



The Adequacy of Human Capital for the Fourth Industrial Revolution Era in the Mining Industry in Zimbabwe

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Abstract

This paper examined the adequacy of human capital in the fourth industrial era. This has been prompted by the fact that human capital has been regarded as the key driver of value creation, financial performance and sustainability. However, concerns have been raised regarding the adequacy of human capital in the new era, particularly in emerging economies such as Zimbabwe. This paper adopted a qualitative critical literature review approach in assessment of human capital preparedness in the fourth industrial era. The paper utilised secondary data extracted from the corporate annual reports and existing related literature. A thematic analysis process was used for analysing qualitative data related to the Zimbabwean mining companies and the analysis was carried out until a saturation point was reached. The findings suggested that the adoption of Industry 4.0 technologies in Zimbabwe's mining industry was still in its infancy, and there was limited investment in human capital development. The study also highlighted several challenges, including inadequate infrastructure, limited access to funding, and a shortage of skilled labour. It was also established that, while there was some training provided, it was inadequate to keep up with the rapid technological changes. The study concluded that the adequacy of human capital in the mining companies in Zimbabwe was a significant concern in the context of Industry 4.0. The study recommended that policymakers and industry stakeholders prioritize investment in human capital development, including upskilling and reskilling programmes, to ensure that the mining industry is well-positioned to take advantage of the opportunities presented by Industry 4.0.

Keywords: Industry 4.0; Adequacy; Mining; Zimbabwe; Human Capital

Introduction

The Fourth Industrial Revolution, also known as Industry 4.0 is characterised by the integration of advanced technologies such as cloud computing, 3D printing, Artificial Intelligence (AI), the Internet

of Things (IoT), big data, drones and robotics among others into the industrial sector. This revolution has brought about significant changes in the way businesses globally operate. The mining industry has not been an exception and in Zimbabwe, mining companies have also been impacted by this revolution, and are expected to adapt to the new technological changes to remain globally competitive. The human capital of any organisation is a critical component for its success, particularly in the mining industry where the workforce is exposed to various risks. The adequacy of human capital in the Fourth Industrial era is a topic of significant concern for mining companies in Zimbabwe. This concern is heightened by the fact that the country is facing a brain drain, with skilled personnel leaving for other countries in search of better opportunities. The purpose of this study was to establish the adequacy of human capital in the era of the fourth industrial revolution in Zimbabwe with a focus on mining companies operating in Zimbabwe.

Background of the Study

The Fourth Industrial Revolution has transformed many industries including the mining industry around the world, with an increasing emphasis on the use of technology and automation. The mining industry plays a crucial role in the economic development of many countries, including Zimbabwe. As the world undergoes the transformative phase of Industry 4.0, mining companies are compelled to adapt to the technological advancements and automation that characterise this era (World Economic Forum, 2018). However, concerns have been raised regarding the adequacy of human capital in the new era, particularly in emerging economies such as Zimbabwe. The Fourth Industrial Revolution is premised on the foundations of the three preceding industrial revolutions. The first industrial revolution introduced the development of steam engines as well as iron and textile industries. Systems such as transportation and communication also became popular in the 18th century. The provision of electrical energy marked the existence of the second industrial revolution while the third revolution occurred in the 1980s when technological advancement gained its momentum. Brown (2020) believes that the world is currently experiencing a transformation to Industry 4.0 popularly known as the Fourth Industrial Revolution predicated on the utilisation of contemporary technologies. These technologies have also been referred to as converging technologies by Bashir, Dahlman, Kanehira, & Tilmes (2022).

Deloitte (2020) adduces that companies are beginning to understand the massive impact of Industry 4.0 and the role of technology in fundamentally transforming business models and processes. Despite the advantages linked to Industry 4.0, several challenges have also originated. Key areas of the economy such as industries, entrepreneurial development, innovation and technology, fiscal policy and taxation have faced problems emanating from the transformation to 4.0. These challenges include figuring out the intermediate steps needed to take to harness and realise the benefits of the Fourth Industrial Revolution.

To contextualise the study, it is important to understand the background of the mining industry in Zimbabwe. Zimbabwe possesses significant mineral resources, including platinum, gold, diamonds, coal, chrome, and nickel. The mining sector has historically been a major contributor to the country's economy, attracting both domestic and foreign investments (Kumari & Dubey, 2018). However, the industry has faced various challenges, such as infrastructure limitations, regulatory frameworks and economic uncertainties. Furthermore, Industry 4.0 has emerged as a significant global phenomenon that has impacted numerous industries, including mining. The convergence of digital technologies, automation, and data-driven decision-making has the potential to revolutionise mining operations, optimising processes and driving efficiency. However, the integration of these technologies also necessitates a workforce with the appropriate skillsets and adaptability to fully capitalise on the benefits of Industry 4.0 (Schumacher & Erol, 2020).

One of the critical components for the success of any organisation is its human capital. The mining industry is a labour-intensive industry that requires skilled personnel to operate and maintain its equipment. As such, the adequacy of human capital in Industry 4.0 is a topic of significant concern for mining companies in Zimbabwe, particularly in light of the country's brain drain. However, the adoption of new technologies requires a skilled workforce that can operate and maintain the new equipment and systems. The mining industry in Zimbabwe has been negatively affected by brain drain, with skilled personnel leaving the country in search of better opportunities abroad. This brain drain is a significant challenge for the industry, as it limits the pool of qualified personnel available to mining companies.

In addition, many organisations including mining companies are facing what can be categorised as a “skills struggle”. This implies that companies are struggling to develop their people with adequate skills that fit in the era of Industry 4.0. According to Makgato (2019) there is a mismatch between the skillsets and employers’ current expectations in this era. It may be inferred from this that there might be low enrolment in the Science, Technology, Engineering and Mathematics (STEM) subjects for sustainable skills supply for the Fourth Industrial Revolution. The mining industry in Zimbabwe is also facing a shortage of skilled personnel due to a lack of investment in training and development programmes. The industry has relied heavily on expatriates to fill skilled positions, which has led to a skills gap among the local workforce. However, the increasing technical complexity of modern business and the time required for personnel to gain skills, experience and judgement in many vital areas makes brain power the critical resource in economies worldwide. Notwithstanding that human capital has been considered as one of the key elements of intellectual capital in an organisation (Mpofu, 2021), its preparedness for Industry 4.0 remains unknown with certainty. There is a dearth of literature pertaining to the preparedness of human capital in Industry 4.0, particularly in developing nations (Deloitte, 2021).

The mining industry in Zimbabwe revealed that the adoption of new technologies has led to increased productivity and efficiency in the industry. However, the study also highlighted that the adoption of new technologies requires a skilled workforce, which is a challenge for mining companies in Zimbabwe. The study recommended that mining companies invest in the training and development of their employees to ensure that they have the necessary skills to operate and maintain new technologies. Another study by Nyamwanza and Zhou (2020) on the impact of Industry 4.0 on the mining industry in Zimbabwe revealed that the adoption of new technologies has led to increased safety and reduced operational costs in the industry. However, the study also highlighted that the adoption of new technologies required a skilled workforce, which is a challenge for mining companies in Zimbabwe. The study recommended that mining companies collaborate with educational institutions to develop training programmes that are aligned with the requirements of the industry.

It is important to review and analyse related literature on human capital and industry 4.0 in developing nations. In the era of converging technologies, understanding human capital factors together with the technical factors may map a way forward for companies in ensuring that their workforce possess skills needed to succeed in Industry 4.0 era. Also, if companies are facing challenges with “skills struggle”, strategic measures such as training and development can be adopted to equip their employees with necessary skills and expertise. Despite the growing research on human capital and Industry 4.0, less has been researched on the challenges faced on developing human capital with skills that meet the needs of Industry 4.0, particularly in the developing countries.

Studies of this magnitude contributes immensely to related literature as well as policy formulation. To literature, the study contributes to the body of knowledge by providing information on the preparedness of human capital towards Industry 4.0. This implies unpacking the adequacy of human capital in terms of competitiveness, knowledge as well as productivity in the Fourth Industrial era. The adequacy of human capital is an essential topic, particularly in developing countries since the world is transforming at an alarming rate and becoming a global village. However, studies that focuses on human

capital and Industry 4.0 are at an infancy stage in developing countries. It is against this background that this study sought to address the knowledge gaps identified in the Deloitte Global report (2018). This study also contributes to policy formulations, by providing measures on the minimum body of knowledge and skills (MBKS) as well as closing the gap of growing mismatch between human capital skills and employer needs in the digital era.

Problem Statement

Although the mining industry has great potential in spearheading the growth of the economies of most developing countries, its potential greatly depends on how the sector performs in the context of the Fourth Industrial Revolution. While it is not in dispute that the human capital element of the mining industry is a critical component for its success in Industry 4.0, its preparedness remains unknown with certainty. There are few, if any, studies that have been conducted to assess the adequacy of human capital for the Fourth Industrial Revolution in the mining sector in Zimbabwe.

Literature Review

Fourth Industrial Revolution

The term Fourth Industrial Revolution is believed to have been propounded by Klaus Schwab of the World Economic Forum (Fox and Signe, 2022). It involves the synthesis of the digital, biological and the physical worlds together with the increasing utilisation of contemporary technologies such as cloud computing, 3D printing, Artificial Intelligence (AI), the Internet of Things (IoT), big data, drones and robotics among others (Ndung'u and Signe, 2020). These technologies have disrupted industries globally and have the capacity to intensify the swiftness and efficacy of the manufacture of products and services. The Fourth Industrial Revolution is premised on the foundations of the three preceding industrial revolutions.

As a result of globalisation, Industry 4.0 technologies are spreading and evolving at a faster rate as compared to the previous revolutions (Schwab, 2016). At the same time, these technologies are having massive impact on a wide range of industries (bid). The emergence of the Fourth Industrial Revolution is significant to Africa because the continent has been lacklustre in capitalising the benefits of the previous revolutions (Technopolis, 2019). The current industrial revolution may offer the continent an opportunity to restructure its economy with the aim of enhancing its international trade so that it assumes its rightful place among its sister continents.

The impact of Industry 4.0 on business models and processes is profound and far-reaching. With the integration of advanced technologies such as automation, robotics, artificial intelligence, and data analytics, businesses are experiencing a transformative shift in how they operate. These technologies enable the optimisation and streamlining of processes, leading to increased productivity, improved efficiency, and enhanced decision-making capabilities (Schumacher & Erol, 2020). For instance, automation and robotics are revolutionising manufacturing processes by enabling precision, speed, and scalability. Data analytics allows organisations to extract valuable insights from vast amounts of data, enabling data-driven decision-making and predictive maintenance. Furthermore, the connectivity and interoperability facilitated by Industry 4.0 enable seamless integration across different stages of the value chain, fostering collaboration and efficiency. Overall, Industry 4.0 presents opportunities for businesses to innovate, adapt, and stay competitive in a rapidly evolving digital landscape.

Human Capital in the Context of the Fourth Industrial Revolution

Human capital continues to be a significant influence in economic growth (Gruzina, Firsova and Strielkowski, 2021). Innovative human capital is becoming an essential factor in the creation of sustainable competitive advantage for organisations in the context of Industry 4.0 (Balog and Demidova, 2021). The adoption of Industry 4.0 technologies requires a highly skilled workforce with the ability to adapt to new technologies and work processes (Brynjolfsson & McAfee, 2014). Numerous scholars have examined the relationship between Industry 4.0 and human capital, highlighting both the opportunities and challenges that arise from this interaction. Deloitte (2020) emphasises that companies are increasingly recognising the massive impact of Industry 4.0 and the role of technology in reshaping business models and processes. However, this transformation also poses challenges related to human capital development and utilisation.

While the emergency and adoption of Industry 4.0 requires individual employees to learn digital competencies and skills so that they are able to interact with the new technologies, employers have a duty to unveil mechanisms to retrain existing and redundant employees (Bikse, Grinevica, Rivza and Rivza, 2022). However, research has shown that in most countries around the world employers do not take seriously their role of assisting in furthering the education and training of their employees (ibid). If employees are to remain competitive in the era of the Fourth Industrial Revolution, they need to possess digital, cognitive, social and behavioural proficiencies in addition to professional capabilities (Balog and Demidova, 2021). This calls for the continuous attainment of new knowledge, the upgrading of skills and vigorous personal development.

Research has shown that the development of human capital is positively associated with organizational performance (Huselid, 1995). In the context of Industry 4.0, organisations with a highly skilled workforce are better positioned to take advantage of the benefits of advanced technologies, such as increased productivity and efficiency (Brynjolfsson & McAfee, 2014).

One key challenge highlighted in the literature is the need to identify the skillsets required in the Fourth Industrial Revolution era. As technology advances rapidly, there is a growing mismatch between the skillsets of the existing workforce and the evolving needs of industries (Makgato, 2019). The demand for digital skills, data analysis, programming, and automation expertise has surged, while traditional skills are becoming less relevant. This discrepancy necessitates strategies for upskilling and reskilling the workforce to ensure their readiness for Industry 4.0 (Schumacher & Erol, 2020).

As a result of Industry 4.0, low-skilled jobs are giving way to automation technologies resulting in most jobs disappearing with the new ones emerging leaving many people behind (Bikse et al., 2022). Moreover, the lack of enrolment in Science, Technology, Engineering, and Mathematics (STEM) fields is a significant concern for sustainable skills development in this era. Makgato (2019) argued that low enrolment in STEM disciplines could limit the availability of talent equipped with the necessary skills to drive innovation and technological advancements. This has been corroborated by Choi, Dutz and Usman (2020) who argued that the major challenge confronting the adequacy of human capital in the context of Industry 4.0 in most African countries is the non-acquisition of the skills needed for the Fourth Industrial Revolution job market by students from pre-school to university.

Balog and Demidova (2021) notes the discrepancy between what most educational programmes offer and what most employers expect from their graduate employees. As such, there is urgent need for African economies to close the skills gap by investing heavily in basic education and also mobilising both public and private resources aimed at financing post-secondary STEM and digital skills development. This also necessitates an urgent need for the upgrading of the curricula at different levels to suit the needs of Industry 4.0. Rymarczyk (2020) has postulated that holders of the highest human capital qualifications will be the key beneficiaries of the current industrial revolution.

Organisations also face challenges in developing their people and nurturing the required skillsets. The rapid pace of technological change necessitates a continuous learning mindset and a culture of innovation within organisations. However, many companies struggle to keep up with these demands and find it challenging to attract, retain, and develop the right talent (Deloitte, 2020).

A study by Kossi et al. (2021) investigated the impact of Industry 4.0 on human capital development in African countries and found that the adoption of Industry 4.0 technologies required a highly skilled workforce. The study concluded that African countries need to invest in human capital development to take advantage of the benefits of Industry 4.0. Similarly, a study by Anohina-Naumecca et al. (2018) examined the challenges and opportunities of Industry 4.0 for human capital development in Latvia. The study found that Industry 4.0 technologies required a new set of skills such as data analysis and programming, and that organisations need to invest in training and development to ensure their workforce has these skills. Another study by Egbetokun et al. (2020) investigated the impact of Industry 4.0 on human capital development in Nigeria and found that the adoption of Industry 4.0 technologies required a highly skilled workforce, and that there was a need for investment in training and development to build this workforce. Finally, a study by Loh et al. (2017) examined the impact of Industry 4.0 on the workforce in Singapore. The study found that Industry 4.0 technologies required a new set of skills, such as data analysis and problem-solving, and that organisations need to invest in training and development to ensure their workforce has these skills.

Research Methodology

The study discussed the adequacy of human capital for the Fourth Industrial Revolution in the mining sector in Zimbabwe. A qualitative critical literature review approach was utilised. This involved the researchers conducting an evaluative analysis of corporate annual reports, sustainability reports as well as other related recent literature to conceptualise the views of varied authors in relation to the preparedness of human capital in the mining industry in Zimbabwe during the period 2020 to 2022. The study focused on mining companies that were operating in Zimbabwe and had their parent companies domiciled in the Southern African region. The researchers sought to provide a detailed analysis on the key aspects of human capital that have direct impact on the adoption and operationalisation of the Fourth Industrial Revolution. From literature analysis, a critical literature review enabled researchers to make valid inferences and identification of knowledge gaps, philosophy gaps as well as methodological gaps.

The study utilised Google scholar search engine to extract valid and acceptable research papers for literature. To buttress the literature, the researchers adopted the forward and backward snowballing to search for the more recent and previous relevant articles respectively. In order to increase the diversity of the sources and make the review more meaningful, the researchers used a combination of peer reviewed journal articles, working papers from development bodies as well as discussion papers from accounting firms. It is important to note that this also helped to overcome the limitation of the scarcity in literature linked to the novel nature of the issue of human capital in the context of Industry 4.0. Data was reviewed until the saturation point was reached. According to Sebele-Mpofu (2020), a point of saturation is reached when further reviewing of data does not reveal any novel information other than the one already established. Thematic analysis was utilised to analyse and interpret the findings of the review. This is in line with the advantages of thematic analysis outlined by Braun & Clarke, (2019).

Findings and Discussion

This paper sought to examine the adequacy of human capital in industry 4.0 among the selected mining companies in Zimbabwe. The previous sections focused on the background of the paper, literature

review as well as the research methodology. This section of the paper discussed the qualitative findings that were established using the thematic analysis. It is important to note that findings were presented based on the themes established during the qualitative analysis. The data was collected using the evaluative critical literature review approach.

Preparedness of Mining Companies for Industry 4.0

Findings showed that mining companies operating in Zimbabwe were not adequately prepared for Industry 4.0. This was mainly because of the state of the Zimbabwean economy which made it difficult for the majority of companies to invest in technological advancement. Zimbabwe has been facing economic challenges for more than two decades which has negatively affected the ability of companies to match their colleagues operating in the developed world in terms of technological uptake. Most of the literature utilised for the study blamed economic challenges experienced by the country as the reason why mining companies were not adequately prepared for Industry 4.0 as compared to mining companies operating in other countries, especially in other continents. However, although the economy has not been performing well which might have negatively affected the preparedness of mining companies operating in Zimbabwe for Industry 4.0, it must be noted that all minerals extracted are exported resulting in these companies generating foreign currency which could have been used to prepare for Industry 4.0.

Lack of Awareness of the Implications of Industry 4.0

From the literature analysis, it was established that there was a lack of awareness of the implications of Industry 4.0 among mining industry stakeholders in Zimbabwe. The majority of scholars suggested the need for education and training on the Fourth Industrial era. This is to ensure that stakeholders understand the potential implications for the industry and the economy as a whole. The results further revealed that there was a gap between the skills and competencies required and that organisations are investing in training and development programmes to address this gap.

Human Capital Aspects not Known with Certainty

The findings revealed that human capital is a key driver of value creation, competitiveness and economic growth at large. However, there was lack of consensus on the human capital aspects that need development. This has led to stakeholders having varied opinions on human capital preparedness in the fourth industrialisation era. The majority of scholars indicated that policy makers were rather passive than active on the regulation of human capital development policies. This implied that government and other related professional bodies were silent on the skillset required for human capital to meet the standard of the industry 4.0. The failure by policy makers has resulted in the contextualisation of human capital development and preparedness.

Skillset Mismatch and Training Programs

The analysis of literature revealed a significant skillset mismatch within the mining companies operating in Zimbabwe. The findings indicated that the rapid technological advancements of Industry 4.0 have resulted in a gap between the existing skillsets of employees and the evolving demands of the digital era. This finding corroborated the argument of Makgato (2019). Many employees in the mining industry in Zimbabwe lacked the necessary digital literacy, data analytics, and automation skills required for efficient operations in the Fourth Industrial Revolution. However, the study also observed the presence of various training programmes and initiatives implemented by the mining companies to address the skillset mismatch. These programmes included internal training workshops, collaboration with educational institutions, and partnerships with technology providers. The findings suggested that mining companies in Zimbabwe were aware of the skillset gap and were taking steps to bridge it through targeted training and development programmes (Deloitte, 2020) although at a snail's pace.

STEM Education

The study findings highlighted the significance of STEM education in preparing individuals for the Fourth Industrial Revolution. The study revealed that mining companies operating in Zimbabwe were increasingly prioritising the recruitment of individuals with STEM backgrounds due to the technical skills and knowledge they possessed. However, the low enrolment in STEM fields, as indicated in the different literature analysed posed a challenge for these companies. To address this issue, findings showed that mining companies were collaborating with policy makers and educational institutions to promote STEM education and engage students at an early age (Mekonnen & Islam, 2021). The findings suggested that proactive recruitment strategies and partnerships with educational institutions were vital for developing a pipeline of talent with the necessary STEM skills to meet the changing workforce needs in the mining industry.

Recruiting and Retaining of Skilled Human Capital

The results of the study indicated that the mining companies in Zimbabwe were facing significant challenges in recruiting and retaining skilled human capital in the Fourth Industrial era. The findings showed that the mining sector was experiencing an acute shortage of individuals with the necessary skills and expertise in new technologies such as artificial intelligence, robotics and big data analytics. The study further deduced that the cost of training and developing existing employees to work in the Fourth Industrial era was prohibitively high, particularly for small and medium-sized mining companies.

It was further established that the Fourth Industrial era required a new set of competencies and skills beyond traditional mining skills, such as critical thinking, problem-solving, and data analysis. There was also an emphasis on the importance of soft skills such as adaptability, teamwork, and communication in the Fourth Industrial era. However, the findings revealed that these skills were difficult to quantify and assess, making it challenging to identify and recruit individuals with the necessary competencies.

Continuous Learning and Adaptability

Study findings showed that most employees in the mining companies lacked a culture of self-development, continuous learning and adaptability which negatively affected their preparedness for Industry 4.0. These findings emphasised the importance of fostering a culture of continuous learning and adaptability within mining companies operating in Zimbabwe. The dynamic nature of technology required employees to constantly update their skills and embrace new technologies. The study revealed that companies with a strong learning culture, characterised by ongoing training programs, knowledge-sharing platforms, and opportunities for upskilling and reskilling, were better equipped to navigate the challenges of Industry 4.0. These companies recognised the need for their workforce to adapt and develop new competencies to remain competitive in the digital era. This is in line with the argument of Balog and Demidova (2021) that human capital has to contend with the need for continuous upgrading of competencies and capabilities to support Industry 4.0. The findings suggested that creating a supportive environment for continuous learning and providing employees with resources and opportunities for skills development were essential for enhancing human capital in the Fourth Industrial era.

Stakeholder Engagement

The findings showed that collaboration among the key stakeholders such as government, industry associations and educational institutions was not impressive. This negatively affected the ability of mining companies operating in Zimbabwe to take advantage of the opportunities emanating from Industry 4.0. The findings indicated the need for collaboration between government entities, industry associations and educational institutions to address a number of challenges identified such as lack of relevant skills and a discrepancy between what educational institutions offered and what mining employers expected.

This collaboration is in line with the recommendations of Nyamwanza and Zhou (2020). The study showed an urgent need for key stakeholders to put their heads together and come up with sound policy measures such as the promotion of STEM education through targeted initiatives, tax incentives for companies investing in employee training and development, and the establishment of public-private partnerships to facilitate knowledge transfer and skills development. By implementing supportive policies, the government can encourage mining companies to invest in human capital development and ensure the adequacy of skills in the industry to drive sustainable growth in the Fourth Industrial era. This supports the argument advanced by Rymarczyk (2020) that employees with adequate and relevant skills will not only benefit their organisations but their nations as well in this Fourth Industrial Revolution era.

Overall, the findings of the study shed light on the human capital challenges faced by mining companies operating in Zimbabwe in the context of Industry 4.0. The findings underscored the importance of addressing skillset mismatches, promoting STEM education, fostering a culture of continuous learning, and implementing supportive policies to enhance human capital readiness. By proactively addressing these challenges, mining companies can position themselves for success in the Fourth Industrial Revolution and contribute to the sustainable growth and development of Zimbabwe's mining industry.

Conclusions

The Fourth Industrial Revolution, characterised by the rapid advancement of technology and automation has had a profound impact on the mining industry in Zimbabwe. This study explored the adequacy of human capital for the Fourth Industrial Revolution in mining companies operating in Zimbabwe. The findings highlighted several key aspects that are crucial for ensuring the readiness and competitiveness of the mining sector in the digital era.

Firstly, the study concluded that there was a skillset mismatch between the existing capabilities of employees and the evolving demands of Industry 4.0. Mining companies operating in Zimbabwe recognised the need to bridge this gap and had begun to implement training and development programmes to address the skillset mismatch. These initiatives aimed to equip employees with digital literacy, data analytics, and automation skills necessary for efficient operations and decision-making (Miskon & Latif, 2018).

Secondly, the low enrolment in STEM fields posed a significant challenge in developing the required talent pool for Industry 4.0. The findings emphasised the importance of promoting STEM education, collaborating with educational institutions, and adopting proactive recruitment strategies to attract individuals with STEM backgrounds. These efforts were essential to meet the changing workforce needs and ensure the availability of a skilled workforce in the mining industry.

Thirdly, fostering a culture of continuous learning and adaptability was crucial for mining companies to thrive in the digital era. Companies that prioritised learning and provided opportunities for upskilling and reskilling were better prepared to navigate the dynamic technological landscape. A supportive learning environment, along with knowledge-sharing platforms and ongoing training programs facilitates the development of a workforce that can embrace new technologies and adapt to changing industry trends (Nascimento & Picanço, 2020).

Lastly, the study highlighted the need for policy interventions to support human capital development in the mining sector. Government entities, industry associations, and educational institutions must collaborate to implement policies that promote STEM education, incentivise investment in employee training, and facilitate knowledge transfer. These policy measures will contribute to the sustainability and competitiveness of the mining industry in the Fourth Industrial era.

The adequacy of human capital in the Fourth Industrial era is a critical factor for the success of mining companies in Zimbabwe. The findings of this research emphasised the importance of addressing skillset mismatches, promoting STEM education, fostering a culture of continuous learning, and implementing supportive policies. By proactively addressing these challenges and investing in human capital development, mining companies operating in Zimbabwe can position themselves for growth and innovation in the digital era, ensuring the sustainable development of the mining industry in Zimbabwe's evolving economic landscape.

Recommendations

Based on the findings of the study, the following recommendations were proffered in order to improve the adequacy of human capital for the Fourth Industrial Revolution in mining companies operating in Zimbabwe.

There is need for government agencies, mining industry associations and educational institutions to collaborate with the aim of promoting STEM education at all levels, starting from primary schools through to tertiary education. There is need to encourage students to pursue STEM subjects and provide scholarships or financial incentives to attract talented individuals towards STEM fields. By nurturing a strong pipeline of STEM graduates, mining companies can ensure a steady supply of skilled professionals equipped to thrive in the Fourth Industrial Revolution.

There is need to continuously assess the skillset requirements of Industry 4.0 and design comprehensive training and development programs to address any skillset mismatches within the mining companies. These programmes should focus on digital literacy, data analytics, automation, and other emerging technologies relevant to the mining industry. Mining companies operating in Zimbabwe may utilise a combination of internal training, external partnerships, and online learning platforms to provide employees with accessible and up-to-date training opportunities.

Mining companies should create a supportive environment that encourages continuous learning and skills development. They should establish knowledge-sharing platforms, mentorship programmes and cross-functional collaborations to facilitate the exchange of expertise and best practices within their respective organisations. It is also recommended that organisations should encourage employees to pursue ongoing professional development and provide resources for upskilling and reskilling. In addition, employees who actively engage in continuous learning and development should be recognised and rewarded.

Strategic partnerships among mining industry associations, educational institutions and technology providers must be established. These partnerships can facilitate knowledge transfer, provide access to specialised expertise, and support the development and implementation of cutting-edge technologies in the mining sector. By leveraging external resources and expertise, mining companies can accelerate their digital transformation and enhance their human capital capabilities.

Mining companies operating in Zimbabwe should engage with industry associations and policy makers and advocate for supportive policies that incentivise investment in human capital development. There is need to lobby for tax incentives or grants that encourage mining companies to allocate resources to employee training and development. The creation of public-private partnerships that facilitate knowledge exchange, research collaborations, and workforce development initiatives should be supported. By fostering a favourable policy environment, mining companies can maximise their efforts in developing an adequate and skilled workforce.

There is need to continuously monitor and evaluate the effectiveness of human capital development initiatives within the mining companies. Regularly assessing the impact of training programmes, identifying areas for improvement, and making the necessary adjustments. Feedback should be regularly collected from employees regarding their skill development and any additional needs or emerging trends should be identified. By incorporating a feedback loop and a culture of evaluation, mining companies can continuously enhance their human capital strategies and adapt to evolving industry requirements.

Limitations

The research utilised a qualitative critical literature review approach, which relied on existing literature and secondary data sources. This approach may introduce bias and limitations inherent in the selected literature. Future research should consider incorporating primary data collection methods such as surveys, interviews, or case studies to gather first-hand insights from mining companies. The study focused on mining companies that were operating in Zimbabwe and had their parent companies domiciled in the Southern African region. Future research may include all mining companies operating in Zimbabwe irrespective of where their parent companies are domiciled in order to improve the representativeness of research findings.

Guidelines for Future Research

Future researchers may do comparative studies to compare the adequacy of human capital for the Fourth Industrial Revolution in different industries and sectors, exploring the preparedness of employees from one sector as compared to employees in other sectors. Comparative studies can provide valuable insights into the specific challenges, strategies, and implications for different industries and shed light on sector-specific best practices.

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