Industry 4.0 and the Role of Human Resource Development in the South African Fabrication and Construction Industry

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Abstract

There is a growing need to align human resources with the latest technologies. The paper explores industry 4.0 technologies and the role of human resource development in the South African fabrication and construction industry. It is understood that a higher level of human resource development results is an improved impact of industry 4.0 technologies. The paper analyses the impact that human resource development has on the implementation of artificial intelligence, the Internet of Things (IoT), Industrial IoT (IIoT), Cyber-Physical Systems (CPS), Cloud Computing, and the Smart Factory Environment. The approach of this study is the use of a comprehensive survey process which includes a questionnaire and observation to obtain data from a selected sample of companies. The data collected on the level of research and development aligned to industry 4.0 was analyzed using statistical methods. The primary findings from the research show human resource development aligned to industry 4.0 have a moderate impact on the South African construction and fabrication industry. Further, the study reveals that adequate employee development focussed on emerging technologies has a positive impact on the productivity and efficiency of the industry. Strengthening the skills needed to implement emerging technologies is the key to a competitive advantage.

Keywords

Industry 4.0, Internet of Things (IoT), Cyber-Physical Systems (CPS), Smart Factory

1. Introduction

The industrial revolution evolved in the 18th century from water and steam-powered mechanical manufacturing facilities to the fourth industrial revolution (IR 4.0) that emerged in the 21st century. The second industrial revolution introduced electric powered manufacturing facilities followed by the third industrial revolution in the late 20th century that introduced the use of computer and internet-based knowledge for further automation.

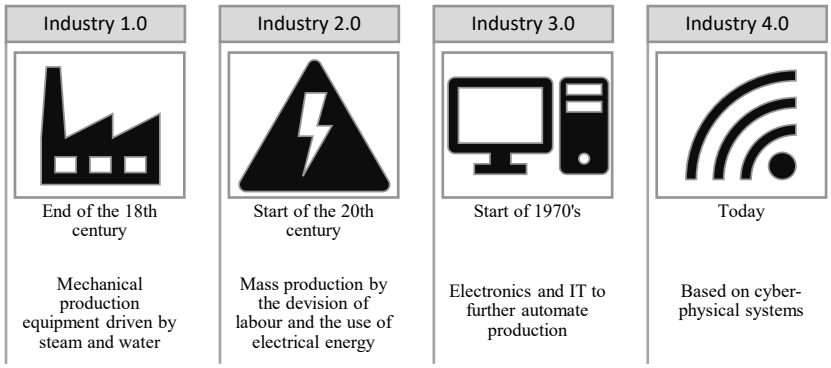

Figure 1: The four stages of the industrial revolution

Industry 4.0 technologies encompass the Internet of Things (IoT), Cyber-Physical Systems (CPS), Cloud Computing, Nanotechnologies, 3D printing, and blockchains, etc. Human resource (HR) development plays an important role in the upliftment of skills. To maintain international competitiveness employee skills must be current with emerging technologies. Figure 1 illustrates the four stages of systematic change from Industrial Revolution 1.0 to 4.0.

2. Statement of the Problem

The growth of any company depends on the performance of employees, and for consistent and sincere growth, skilled employees equipped with the latest technologies are very important. With a lack of expertise, companies will continue using conventional methods. If the skill is not available companies are reluctant to implement new technologies. There is a need for human resource development with a focus on emerging technologies. The downsizing of companies in South Africa is a result of competitiveness in the market. The South African fabrication and construction industry faces a challenge making them less competitive internationally.

3. Research Question

What is the role of human resource development on industry 4.0 in the South African fabrication and construction industry?

4. Literature Review

It is supposed that South Africa has a restricted manufacturing base and is under equipped for Industry 4.0. (Campbell, 2017) (Tsedu, 2017). Industry 4.0 aims to make the features of previous industrial revolutions more supportable, at the same time introducing more themes and topics such as globalization and international issues, emerging issues, society, social well-being, and environmental impacts (Basak, 2017).

Undoubtedly, human resource development plays an important role in every industry. Various research works have been done relating to human resource development and its impact on the industry. A case study looking at human resource management in a South African construction company identifies and explores the impact of HR management practices on employee performance. The data analyses identify the levels at which various human resource management practices are adopted. On top of the list are training and development, yearly bonuses, mentorship, and good workplace conditions. Salary structure, promotion opportunities, performance-based incentives, monetary incentives, and fringe benefits follow at the next level. Following these in descending order of implementation is career development, appreciation from managers, good communication systems, fair performance appraisal systems, job security, overtime salary, administrative practices, job rotation, and motivational talks (Ngwenya, 2017).

A research paper focusing on South African construction companies has established that projects experiencing quality and cost overruns are due to inefficient leadership (Liphadzi, et al., 2015). The major focus was on to identify the factors that contribute to the success of projects in the South African construction industry. The paper identifies the core factors impacting on the success of projects. These factors are conflict resolution, results monitoring, informed judgment, team building, empowerment, discipline, positive expectations, initiative, sense of responsibility, problem-solving, communication, planning, time management, conceptualization, visioning, influencing, goal setting, and ethics. Furthermore, the findings show that the main characteristics in construction and project managers are good communication skills, vision, passion, self-discipline, confidence, creativity, honesty and reliability, knowledge, integrity, inspiration, and decisiveness.

The human input in the sustainability of an electronic document control system plays an important role in the industry. A case study focused on electronic document management systems looks at the aspects that could go wrong thought implementing such systems. Aspects of knowledge have been identified as a backdrop. The main points relating to knowledge include the ability to understand and act upon accordingly. The focus is also on the value of knowledge in the industry. Furthermore, the management of electronic document systems is highlighted as an important aspect. A high emphasis is placed on the critical effect of human resource management on the ability to understand and act upon aspects. Through the study, the researcher has found an improvement in human efficiency in an organization. The results were established by implementing a structure to manage an electronic document control system. (Groenewald, 2004).

The client who was part of this study explored various electronic document management packages. With a large amount of paper-based document control, the research has found that at times information was lost or not available, and this was the result of documents not been filed correctly. There was no monitoring of file tracking and this results in a lot of files going missing. The client looked at improving the efficiency of the employees and at the same time

reduce the large amount of paper that was used. Ideally, the aim was to ensure that all information stored in a manner where it is easy to access and well retained in a document system (Groenewald, 2004).

Furthermore, the author stresses the fact that the groundwork must be done before implementing an electronic document management system. Organizations should not fail to realize that such systems are not stand-alone without human input. Once again, the stress is on knowledge and training forming the base of any platform. It is important to manage the knowledge capital of the organization. Running parallel to implementing a new system it is necessary to review human resource management policies and procedures and build a knowledge management culture in the organization. Thus, the importance to drive knowledge agility (Groenewald, 2004).

Skills management forms an important part of human resource management practice. The difficulty to find suitability skills in the industry has been an ongoing concern. In the Engineering and Technology industry, there is an increasing number of reports on skills shortage. A review of studying an organization found that skills management is inadequate. It goes down to the organization's decisions and behavior to skills management. For effective intervention targeting, it is necessary to properly address the skills gaps (Romo, 2014).

A study has identified a solution for the development of construction SMME's in the Gauteng province. The author recommends having the necessary education/skills/qualifications, attending leadership training course, availability of financial benefits, rewards and incentives, adapting practices of current larger construction companies, learning new skills that will enhance the firm's capabilities (Tshikhudo, 2016). Working conditions, education, and training have been identified as the main factors to sustainable construction (Thobakgale, 2016). Education and training is an important part for professionals in the construction field to recognise the benefits of implementing value management in the industry (Lourens, 2016). Key skills such as project management, materials ordering, and handling as important indicators in the South African construction industry (Sibiya, 2014). Another key skill for successful projects is effective communication between team members (Tamin, et al., 2016).

A research study on human resource management practices in Quantity Surveying firm's emphasis on the importance of having the right mix of resources to achieve a productive, efficient, and high-performance team. Stress, lack of motivation, low commitment, and low productivity is identified as the result of an organization failing to understand and meet employees' expectations. The various human resource management practices were evaluated. The factors focused on are employee strength, employee welfare, training, mentoring, and succession. For the improvement of productivity and performance, a recommendation is made that quantity surveying firms ensure suitable recruitment and selection processes. Furthermore, a recommendation is made that organizations should put more emphasis on employee mentoring and succession. Quantity surveying firms need to be active in their human resource management. Ultimately this is key to improve the organizations' innovation and competitiveness in the local and international markets. Staff strength has been identified as low. In many firm's quantity surveyors tend to seek employment elsewhere. The main reason for employees leaving or wanting to leave is due to the firms not meeting employee's needs. The recommendation to curb the high employee turnover and ensure employees undertake their jobs effectively lies in the selection process. It is required that when recruiting the quantity surveying firms should have a good understating of the skills, aptitude, abilities, and other characteristics that are known and understood. This will reduce the employee turnover rate, increase work efficiency, and improve employee satisfaction (Oke, et al., 2016).

Various factors depend on human resource management principles. Productivity has great dependence. Also, employee performance has a reliance on management principles. Employees' contribution to an organization is very important. Research shows that workforce performance is affected by human resource management practices. Human resource management must maintain a talented workforce. Furthermore, the system needs to develop, and attract the workforce. A good workforce spirit is needed to keep the organization's objectives. The study investigated human resource management practices and the efficiency thereof of construction worker productivity. Furthermore, the study identified key human resource management practices. An assessment was done on the effect of these key practices on workforce productivity and performance. The study focused on a single construction company. The findings show practices that improve productivity and performance (Ngwenya & Aigbavboa, 2016).

It is imperative that human resource management practices and implemented. This will ensure the improvement of employee productivity as well as performance. In this way, an organization maintains a competitive advantage in the market. The key is for employees to be content and pleased with better output. It is easier for management to motivate employees who are happy and satisfied. The research findings show that performance and productivity will rise due to certain aspects including employee acquaintance on the job, greater competency of employees, encouraging attitude of employees, and employee's ability. The study has found that employees with high morale are more productive and perform better. The study has identified two categories of factors affecting productivity and performance. The first factor is related to human resource and includes reward equity, service structures, effective training and establishment thereof, employee career development, the fairness of performance management, and employment prospects. The second factor is organizational related and includes business policies, business culture, effective communication,

suitable working setting, organizational loyalty and pride, and the active incorporation of work relations (Oke, et al., 2016).

Mentoring plays an important role as part of human resource development in the South African construction industry. As paper looking at the industries' current status and future requirements examine the past theory, research, and practices to find the gaps in terms of the understanding of mentoring that is relevant to human resource development professionals (Liphadzi, et al., 2015). The key factors regarding mentoring are career development, organization development, and training and development. Mentorship benefits both the individual and the organization. The author stresses the need to transfer skills. In both the public and private sector construction industry, the transfer for skill is important for the sustainability of an organization. The focus is on skills transfer from senior engineers to junior engineers. This needs to be a constant and ongoing process. Undoubtedly, in the private and public sectors, it is evident that there is a lack of good mentorship. Emphasis must be placed on professional development in the industry. At the same time, good mentorship is required for any professional development program. To highlight once again, professional development programs together with mentoring will benefit both the employees and the company in many ways.

Retaining skills is indeed a challenge in the industry. A great challenge lies in retaining managers who have company-specific skills and experience. In a research paper on this topic, the author highlights that to promote a competitive advantage it is important to retain top and middle managers who have expertise relating to the organization's specific operations. Also, this serves as a long-term investment for the organization. The paper focuses on the challenges and effective retention strategies in the industry. The attention is on retaining the top and middle-level managers. Findings show that for the retention of top and middle-level managers leadership and performance management practices are looked at as effective. Certain changes have increased the challenges faced regarding retaining management. These changes include the ongoing improvement in technology, access to international information, and the evolution of multinationals organizations. The result is unstable and open business environments. It is found that difficulty in retaining management is due to factors such as outdated technologies, traditional hierarchies, affirmative action strategies, little attention to employee wellbeing, and poor work environments. Furthermore, it is found that HR professionals regard performance management and leadership as retention strategies. The conclusion made by the author is that the challenges and retention strategies that are identified to a larger extent apply to middle management in comparison to top management (Uitzinger, et al., 2018).

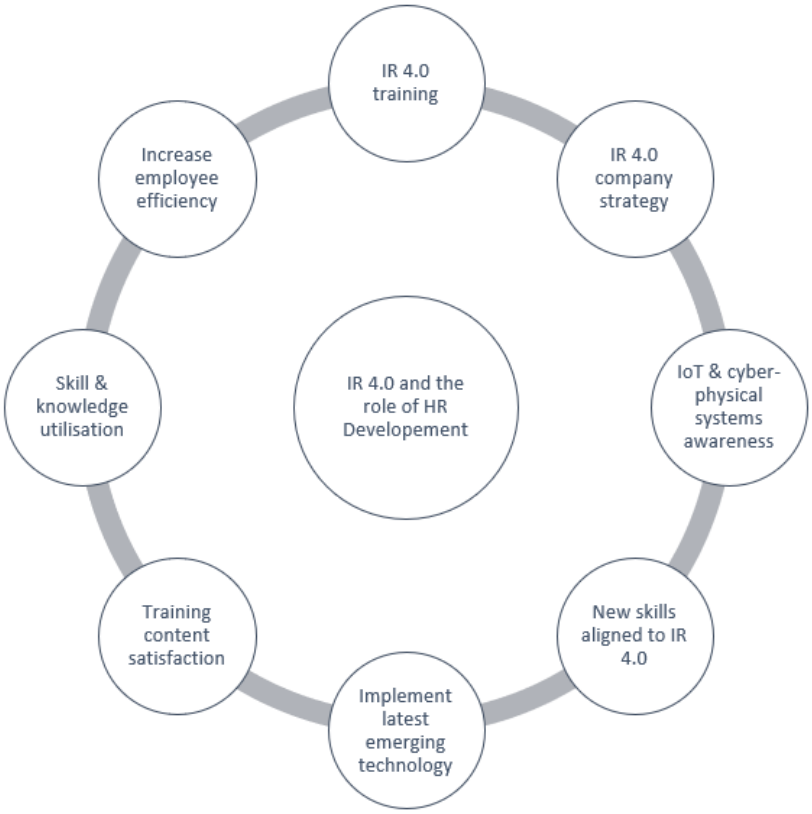

Figure 2: Factors Contributing to IR 4.0 and the Role of HR Development

The literature reviewed identifies and addresses various components of human resource development. The benefits of human resource development are evident. Human resource development plays a crucial role in the implementation of Industry 4.0 technologies. This paper looks at the level development factors contribute to the impact of industry 4.0 in the South African fabrication and construction industry. Through the research, an analysis is made on the fabrication and construction industries' implementation of the contributing factors. The factors contributing to Industry 4.0 and the role of human resource development are shown in Figure 2.
Through studying the level of implementing these factors a conclusion is drawn on the impact and adaptability in the industry. There are limited literature and research on the effect of industry 4.0 on the South African fabrication and construction industry. The subject has not been explored enough hence this work addresses the research gap in the area of study.

5. Methodology

The main objective of this research is to assess the role of human resource development on industry 4.0 in the South African fabrication and construction industry. The understanding is that a higher level of human resource development results in improved productivity and competitiveness.
Quantitative quasi-experimental research is used to establish the relationship among the variables studied. The research design is also known as a casual-comparative design and is used to find a relationship between independent and dependent variables after an occurrence. The analysis of this design method determines whether the independent variable affected the outcome.
A comprehensive questionnaire will be answered by individuals of the sample companies and/or answered through observation and interviews carried out at the various companies. The gathered data is tabulated and shown in the form of a bar graph. The gathered data is analyzed using various statistical tools and techniques.
This research study mainly focuses on the Construction and Fabrication industry servicing the mining and marine mining sector. The area of research is restricted to South Africa and South Africa based construction companies established in cross border African countries. The study focuses on structural steel, static mechanical and piping fabrication companies, and to a small extent dynamic mechanical equipment manufacturing companies servicing the abovementioned sector. The questionnaires were distributed among the construction and fabrication industry in Gauteng, Limpopo, and the Western Cape provinces. Questionnaires were also completed by interviewing people and observing operations in the industries. The Likert scale using 5 points was used to determine the level of the various questions. The results for each question are tabulated in table 1 shown below.

Table 1: Results Template

	Construction Companies					**Fabrication Companies**					**Combined Sector**				
Rating Scale	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Score															
$\bar{x}$															
σX															
R															

($\bar{x}$ = Mean; σX = Standard deviation; R = Rank)

6. Results and Analysis

The analysis looks at each sector, construction and fabrication, independently. The construction and fabrication industries' feedback or observation is tabulated. The mean item score, standard deviation, and rank for the construction, fabrication and a combination of the two sectors per question are determined. A T-test is done to determine the difference in the data obtained from the two sectors. Table 2 below is an analysis of the results. Tables 3 and 4 below is the t-test data for two-sample assuming equal variances and unequal variances. Each factor is analyzed. Table 5 shows the t-test comparing the mean results for the construction and fabrication sector.

Table 2: Results analysis

	Construction Companies			Fabrication Companies			Combined Sector		
Factors	**$\bar{x}$**	**σX**	**R**	**$\bar{x}$**	**σX**	**R**	**$\bar{x}$**	**σX**	**R**
1) Industry 4.0 training	2,47	1,73	10,00	3,67	1,79	8,00	2,81	2,86	10,00
2) Industry 4.0 part of the organization's strategy	2,73	2,55	8,00	3,50	0,84	10,00	2,95	3,11	9,00
3) Every individual is happy with the content of industry 4.0 training provided	2,73	1,87	8,00	3,50	1,64	10,00	2,95	3,27	9,00
4) Education on IoT and cyber-physical systems	3,13	2,74	3,00	4,00	1,64	6,00	3,38	4,15	4,00
5) Encouragement to learn new skills aligned with industry 4.0	3,00	2,45	4,00	4,33	1,30	1,00	3,38	2,59	4,00
6) Commitment to implement the latest emerging technologies	2,73	1,87	8,00	4,00	1,10	6,00	3,10	2,17	6,00
7) Satisfaction with the information provided during training	2,73	2,55	8,00	4,17	1,30	4,00	3,14	2,59	5,00
8) Utilization of the knowledge acquired through the training programs	3,40	2,24	2,00	4,17	1,30	4,00	3,62	3,19	2,00
9) Training and development have increased the efficiency of employees	3,60	1,73	1,00	3,67	1,30	8,00	3,62	2,77	2,00
10) Employee training aligned to the latest emerging technologies to increase employee job performance levels	2,53	2,24	9,00	4,17	1,30	4,00	3,00	2,05	7,00
Mean of Means	2,91			3,92			3,20		
Standard Deviation	0,37			0,28			0,60		

($\bar{x}$ = Mean; σX = Standard deviation; R = Rank)

Table 3: t-Test: Two-Sample Assuming Equal Variances

Factor	Sector	Mean	Variance	Observations	Pooled Variance	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
1	Construction	2,467	1,410	15	1,109	19	-2,359	0,015	1,729	0,029	2,093
	Fabrication	3,667	0,267	6							
2	Construction	2,733	0,781	15	0,865	19	-1,707	0,052	1,729	0,104	2,093
	Fabrication	3,500	1,100	6							
3	Construction	2,733	1,352	15	1,075	19	-1,530	0,071	1,729	0,142	2,093
	Fabrication	3,500	0,300	6							
4	Construction	3,133	0,981	15	0,828	19	-1,972	0,032	1,729	0,063	2,093
	Fabrication	4,000	0,400	6							
5	Construction	3,000	1,000	15	0,912	19	-2,890	0,005	1,729	0,009	2,093
	Fabrication	4,333	0,667	6							
6	Construction	2,733	1,352	15	1,207	19	-2,387	0,014	1,729	0,028	2,093
	Fabrication	4,000	0,800	6							
7	Construction	2,733	0,781	15	0,725	19	-3,486	0,001	1,729	0,002	2,093
	Fabrication	4,167	0,567	6							
8	Construction	3,400	1,114	15	0,970	19	-1,611	0,062	1,729	0,124	2,093
	Fabrication	4,167	0,567	6							
9	Construction	3,600	1,257	15	1,102	19	-0,131	0,448	1,729	0,897	2,093
	Fabrication	3,667	0,667	6							
10	Construction	2,533	0,981	15	0,872	19	-3,621	0,001	1,729	0,002	2,093
	Fabrication	4,167	0,567	6							

Table 4: t-Test: Two-Sample Assuming Unequal Variances

Factor	Sector	Mean	Variance	Observations	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
1	Construction	2,467	1,410	15	19	-3,225	0,002	1,729	0,004	2,093
	Fabrication	3,667	0,267	6						
2	Construction	2,733	0,781	15	8	-1,580	0,076	1,860	0,153	2,306
	Fabrication	3,500	1,100	6						
3	Construction	2,733	1,352	15	18	-2,048	0,028	1,734	0,055	2,101
	Fabrication	3,500	0,300	6						
4	Construction	3,133	0,981	15	15	-2,385	0,015	1,753	0,031	2,131
	Fabrication	4,000	0,400	6						
5	Construction	3,000	1,000	15	11	-3,162	0,005	1,796	0,009	2,201

	Fabrication	4,333	0,667	6						
6	Construction	2,733	1,352	15	12	-2,679	0,010	1,782	0,020	2,179
	Fabrication	4,000	0,800	6						
7	Construction	2,733	0,781	15	11	-3,745	0,002	1,796	0,003	2,201
	Fabrication	4,167	0,567	6						
8	Construction	3,400	1,114	15	13	-1,866	0,042	1,771	0,085	2,160
	Fabrication	4,167	0,567	6						
9	Construction	3,600	1,257	15	13	-0,151	0,441	1,771	0,882	2,160
	Fabrication	3,667	0,667	6						
10	Construction	2,533	0,981	15	12	-4,085	0,001	1,782	0,002	2,179
	Fabrication	4,167	0,567	6						

Table 5: t-Test: Two-Sample

	Assuming Equal Variance		Assuming Unequal Variance	
	Construction	Fabrication	Construction	Fabrication
Mean	2,905	3,918	2,905	3,918
Variance	0,138	0,094	0,138	0,094
Observations	10,000	10,000	10,000	10,000
Pooled Variance	0,116		17,000	
df	18,000		-6,654	
t Stat	-6,654		0,000	
P(T<=t) one-tail	0,000		1,740	
t Critical one-tail	1,734		0,000	
P(T<=t) two-tail	0,000		2,110	
t Critical two-tail	2,101			

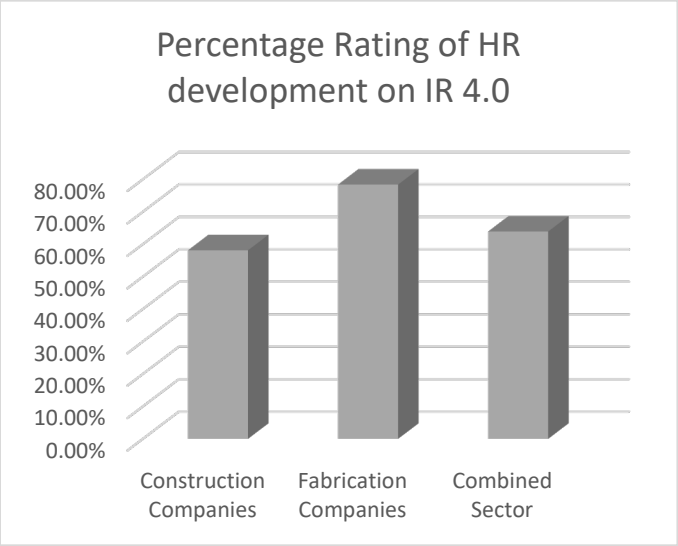

Figure 3: Percentage Rating of HR Development on IR 4.0

Figure 3 presents the bar chart that shows the percentage rating comparison between each sector and the combined result. The role of HR development on industry 4.0 in the construction industry has a mean item score of 2.91 and a standard deviation (SD) = 0.37. The impact is rated at 58 %. The role of HR development on industry 4.0 in the fabrication industry has a mean item score of 3.92 and a standard deviation (SD) = 0.28. The impact is rated at 78 %. Fabrication companies show a higher mean item score than construction companies. With a combined mean item score of 3.20, it is evident that at a moderate level the fabrication and construction sectors HR development impacts industry 4.0. Human resource development aligned to industry 4.0 is rated 64%. The mean result comparison two-tailed P value is less than 0.0001. The difference between the two sectors is statistically significant. These statistics are an indication of employers' commitment to training and development of staff keeping them up to date with the latest technologies. Also, we see the effect of the latest technologies on employees' work efficiency and job performance levels.

7. Recommendation and Conclusion

The main goal of this paper was to study the role of human resource development on industry 4.0 technologies in the South African construction and fabrication industries. The challenges faced by them are focused in this paper. The aspects relating to the objectives to this paper are employees usage of the training skill and knowledge acquired through the training programs; the effect of training and development on the efficiency of employees; employee training aligned to the latest emerging technologies to increase employee job performance levels; individuals being happy with the content of industry 4.0 training provided; adequate provision of Industry 4.0 training; industry 4.0 awareness and training as part of organizations strategy; employees at all levels including unskilled employees are made aware and / or educated on IoT and cyber-physical systems; employees encouraged to learn new skills aligned to industry 4.0; and each departments commitment in implementing the latest emerging technologies. The statistics show that human resource development aligned to industry 4.0 is at a moderate level. Furthermore, showing that skills development programs offer a moderate level of benefit to employees. It is recommended that employees are trained and made aware of the benefits of industry 4.0 technologies. At the same time continuous monitoring needs to be done to determine if employees are happy with the content of training, the information provided, and the effect of job performance levels. Evaluation of the training offered needs to be done with the results obtained through the continuous monitoring, and improvements made where required. Training must not be restricted to selected levels in an organization, top management to general workers need to be educated on an ongoing basis. Management needs to move away from traditional methods and even though new technology may be complex it needs to be implemented. It all starts with training and development from the top management going down. Companies need to invest more time and resources in training and development aligned with the latest technological advancements. Training and development need to be on a regular and ongoing basis. The impact of the training offered needs to be monitored. Through training will people gain an understating of the advantages posed by adopting new technologies.

With human resource development impacting on industry 4.0 technologies at a moderate level in the South African construction and fabrication industry, there is room for improvement. Companies need to invest more time and resources in training and development to be current with the advancements in technology and to be efficient.

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Biographies

Uzayr Karimulla is a student at the University of Johannesburg, Department of Mechanical and Industrial Engineering Technology. He earned his bachelor's in mechanical engineering technology from the University of South Africa, and his master's in mechanical engineering technology from the University of Johannesburg, South Africa. His work experience is in the mining construction and heavy lift industry.

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