018; Curtis et al., 2007; Lanure et al., 2023). Each of the maturity levels is briefly discussed below:

The **Initial Level (Level 1)** is characterised by inconsistency or the lack of formal management of employee development practices (Bakkah, 2024; Carnegie Mellon University, 1995; Humphrey, 1989).

The **Managed Level (Level 2)** encompasses formalised employee management and development strategies, with an awareness of the required employee capabilities (Bakkah, 2024; Humphrey, 1989; Carnegie Mellon University, 1995). However, practices are still reactive, and there is insufficient alignment among HR employee development practices (Bakkah, 2024; Lanure et al., 2023).

The **Defined Level (Level 3)** concerns competency management (Humphrey, 1989; Carnegie Mellon University, 1995). Organisations explain and advance employee capabilities that align with their talent development strategic decisions and goals. HR employee development strategies are formulated and constantly employed within the organisation (Bakkah, 2024; Lanure et al., 2023).

The **Predictable Level (Level 4)** involves employee capability management and development (Carnegie Mellon University, 1995; Humphrey, 1989). At this level, creating an information-focused strategy for HR management is crucial. In addition, the transformation demand in employee capabilities is recognised (Bakkah, 2024; Lanure et al., 2023).

The **Optimising Level (Level 5)** encompasses change management (Carnegie Mellon University, 1995; Humphrey, 1989). Continuous improvement in people development processes is emphasised. Innovative HR practices are implemented to support and manage the capability challenges in the evolving requirements of the organisation (Bakkah, 2024; Lanure et al., 2023).

The P-CMM helps organisations determine the current maturity of their employees' development strategies for decision-making and create systems for employee development during the change process (Baradaran & Habibi, 2020; Chen & Wang, 2018; Curtis et al., 2001). With the application of the P-CMM, organisations can create a programme for continuous employee development, set priorities for improvement, integrate employee development with process improvement, and foster a culture of excellence (Baradaran & Habibi, 2020; Widyawati et al., 2025). The P-CMM is highly recommended as an efficient strategy for improving employee capabilities and quality, as well as for gaining a competitive edge during the digital transformation process (Baradaran & Habibi, 2020; Dangmei, 2017; Widyawati et al., 2025).

Specific objective 2: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Initial Level: Maturity Level 1

At Level 1 of the P-CMM, the line managers indicated that basic computer literacy would be required to adapt to the 4IR and perform digital jobs within smart automotive manufacturing organisations (Khumalo, 2020; Lorenz et al., 2019).

The line managers confirmed that at the Initial Level of the P-CMM, the assembly employees with positive behaviours would thrive in automotive manufacturing cyber-physical systems, thereby ensuring the efficiency of smart manufacturing and innovative quality-control processes (Onyilo et al., 2020). Additionally, this study confirmed that manufacturing smart vehicles, such as hybrid electric cars, would require assembly employees to adapt to 4IR digital changes with a positive attitude and a willingness to learn about cyber-physical systems (Adeyinka, 2023).

The assembly line managers cautioned that automotive manufacturing organisations could not avoid using internet-connected equipment, such as smart laptops and tablets, when adopting Fourth Industrial Revolution (4IR) digitalisation, which involves AI, IoT, ML, cloud computing, smart robotics, and tools (Alaba, 2024; Hassan et al., 2023; Kallier, 2022). Line managers noted that at Level 1 of the P-CMM, the introduction of 4IR smart technologies compelled several automotive manufacturing organisations to digitalise their plant production systems, incorporating smart robotics, smart machines, and tools required for enhanced efficiency, precision and quality (Ahmadi et al., 2023; Devaraj et al., 2025; Roy, 2022).

Regarding training at the Initial Level of the P-CMM, the line managers of assembly employees concurred with the recommendation that automotive manufacturing managers should consider basic computer literacy training as the foundational stage in developing employees' new technical capabilities to adapt to the 4IR (Lorenz et al., 2019; Martin, 2022).

This study found that adapting to the 4IR could only be achieved through involving and sharing information with employees, helping them to meet organisational objectives in the digital world (Adekanmbi & Ukpere, 2022; Ngobeni et al., 2022; Venkatesh, 2022).

Specific objective 3: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Managed Level: Maturity Level 2

At Maturity Level 2 of the P-CMM, the line managers in this present study agreed that, with AI and IoT transforming the manufacturing industry, advanced computer skills were vital for ongoing training and development (Ganeshan et al., 2022; Govender et al., 2022; Mkhize & Parumasur, 2022; Turner, 2022).

This study confirmed that, at the Managed Level of the P-CMM, assembly employees would need to demonstrate positive behaviours and a willingness to accept 4IR digital change in order to develop new capabilities for integration into the entire process of CPPSs (Grabler et al., 2021; Kruger, 2022; Van der Westhuizen, 2021).

The line managers in this study advised that assembly employees should adopt positive attitudes towards 4IR technological change, as it would benefit them (Adekanmbi & Ukpere, 2023; Venkatesh, 2022).

Furthermore, this study confirmed that within the context of the 4IR—characterised by AI and ML—the deployment of programmable logic controllers was vital for the continuous monitoring and management of automotive assembly plant systems (Ojubanire et al., 2025; Osman et al., 2025; Putro et al., 2025).

Regarding workplace change at the Managed Level of the P-CMM, the assembly line managers confirmed that automotive manufacturing organisations were required to utilise advanced technologies such as cutting-edge robotics, including AI applications, which would necessitate transforming traditional assembly plants into digitalised and innovative structures (Devaraj et al., 2025; Inyang et al., 2023; Monye et al., 2023).

This study's findings highlighted that investing in lifelong learning was a key way for employees to acquire new skills in AI, data analytics and IoT, helping them adapt to the 4IR digital transformation in automotive manufacturing organisations (Alexander, 2022; Gorski et al., 2023; Fanoro et al., 2021).

The line managers of the assembly employees emphasised that South African automotive manufacturing organisations should align their training and development strategies with succession planning to empower employees to acquire the new capabilities needed for the 4IR (Fernando & Santhosh Kumar, 2022; Lexe & Lago, 2023; Van den Heever et al., 2021).

Furthermore, the study suggested that employee engagement was a crucial strategy for automotive manufacturing organisations to enhance employees' commitment to their production tasks during the adaptive phase of the 4IR (Dutta et al., 2023; Gangeni, 2020; Gaur, 2020).

Specific objective 4: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Defined Level: Maturity Level 3

At Level 3, this study found that employees needed to develop new skills in software development, AI, IoT, ML, robotics, smart machines, Python, automation, 3D printing, additive manufacturing, cloud computing, big data analytics, and CPPSs. The findings are corroborated in the literature (Griffin & Mary, 2020; Macpherson et al., 2023; Schwab, 2016).

The assembly line managers confirmed that employees with proactive behaviours would thrive in automotive manufacturing cyber-physical systems, thereby ensuring the efficiency of smart manufacturing and innovative quality-control processes (Colledani et al., 2018; Grabler et al., 2021; Onyilo et al., 2020).

Regarding attitudes at the Defined Level of the P-CMM, line managers are encouraged to foster positive attitudes among assembly employees towards 4IR digitalisation (Chung & Kim, 2024; Khuzwayo, 2023; Ledwaba, 2022).

Furthermore, this study confirmed that automotive manufacturing required autonomous tow motors and variable-speed drives to enable precise control of vehicle speed, ensuring alignment with specific assembly production standards for energy efficiency and performance enhancement (Alie & Irawan, 2025; Duanaputri et al., 2025; Rangarajan, 2025).

Likewise, at the Defined Level of the P-CMM, this study corroborated that, to maintain a competitive advantage in the era of 4IR, automotive manufacturing organisations would need to implement innovative technological applications both within and beyond plant processes (Ahmadi et al., 2023; Inyang et al., 2023).

The line managers of the automotive manufacturing organisation agreed that training and development should emphasise AI, IoT, ML, smart robotics, smart machines, Python, automation,

3D printing, additive manufacturing, cloud computing, big data analytics, and CPPSs (Griffin & Mary, 2020; Macpherson et al., 2023; Schwab, 2016).

Additionally, at Level 3 of the P-CMM, line managers confirmed that employee support was required, leading many manufacturing organisations to revise their training policies and assist employees in acquiring new skills (Angevine et al., 2021; Shobha & Johnson, 2022).

Specific objective 5: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Predictable Level: Maturity Level 4

At Predictable Level 4 of the P-CMM, the assembly line managers agreed that fundamental coding and programming languages, 3D printing, augmented and virtual reality, and system integration were critical technical capabilities for automotive manufacturing organisations and should be incorporated into 4IR continuous training and development programmes (Griffin & Mary, 2020; Karabulut & Akyuz, 2023).

This study highlighted that at Level 4 of the P-CMM, line managers should support assembly employees in adopting positive behaviours to embrace 4IR technological change (Adekanmbi & Ukpere, 2022; Roberts et al., 2022; Venkatesh, 2020).

In relation to this, the study found that positive attitudes not only facilitated acceptance of change but also fostered ongoing learning, thereby developing new capabilities necessary to remain competitive in the era of the 4IR (Adeyinka, 2023; Ledwaba, 2022; Siddiqui, 2011).

This study confirmed that angle detection sensors were vital equipment for automotive manufacturing organisations in the era of the 4IR. Assembly employees would be required to use these sensors during the production of smart vehicles (Alie & Irawan, 2025; Duanaputri et al., 2025; Rangarajan, 2025).

The assembly line managers agreed that at Level 4 of the P-CMM, the automotive manufacturing production systems and facilities should transition to full digitalisation, emphasising the role of smart computers for efficient assembly plant operations with big data analytics and cloud computing services (Hammad et al., 2025; King & Cnop, 2025; Mukhudwana et al., 2025).

Regarding training at Level 4, this study recommends that basic coding and programming language applications, 3D printing, augmented and virtual reality, and system integration are essential technical capabilities for automotive manufacturing organisations and should be considered when developing 4IR continuous training and development programmes. These findings are supported in the literature (Popova, 2020; Karabulut & Akyuz, 2023).

This study found that automotive manufacturing organisations should support and empower their employees through succession planning to help them develop new capabilities, which would facilitate the manufacturing of autonomous and hybrid electric vehicles (Fernando & Santhosh Kumar, 2022; Lexé & Lago, 2023; Pavlinek, 2020; Twinomurinzi et al., 2020).

Specific objective 6: To determine the 4IR capabilities for automotive assembly employees in a P-CMM Optimising Level: Maturity Level 5

At Maturity Level 5, this study found that employee engagement should be prioritised in manufacturing to stimulate interest in acquiring new capabilities in ML, robotics and cybersecurity, as 4IR CPPSs that utilise AI are adopted (Oosthuizen, 2021; Victoria et al., 2021).

At the P-CMM Optimising Level, this study confirmed that managers should communicate the importance of self-managed behaviours to employees, to ensure their relevance and job security in the 4IR digital workplace (Chung & Kim, 2024; Mayer et al., 2024; Suifan et al., 2018).

Furthermore, this study found that manufacturing smart vehicles, such as hybrid electric cars, required assembly workers to adapt to 4IR digital change with a positive attitude and thus the willingness to master the cyber-physical systems (Adeyinka, 2023; Onyilo et al., 2020; Van der Westhuizen, 2021).

Line managers emphasised that industrial and collaborative smart robotics constituted the core equipment driving 4IR digitalisation, with mass AI applications in smart automotive manufacturing organisations. These findings are corroborated in the literature (Anzolin & Andreoni, 2023; Boyal & Aigbavboa, 2025; Igbal et al., 2025).

The assembly line managers confirmed that the effectiveness of the 4IR in automotive manufacturing enabled seamless real-time communication, connectivity between humans, and the integration of AI

smart tools, machines and robots through the IoT on smart computers and laptops for a digitised assembly environment (Ahmad et al., 2023; Inyang et al., 2023; Mukhudwana et al., 2025).

This study therefore recommends that assembly employees embrace 4IR digital changes with a positive attitude and a willingness to be trained in cyber-physical systems (Adeyinka, 2023; Onyilo et al., 2020; Van der Westhuizen, 2021).

Furthermore, the findings of this study at the Optimising Level of the P-CMM indicated that the 4IR era was disruptive and would require automotive manufacturing assembly line managers to implement coaching and mentorship programmes to help employees thrive in the automotive manufacturing sector (Gubicza et al., 2024; Kumar, 2020; Reeves, 2023).

Specific objective 7: To obtain, from a panel of talent development experts, an evaluation of the People Capability Maturity Model of the 4IR capabilities for assembly employees in a South African automotive manufacturing organisation and recommendations in this regard

The talent development experts agreed that the P-CMM would assist organisations in aligning human resource development policies and practices with strategic goals, ensuring that employees focus on organisational objectives. This finding is echoed by Widyawati et al. (2025). This study confirmed that the P-CMM was essential, as assembly line managers in automotive manufacturing organisations were required to provide employees with ongoing training and development to acquire new skills in 4IR technological applications (Maisiri & Van Dyk, 2021; Macpherson et al., 2023). Furthermore, the panel members emphasised that applying the P-CMM was crucial for providing a framework for implementing talent development policy strategies (Poppelbuß & Roglinger, 2011; Tripathi, 2014).

The experts reported that the P-CMM aimed to measure and improve human resource development practices, including employee capabilities (Bakkah, 2024; Chen & Wang, 2018; Lanure et al., 2023). They had also found that the P-CMM traced the progression from ad hoc activities to defined levels, measurable outcomes and standardised and improved processes (Paulk, 1993; Curtis et al., 1995).

Furthermore, the assessment of the P-CMM in this study confirmed that, at Level 5 Optimisation, the ongoing improvement of people development processes was prioritised (Bakkah, 2024; Lanure et al., 2023).

The panel agreed that the P-CMM would help the automotive manufacturing organisation to assess its employees' current decision-making maturity levels and establish systems for employee development during the change process (Baradaran & Habibi, 2020; Chen & Wang, 2018; Curtis et al., 2001).

According to the panel of experts, at Managed Level 2 practices remain reactive, and there is insufficient alignment among HR employee development activities (Bakkah, 2024; Lanure et al., 2023).

Additionally, the panel pointed out that at Defined Level 3, organisations explain and develop employee capabilities that align with their talent development strategies and goals (Bakkah, 2024; Lanure et al., 2023).

The panel recommended that the P-CMM embed a learning culture to help organisations foster a culture of continual employee development, improvement and cooperation, leading to positive feedback and an encouraging work environment (Tripathi, 2014; Widyawati et al., 2025).

The panel evaluation corroborated that Managed Level 2 encompassed formalised employee management and development strategies, with an awareness of the required employee capabilities (Bakkah, 2024; Carnegie Mellon University, 1995; Humphrey, 1989; Lanure et al., 2023).

Furthermore, the panel found that the P-CMM provided organisations with a valuable opportunity to improve employee engagement, development, performance and growth, as well as employee adaptability and retention (Baradaran & Habibi, 2020; Widyawati et al., 2025).

Specific objective 8: To make recommendations for future research and practice

(Recommendations for future research and practice are presented in the recommendations section of this chapter.)

5.2 Limitations

Despite the significant findings of the research project, several limitations were identified and are presented below.

The primary limitation was that the use of a qualitative research approach restricted the generalisation of the findings. However, the aim of this research project was not to generalise to the automotive industry at large, but rather to explore the perceptions of assembly employees and line

managers regarding capabilities and talent development required of assembly employees for the 4IR in a South African automotive manufacturing organisation. Moreover, the researcher provided detailed descriptions of the participants, context and findings to facilitate the transferability of the findings to other contexts.

The second limitation was the use of semi-structured interviews in busy automotive assembly plants. Face-to-face interviews were not a priority for assembly employees, resulting in intermittent data collection while the researcher waited for volunteers. Moreover, this data-collection method proved time-consuming for line managers with critical production duties. Nevertheless, the researcher remained patient and adaptable, scheduling interviews at convenient times for both assembly employees and line managers. Once the interviews had begun, participants were fully engaged, yielding valuable, detailed data.

Third, the interviews were conducted in English, which was not the participants' first language. Some assembly employees might have conveyed their perceptions more confidently if the interviews had been held in their native language.

Fourth, the samples consisted of assembly employees and line managers from only one automotive manufacturing organisation in South Africa. Therefore, the researcher could not gain a broader understanding of the perceptions of assembly employees and line managers across multiple automotive manufacturing organisations. While more organisations had been invited to participate in the research project, only one organisation accepted the invitation.

Fifth, the researcher selected the P-CMM as the theoretical framework for the research project. However, this model is mainly used in the information technology sector and is not commonly associated with the automotive manufacturing industry. Nonetheless, since the 4IR emphasises technological capabilities, the researcher decided to adopt the P-CMM for this research project.

Finally, this research project concentrated on developing and evaluating a P-CMM specifically for assembly workers. However, assembly workers do not operate in isolation; they are part of a larger system. The researcher, nevertheless, chose to keep the study focused and did not adopt a broader perspective.

5.3 Recommendations

Considering the limitations mentioned above, the researcher offers recommendations for future research and practice.

5.3.1 Recommendations for future research

First, future studies could utilise a quantitative research approach to improve the generalisability of the findings to the South African automotive industry. A quantitative approach would include multiple automotive manufacturing organisations and large samples of assembly employees and line managers. Additionally, future researchers can adopt a mixed-method approach to ensure that the phenomenon is thoroughly understood through rich data, and the emerging themes can then be validated with a quantitative survey.

Second, future researchers could consider using qualitative surveys to collect data from assembly employees and line managers, as these surveys can be completed at more convenient times, and some participants may prefer written responses to spoken ones.

Third, semi-structured interviews can be carried out in the native languages of assembly employees and line managers. This method may help participants feel more comfortable sharing their perceptions, which could result in richer and more detailed data.

Fourth, future research can employ other theoretical frameworks, such as the job demands-resources (JD-R) model or career construction theory, to examine the necessary capabilities of assembly employees in a South African automotive manufacturing organisation for the 4IR.

Finally, future research can develop and evaluate a P-CMM for the entire assembly line, including line managers, since these employees should be at the forefront of the technological advancements needed by future automotive production systems.

5.3.2 Recommendations for practice

In this section, general and specific practice recommendations are outlined.

General recommendations

First, it is strongly recommended that South African automotive manufacturing organisations use the findings of this research for 4IR planning, alignment, enhancement and implementation of their current capabilities development strategies for assembly employees.

Second, it is essential that South African automotive manufacturing organisations utilise the P-CMM as a framework to identify the new capabilities required by the 4IR for assembly employees. Training opportunities linked to new capabilities, such as new skills and knowledge, must be embedded within the P-CMM.

Third, the developed P-CMM for the South African automotive manufacturing organisation should be implemented to evaluate the current capability maturity level of assembly employees. The P-CMM will assist the organisation in managing new-capability challenges and talent gaps across its assembly plants.

Fourth, the human resource development (HRD) department of the automotive manufacturing organisation should draw on the findings of this research to address the high demand for new capabilities required by 4IR smart technologies.

Fifth, the talent development decision-makers should apply the findings of this research to amend and enhance existing training and development policies and strategies, helping assembly employees acquire the new capabilities required by the 4IR.

Specific recommendations

First, South African automotive manufacturing organisations should foster a culture of lifelong learning. Assembly employees should actively adopt this mindset. Embracing lifelong learning would allow the assembly line to remain current with the latest 4IR technological trends, improving its existing capabilities in the automotive manufacturing plant. Moreover, this approach will help assembly employees acquire new capabilities demanded by the 4IR through ongoing training and development programmes, ensuring they remain competitive in smart automotive manufacturing.

Second, assembly employees should be supported through ongoing training and development in specific skills and knowledge, including AI, ML, IoT, cloud computing, big data analytics, basic computer literacy, and soft skills. These capabilities have been recommended as essential for automotive manufacturing organisations to adapt to 4IR digitalisation.

Third, it is recommended that awareness and understanding of 4IR impacts be communicated to assembly employees to ensure they are aligned with technological changes within the South African automotive manufacturing assembly organisation. This can be achieved through ongoing positive communication, helping assembly employees adapt to the 4IR transition and the challenges of developing new capabilities. Assembly employees should understand the benefits of 4IR smart automotive manufacturing, such as producing modern vehicles, and why they need to acquire new capabilities. This will enable assembly employees to engage, collaborate, and participate in 4IR digitalisation for smart automotive manufacturing.

Fourth, it is strongly recommended that assembly employees maintain positive behaviours and attitudes to align with their 4IR work responsibilities. They should recognise the importance of engaging with their new job activities by developing the new capabilities required by 4IR smart automotive manufacturing organisations. Positivity is highly encouraged so that assembly employees can build confidence in developing their talents to remain relevant in 4IR smart automotive manufacturing for modern car production.

Fifth, assembly employees should embrace the 4IR and be willing to develop new capabilities to retain relevance in human-machine interaction in the automotive assembly plant's cyber-physical production processes. According to the findings of this research, assembly employees' capabilities are becoming outdated, and no organisation will retain employees with obsolete skills. Therefore, it is crucial for assembly employees to recognise the reality of the new capabilities challenge and align with their evolving roles to avoid obsolescence in 4IR smart automotive manufacturing organisations.

Sixth, the physical workspace should adapt to the transition to 4IR digitalisation for a smart automotive manufacturing organisation specialising in hybrid electric and autonomous vehicles. This research recommends a digitalised automotive assembly plant to facilitate the movement of smart tools, machines, robots and other 4IR technologies enabled by AI. A digitalised, modern 4IR automotive manufacturing assembly plant is advised to enable seamless operations and collaboration between humans and machines for the assembly of smart vehicles.

Seventh, assembly employees should be provided with individual development plans and opportunities for social networking as essential talent development strategies to acquire relevant new capabilities required by the 4IR. Personal development would help assembly employees identify their talent gaps and suggest the types of new capabilities needed for talent development programmes to adapt to 4IR smart automotive manufacturing. Social networking would support the South African automotive manufacturing organisation by enabling benchmarking, interaction, and connection with assembly employees from various automotive manufacturing organisations across South Africa.

Eighth, it is advised that line managers clearly communicate the 4IR business strategy of automotive manufacturing organisations. This will assist assembly employees in developing goals and plans aligned with the new responsibilities and roles in smart automotive manufacturing.

Ninth, automotive manufacturing organisations should provide assembly employees with essential tools, such as smart laptops, computers and self-service touch screens, during the era of 4IR smart automotive manufacturing. This recommendation is important because most operations in the assembly plant will be digitalised, connected via the IoT, and accessed through smart computers and laptops.

Tenth, it is crucial that the line managers of the automotive manufacturing plant use the developed P-CMM as guidance for support strategies such as succession planning, investment planning, engagement and empowerment, and compliance with training attendance. All these support strategies have been highlighted as strong recommendations from the P-CMM to ensure a swift transition to the 4IR for assembly employees in smart automotive manufacturing organisations.

Finally, it is strongly recommended that the South African automotive manufacturing organisation establish mentorship and coaching support programmes for assembly employees to help them adapt to the increasing demand for new capabilities.

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