Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/SA6.20250142
Published: May 12, 2025

Assessing the Training Skills Requirement for Implementing Industry 4.0 Technologies in the Manufacturing Sector

Felicia Sibiya
Department of Quality and Operations Management,
University of Johannesburg, Johannesburg, South Africa
felicia971127@gmail.com

Takalani Tshabalala
Senior Lecturer
Department of Quality and Operations Management,
University of Johannesburg, Johannesburg, South Africa
tshabalalat@uj.ac.za

Abstract

The main goal of this study is to investigate the training skills requirements for implementing Industry 4.0 technologies in the manufacturing sector. Employing a concurrent embedded mixed-methods strategy, this study harmoniously combines qualitative and quantitative data collection, affording equal weight and significance to both types of research data gathered. The findings of this study demonstrate that all constructs utilized in the research were deemed to be valid and reliable. This is confirmed by the extensive examination of existing literature as well as the empirical evidence obtained through this study. It is noteworthy to mention that this study made a substantial contribution by successfully creating a measuring instrument, specifically a questionnaire, that accurately assesses the effectiveness of training. This necessitates addressing the knowledge and competence obstacles associated with the technologies and processes of Industry 4.0, while also developing innovative strategic approaches to holistic human resource management within manufacturing companies.

Keywords
Training Skills, Industry 4.0, Technologies, Manufacturing

1. Introduction

In the midst of technological advancements, the era of information proliferation, and the ever-evolving global economy, companies have been compelled to redefine their operational strategies. Regrettably, the inevitability of change looms upon us. Those enterprises reluctant to adapt face the perilous consequences of being overshadowed, disregarded, or even rendered obsolete by their rivals, which may ultimately lead to their demise. Industry 4.0 technologies enable business processes, production lines, and teams to work together regardless of location, time zone, network or other aspects (Murphy,2022). Smart factories can scale production up or down faster. Through the creation of jobs and the improvement of life through a wide range of products, such as technology, food and pharmaceuticals technology. The economy's engine of innovation and prosperity is manufacturing.

The term "I4.0" was initially created to describe the application of advanced technology and automation in the manufacturing sector. The availability of skilled workers plays a crucial role in the successful implementation of I4.0. Additionally, the concept of I4.0 is relatively novel in the South African manufacturing industry, and as a result, there is a scarcity of empirical studies and research conducted on this topic (Murphy,2022).

1.1. Problem statement

The digital revolution has enabled utilities to better predict and prevent outages with predictive maintenance, real-time monitoring, and advanced analytics (Spector, and Ma, 2019). The manufacturing industry alone exported a record R69.2 billion in goods and employ over 80,000 people manufacturing in 2023, accounting for more than 4% of the country's GDP. Nevertheless, numerous gaps remain in the realm of Industry 4.0, specifically pertaining to the matter of human competence. While companies grapple with various hurdles in this new paradigm, the foremost concern lies in adequately equipping their workforce with the essential proficiencies required to thrive within an altered professional landscape.

1.2. Aim and Objectives

The main goal of this study is to investigate the training skills requirement for implementing Industry 4.0 technologies in the manufacturing sectors.

The study was conducted with the explicit aim of achieving the following objectives:

1. Determine measures are organizations adopting to alleviate the influence of the Fourth Industrial Revolution on employment and skill demands?
2. Evaluate the essential skills required for Industry 4.0 in the South African manufacturing sector.
3. Identify the implications of the Fourth Industrial Revolution on employment and the necessary skill sets within the manufacturing sector of South Africa

2. Literature review

The critical analysis of literature is presented in Table 1.

Table 1: Critical analysis of literature

Year	Citation	Author	Title	Methodology	Major Research contribution	Contribution of own research (gap)
2021	91	Whisper Maisiri and Liezl Van Dyk	Industry 4.0 skills: A perspective of the South African manufacturing industry	The research design employed for this study was a qualitative descriptive approach, carefully selected participants were enlisted through purposive sampling, utilizing various channels such as LinkedIn, email, and telephone.	This study shows that the new way of doing things in industry 4.0 requires more advanced skills than the old way. Companies should help their workers learn these new skills so they can keep their jobs.	The study can assist HR practitioners and manufacturing professionals in developing strategies and innovative technologies to effectively manage the changing skill requirements of Industry 4.0 and protect job positions.
2023	45	V Di Sabato	Training as a facilitator for Industry 4.0	This study used a qualitative method for collecting data	The study centered its efforts on establishing a harmonious workplace environment that mitigates anxiety surrounding the ambiguous future, symbolized by inevitable transformations.	This research will help the workers in the manufacturing sector know how to do their jobs better. It will make it easier for them to accept and adjust to any changes that need to be made.
2021	77	Jagannathan, S. and Khatiwada	Reaping the benefits of industry 4.0 through skills development in high-growth	This study used the systematic approach method	The research emphasizes the need for a shift from traditional institution-centred training towards a more diverse	This research will greatly benefit the Eskom power station by providing comprehensive training in digital skills at varying levels, including basic,

			industries in southeast Asia.		and adaptable approach that incorporates various methods such as e-learning, on-the-job training, and intensive bootcamps.	intermediate, and advanced. As workplaces continue to undergo rapid digital transformation, it is imperative to enhance the station's capabilities in this domain.
2020	151	Steven McKee and Danny Gauch	Implications of Industry 4.0 on Skills Development	The PRISMA approach was employed in this study	This research centers on the obstacles faced by TVET (Technical and Vocational Education and Training) in adapting to the ongoing transformation, necessitating the enhancement of learning methods and the reskilling of individuals.	This research will help the Eskom power stations become like train systems, so that they can teach people the skills they need to support the fourth industrial revolution.
2022	73	Abdelkarim walid Alhloul and Dr. Eva Kiss	Industry 4.0 as a Challenge for the Skills and Competencies of the Labor Force: A Bibliometric Review and a Survey	A hybrid approach that combines bibliometric analysis on the Scopus database with a systematic literature review.	This study tried to figure out what new things people will need to learn for Industry 4.0.	This comprehensive study will provide manufacturing human resources with a holistic understanding of the imperative need to impart training to their labor force in order to effectively harness and leverage emerging technologies.
2024	72	Li, L	Reskilling and Upskilling the Future-ready Workforce for Industry 4.0 and beyond	This research employed quantitative methodologies resulting in a comprehensive sample of 636 manufacturing companies.	The primary focus of this study is to delve into the topic of reskilling and upskilling the workforce in preparation for the future, particularly in the context of Industry 4.0 and the subsequent advancements that lie ahead.	This research will enable human resources to dedicate considerable resources towards providing these valuable learning opportunities to their workforce, ensuring that they are both affordable and easily accessible. Additionally, it will empower employees with the necessary reskilling and upskilling tools, further enhancing their professional development.
2022	321	Bokhori Bin, Amin	The Impact of Learning and Development on Employees' Productivity in Electrical	To examine the relationship, a sample size of 222 respondents was taken from 28 electrical manufacturing sectors, which included people	The study examines the relationship between effective training contents, effective training techniques, and employees'	This study will help human resources management implement effective training in the organization for employees to always stay motivated.

			Manufacturing Sector	361 samples and 6322 people.	productivity and effective training need analysis (TNA) and employee's productivity.	

3. Methodology

In this study, a quantitative approach was used. Questionnaires were used to collect primary data. Due to its impartiality, which is primarily influenced by the accuracy of the questions asked of the control group chosen for the study, questionnaires were found to be a reliable method for obtaining data (Jaeger and Banks, 2023).

3.1 Population size and Sample size

The population of the study is made up of 250 manufacturing companies in the Mpumalanga province in South Africa. These are enormous assembling firms that have worked for the beyond a decade to give information important to proficiency choices in Mpumalanga's assembling area. Likelihood inspecting was used to choose the 250 firms which comprised the designated populace.

Different types of companies that make things were put into groups using a method called stratified sampling (Bowen, 2009). The companies were sorted into various manufacturing categories using stratified sampling: Aliments (10.7%); tobacco and beverages (21.3%); fabrics (3.9%); footwear and clothing (4%); furnishings and wood (8%); publishing and printing on paper (11.2%); petroleum-based products and chemicals (3.9%); metallurgy (23.3%); non-metallic minerals (7%); transport and equipment for transportation (6.7%). Out of 250 people who were asked to answer a survey, 152 responses were received.

4. Results

Based on Table 2, Critical Thinking was identified as the most significant criterion in the Soft Skills cluster, with a weight of 0.19. This was followed by Creative Thinking and Leadership, with weights of 0.15 and 0.116, respectively. The analysis of the results showed that out of the 12 sub criteria, Critical Thinking, Creative Thinking, and Leadership collectively account for approximately 45% of the overall importance within the Soft Skills cluster.

Table 2: The weights assigned to sub-criteria within the soft skills cluster.

Sub-Criteria	**Weights**
Teamwork	0.07
Leadership	0.12
Collaboration	0.08
Creative Thinking	0.51
Critical Thinking	0.19
Communication	0.84
Adaptability	0.06
Self-Confidence	0.07
Growth Mindset	0.04
Empathy	0.04
Cultural Awareness	0.05
Social-Emotional Learning	0.06

Table 3: The allocation of importance to various sub-criteria within the technical skills cluster

Sub-Criteria	**Weights**
Computer Programming	0.10
Coding	0.07
Project Management	0.33
Financial Management	0.15
Mechanical Functions	0.11

Scientific Tasks	0.09
Technology-based Skills	0.14

Based on the findings presented in Table 3, it is evident that Project Management holds the utmost significance within the realm of Technical Skills, with a weightage of 0.33. This is closely followed by Financial Management and Technology based Skills, which hold weights of 0.15 and 0.14, respectively. Upon careful analysis of the results, it becomes apparent that these three sub-criteria, namely project management, financial management, and technology-based skills, collectively contribute to nearly 60% of the overall importance within the technical skills cluster.

Table 4 The weights of sub-criteria within the entrepreneurship cluster.

Sub-Criteria	**Weights**
Creativity	0.18
Courage	0.04
Curiosity	0.05
Resilience	0.05
Resourcefulness	0.05
Initiative	0.07
Innovation	0.18
Industriousness	0.08
Ingenuity	0.05
Risk-Taking	0.05
Business Acumen	0.04
Optimism	0.04
Business Execution	0.05

Based on the analysis presented in Table 4, it becomes evident that the utmost crucial factor within the Entrepreneurship cluster is none other than Creativity, with a remarkable weight of 0.18. This is closely followed by innovation and industriousness, boasting weights of 0.18 and 0.08 respectively. It is truly fascinating to observe that these three sub-criteria, namely creativity, innovation, and industriousness, collectively hold an astounding 50% of the overall significance within the realm of Entrepreneurship.

5. Recommendation

Out of 250 people who were asked to answer a survey, 152 of them did it and sent it back. To make sure that everyone participates in the future, the people who ask for the survey should do more to show that they appreciate the time it takes to fill it out. They could put the results of the survey on their website or ask the people who answered the survey for their contact information so they can talk to them later. They should also let the people know how their answers have helped to make things better.

Invest in the right technologies and tools.

Having a proper understanding of various digital technologies and how they can be effectively utilized in everyday operations is essential for the success of any digital transformation (DT) process. These technologies encompass a wide range of tools such as Artificial Intelligence (AI), Internet of Things (IoT), big data analytics, robots, and many others. It is crucial for manufacturing organizations to invest in the technologies that align with their specific structure and size to maximize their utilization and achieve a higher return on investment within a shorter timeframe (Benitez, Ferreira, Ayala, and Frank, 2022) . The approach to implementing these technologies may vary across different manufacturing sectors and is influenced by factors such as the financial and human resources available within the organization. Therefore, it is imperative to highlight the importance of investing in technologies that suit the organization's needs rather than simply adopting the most advanced technologies available in the market. This is because the best technologies may not necessarily be the most suitable for the organization's unique requirements and capabilities.

Invest in staff training.

The imperative to invest in comprehensive training programs aimed at developing and honing technical expertise, to effectively navigate the rapid progression of digital technologies, stands as an indispensable factor in fostering triumph

within the digital transformation journey. In the pursuit of mastery, it is imperative to recognize that technical skills alone are insufficient; an astute appreciation for intellectual depth and the cultivation of empathetic human skills are equally indispensable. The significance of investing in training initiatives, such as innovation management or change management, cannot be overstated, particularly when it comes to equipping middle managers with the necessary tools to comprehend and address their employees' apprehension towards change. By arming them with effective strategies, these managers can effectively navigate and conquer resistance, thereby fostering a more receptive environment for organizational transformation.

Craft a comprehensive yet flexible/adaptable budget
Creating a budget that aligns with the objectives of the manufacturing organization to attain success in the realm of digital technology is of paramount significance. This will also ascertain the extent to which the organization should invest in advancing its digital technologies. When formulating a budget for digital technology, numerous factors must be considered, such as cost-benefit analysis, projected return on investment, and the payback period for the project. It is imperative for every manufacturing organization to allocate a designated percentage of its profits annually towards digital technology processes to keep pace with the evolving digital landscape, as this is an ongoing endeavour.

Engage every department in the formulation of a comprehensive strategy
By involving all departments in the development of the DT strategy, organizations can effectively mitigate resistance to change during the implementation phase. This collaborative approach not only streamlines processes and enhances efficiency, but also reduces the likelihood of failure in effectuating this momentous change. As previously stated, the concept of digital transformation (DT) extends beyond just operational and production departments; it necessitates involvement from all departments within an organization. When formulating a DT strategy, it is imperative for decision-makers to engage not only all departments within the organization, but also the key stakeholders who will be most impacted by this transformative shift, such as suppliers. In fact, many organizations take it a step further by forging enduring partnerships with their primary suppliers or distributors, ensuring that their DT initiatives are meticulously coordinated to maximize the benefits of this evolution.

Initiate the venture within a specific sector of the enterprise beforehand.
Communication holds utmost importance in projects that aspire to bring about substantial change. The leadership should effectively convey the objectives of incorporating digital technologies to the workforce, thereby alleviating any apprehensions regarding job security, and persuading them that these technologies will merely reshape their roles, not render them obsolete. Additionally, communication acts as a doorway to welcome innovative ideas from employees, fostering a sense of involvement in crafting the project's strategy and enhancing their dedication towards accomplishing its goals.

Designate a sponsor at the board or executive level for the project.
The endorsement of top management is a pivotal element for success, as proven by past endeavors within the realm of manufacturing organizations. Indeed, such support wields a profound influence in revolutionizing the very fabric of the organization's culture, fostering a newfound digital-centric mindset among its workforces. Moreover, this invaluable support serves as a catalyst for middle managers, empowering them to embark upon this transformative journey and exhibit their digital prowess within their respective domains, thereby cultivating a workforce primed for the digital age.

6. Conclusion

In conclusion, it is imperative for existing employees to enhance their technological and automation skills in order to effectively comprehend the digital economy and meet its demands. Conversely, the younger generation represents a promising pool of potential employees who are eager to broaden their knowledge and readily adapt to future job requirements. In order to embrace the advent of Industry Revolution 4.0, organizations must actively cultivate a workforce that is well-versed in the latest technologies. It is the responsibility of these organizations to provide comprehensive training programs that enable their employees to upgrade their skills. By doing so, these training initiatives will not only mitigate potential errors in the future, but also ensure seamless product processing and service provision by their employees.

When a company successfully adjusts to the shifts in its industry, it acknowledges and grasps the fact that the advancements in technology are propelling us into the era of the fourth industrial revolution. In today's highly competitive global market, there is a scarcity of skilled individuals. Therefore, it is crucial for organizations to invest

in training and nurturing a workforce that is prepared for the forthcoming changes. As companies strategically plan, the employment landscape becomes an increasingly important aspect to consider. To effectively engage in strategic workforce planning, businesses must first comprehend the evolving nature and specific skill demands of the workforce.

References

Alhloul, A. and Kiss, E., Industry 4.0 as a Challenge for the Skills and Competencies of the Labor Force: A Bibliometric Review and a Survey. *Sci*, *4*(3), p.34, 2022.

Amin, B.B.M., The Impact of Learning and Development on Employees' Productivity in Electrical Manufacturing Sector at Penang, Malaysia. *Journal of Positive School Psychology*, pp.6928-6937, 2022.

Benitez, G.B., Ferreira-Lima, M., Ayala, N.F. and Frank, A.G., Industry 4.0 technology provision: the moderating role of supply chain partners to support technology providers. *Supply Chain Management: An International Journal*, *27*(1), pp.89-112, 2022.

Di Sabato, V. and Savov, R., Training as a facilitator for Industry 4.0. *Revista de Gestão*, *31*(3), pp.291-306, 2023.

Jaeger, A. and Banks, D., Cluster analysis: A modern statistical review. *Wiley Interdisciplinary Reviews: Computational Statistics*, *15*(3), p.e1597, 2023.

Jagannathan, S. and Khatiwada, S., *Reaping the Benefits of Industry 4.0 through Skills Development in High-Growth Industries in Southeast Asia: Insights from Cambodia, Indonesia, the Philippines, and Viet Nam* [online], 2021

Li, L., Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. Information Systems Frontiers, 26(5), pp.1697-1712, 2024.

Maisiri, W. and Van Dyk, L., Industry 4.0 skills: A perspective of the South African manufacturing industry. *SA Journal of Human Resource Management*, *19*, p.1416, 2021.

McKee, S. and Gauch, D., Implications of industry 4.0 on skills development. *Anticipating and preparing for emerging skills and jobs: Key issues, concerns, and prospects*, pp.279-288, 2020.

Murphy, J. and Mishra, S., Challenges and solutions to blockchain-based management of IoT devices in smart cities. *Issues in Information Systems*, *23*(4), 2022.

Spector, J.M. and Ma, S., Inquiry and critical thinking skills for the next generation: from artificial intelligence back to human intelligence. *Smart Learning Environments*, *6*(1), pp.1-11, 2019.