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Disruptive technologies and the future of teaching and learning: Enhancing pedagogies in education and learning in the Twenty-First Century

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ABSTRACT

The study examined the effects of rapid technological progress, driven by the Fourth Industrial Revolution (4IR) and Artificial Intelligence (AI), on education. Its objective was to understand how these transformations pose challenges to conventional teaching practices and how educators can adapt to enhance the quality of instruction and students' global competitiveness. Through a doctrinal approach, the study reviewed the literature, case studies, and reviews of younger, tech-savvy educators and older instructors facing challenges with technology integration, capturing educators' perceptions at various career stages. Findings revealed a divide in acceptance and adaptation to new technologies, with younger educators embracing innovation while older generations express concerns about the decline in the quality of intellectual discourse. Traditional methods, seen as slower yet more effective at fostering deep understanding, contrast with modern digital tools that often lead to superficial engagement. The study highlights the need for a balanced approach that leverages technology to enhance learning without compromising intellectual rigor. Recommendations include integrating technology to complement traditional educational practices and encouraging educators to undergo training that fosters both technological proficiency and an understanding of scholarly engagement. Institutions ought to promote discussions between technology and pedagogy to uphold academic standards. This study adds to the current body of scholarship by connecting emerging technology with educational practices, highlighting the significance of intellectual engagement in the digital era, and advocating for further research on aligning technology with academic excellence.

Keywords: ChatGPT, Chatbots, 4IR, AI, Teaching and Learning, Higher Education Institutions (HEIs).

INTRODUCTION

The rapid evolution of technology in recent years, particularly through the Fourth Industrial Revolution (4IR) and the rise of Artificial Intelligence (AI), has dramatically reshaped various sectors, with education among the most affected.[1] Ilori and Ajagunna argue that while these technologies are

[1] M. O. Ilori and I. Ajagunna, " Re-Imagining the Future of Education in the Era of the Fourth Industrial Revolution," *Worldwide Hospitality and Tourism Themes* 12, no. 1 (2020): 3–12.

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advancing education systems, they have also introduced a new vista regarding what is learned and how it is learned in schools.[2] Yusuf et al. assert that to thrive in these times, we must prepare the future workforce to understand, learn, and utilise useful applications in academia.[3] They contend that educational institutions are laboratories for research and innovation, where 4IR technologies are used to improve human lives.[4] As traditional teaching practices encounter unprecedented challenges, educators are increasingly called upon to navigate this transformative landscape.[5] Penprase argues that today's Higher Education was designed to meet the needs of the past industrial revolution with mass production powered by electricity.[6] The systems are suited for an automation economy. The scholars assert that today's students face major challenges in demographics, population growth, global health, literacy, inequality, climate change, nuclear proliferation, and more, premised on the values of future sustainability.[7] Essentially, students today leave higher institutions with the 4IR, which has significantly different market demands from those that previously existed. The automation economy resulting from technologies of the Fourth Industrial Revolution is changing the way we live and work. Scholars advise that these technological advances are aimed at preparing future generations for the future state.[8] The idea of teaching to change the world serves as a powerful tool for societal transformation, and HEIs can be transmitters of that change through curriculum development.[9]

The 4IR had already had a significant impact before the COVID-19 pandemic seized South Africa and the global community. Although the swift integration of technology in education may represent a substantial advancement for some, it raises concerns for many, particularly for Luddites. This trend encompasses various sectors, including AI, robotics, the Internet of Things, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing.[10]

The term "disruptive technologies" refers to the transformation of human daily activities into more physical and digital forms. Marwala posits that the Fourth Industrial Revolution (4IR) "is not a distant era awaiting us in the future; instead, it is the present reality that permeates our everyday existence."[11] During the COVID-19 pandemic, severe lockdowns that interconnected the entire globe through technological means highlighted this reality. The peak of the pandemic was perceived as the new normal, with individuals engaging and working in a digital environment. Advocates of technology regard it as "a solution for transforming all facets of work, life, and the environment, crucial for alleviating Africa's historical and persistent inequalities and injustices."

However, this study holds a different perspective, particularly in light of the deteriorating socio-economic conditions in some areas of the African Continent, where evidence indicates that thousands of individuals are losing their jobs daily. The legal and ethical ramifications of the 4IR, along with its associated elements such as artificial intelligence, robotics, and autonomous vehicles, are viewed as raising significant concerns regarding machines usurping tasks traditionally performed by humans, to the extent that AIs are perceived as surpassing human capabilities.

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[2] Ilori and Ajagunna, " Re-Imagining the Future of Education in the Era of the Fourth Industrial Revolution."

[3] B. Yusuf, L. M. Walters, and S. N. Sailin, "Restructuring Educational Institutions for Growth in the Fourth Industrial Revolution (4IR): A Systematic Review," *Int. J. Emerg. Technol. Learn.* 15, no. 3 (2020): 93–109.

[4] Yusuf, Walters, and Sailin, "Restructuring Educational Institutions for Growth in the Fourth Industrial Revolution (4IR): A Systematic Review."

[5] Bryan Edward Penprase, "The Fourth Industrial Revolution and Higher Education," *Higher Education in the Era of the Fourth Industrial Revolution* 10, no. 1 (2018): 978–81.

[6] Penprase, "The Fourth Industrial Revolution and Higher Education."

[7] G. Lueddeke, *Global Population Health and Well-Being in the 21st Century: Toward New Paradigms, Policy, and Practice* (Springer Publishing Company, 2015); C. Schreiner, E. K. Henriksen, and P. J. Kirkeby Hansen, " Climate Education: Empowering Today's Youth to Meet Tomorrow's Challenges.," 2005; T. P. Soubbotina, *Beyond Economic Growth: An Introduction to Sustainable Development* (World Bank Publications, 2004).

[8] J. C. Glenn, T. J., Gordon, and E. Florescu, *2013-14 State of the Future* , vol. 1 (The Millennium Project, 2014).

[9] J. Oakes et al., *Teaching to Change the World* (London: Routledge, 2018).

[10] Klaus Schwab, " The Fourth Industrial Revolution," World Economic Forum, 2016, https://www.scirp.org/%28S%28czeh2tfqyw2orz553k1w0r45%29%29/reference/referencespapers.aspx?referenceid=2019783#:~:text=Schwab%2C K. (2016) The Fourth Industrial Revolution. World Economic Forum.

[11] T. Marwala, "UJ's Prof Tshilidzi Marwala Stresses the Need to Invest in Human Capital to Build 4IR Infrastructure," 4th Industrial Revolution, News, Opinion Pieces, September 10, 2020, https://news.uj.ac.za/news/ujs-prof-tshilidzi-marwala-stresses-the-need-to-invest-in-human-capital-to-build-4ir-infrastructure-2/.

While the widespread use of technology in teaching and learning is mandatory to meet market and future demands, what remains worrying is the job security of the current workforce, which is not adequately technologically empowered and is accustomed to traditional pedagogy.[12] The education landscape evolves with just small seeds of change in the curriculum and in equivalence. To be relevant to the global village requires cultivating higher standards recognisable worldwide.[13]

This article illustrates the complexities of the concept of teaching to change the world, challenging educators to consider how their pedagogy may unintentionally uphold existing power structures rather than dismantle them.

LITERATURE REVIEW

Padmaja and Mukul posit that due to technological disruptions, Higher Education Institutions (HEIs) have been forced to realign their strategies for survival and growth, both in academia and in industry.[14] They argue that, due to the acceleration of disruption in higher education, it is now imperative for educators to continually upskill and reskill to meet the needs of the future digital age.[15] The scholars further argue that technological advancement is an unstoppable wave, and the lack of relevant skills to address disruptions in higher education is a major challenge that needs to be addressed effectively.[16] Daher and Ziade contend that while technology affects employment patterns by enabling remote work and flexible arrangements, traditional vacations are increasingly outdated as new artistic roles emerge. They recommend continuous skill development, flexible working arrangements, employer transparency about automation, and the development of transferable human abilities, all of which are required for adaptation and to influence policies and strategies to maximize promises while reducing disruption.[17]

HEIs must acknowledge the impact of disruptive technologies; integrating these tools into the curriculum requires a balanced strategy that aligns technology with effective teaching practices in the current educational environment.[18] Merely implementing technology is insufficient; it must be approached thoughtfully and strategically to enhance the learning experience rather than hinder it. Central to this balanced strategy is the understanding that technology should serve to enhance, not replace, traditional teaching methods.[19] Effective teaching practices are founded on understanding how students learn best, adapting teaching methods to various learning styles, and fostering an engaging and supportive educational environment. When technology is utilized in accordance with these principles, it can encourage collaboration, stimulate critical thinking, and enable personalized learning, ultimately enhancing the educational experience with intention.[20] Effective teaching methods are based on recognizing how students learn best, tailoring approaches to diverse learning preferences, and establishing an engaging and supportive learning environment.[21] When technology is utilized alongside these principles, it can promote teamwork, encourage critical thought, and support individualized learning.[22]

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[12] D. Thornburg, *The New Basics: Education and the Future of Work in the Telematic Age* (ASCD, 2002).
[13] T. M. Moe and J. E. Chubb, *Liberating Learning: Technology, Politics, and the Future of American Education* (John Wiley and Sons, Ltd., 2009).
[14] V. Padmaja and Kumar Mukul., "Upskilling and Reskilling in the Digital Age: The Way Forward for Higher Educational Institutions.," in *Transforming Higher Education through Digitalization* (CRC Press, 2021), 253–75.
[15] Padmaja and Kumar Mukul., "Upskilling and Reskilling in the Digital Age: The Way Forward for Higher Educational Institutions."
[16] Padmaja and Kumar Mukul., "Upskilling and Reskilling in the Digital Age: The Way Forward for Higher Educational Institutions."
[17] Malak Mohammad Daher and Fouad Ziade, "Technology, Workforce, and the Future of Sustainable Work," in *Navigating the Intersection of Business, Sustainability and Technology* (Singapore: Springer Nature Singapore, 2024), 119–36.
[18] O. T. Akintayo et al., " Evaluating the Impact of Educational Technology on Learning Outcomes in the Higher Education Sector: A Systematic Review," *International Journal of Management & Entrepreneurship Research* 6, no. 5 (2024): 1395–1422.
[19] N. S. Alotaibi, "The Impact of AI and LMS Integration on the Future of Higher Education: Opportunities, Challenges, and Strategies for Transformation," *Sustainability* 16, no. 23 (2024): 10357.
[20] J. Hutson et al., " Artificial Intelligence and the Disruption of Higher Education: Strategies for Integration across Disciplines," *Creative Education* 13, no. 12 (2022).
[21] V. Bhardwaj et al., "Redefining Learning: Student-Centered Strategies for Academic and Personal Growth," *Frontiers in Education* 10 (2025): 1518602.
[22] Bhardwaj et al., "Redefining Learning: Student-Centered Strategies for Academic and Personal Growth."

Educational technologies, while disrupting educational spaces, face limitations in social change. Giroux argues, quoting Freire's seminal work, that the banking model of education treats students as passive recipients of knowledge.[23] He argues that this model can perpetuate injustices rather than resolve them. Freire suggests that true education should empower learners to engage critically with the world around them. This raises questions about the effectiveness of standard teaching methods in effecting meaningful change and challenges the simplistic idea that education alone is a panacea. Jarvis, on Freire's view of education, posits that education is a process; however, it is a human process, and its outcome is that authentic humans transform the world and humanize that transformation.[24] Freire reemphasised in his work 'Pedagogy of Freedom' that teaching is a human act. While the idea of education is ideological, the humanness of the process also emphasizes its ethical nature.[25] Despite the integration of technology and artificial intelligence, the human factor remains prominent in the educational landscape, and the empowerment it provides in enhancing the delivery of education during educational technology disruptions cannot be overstated.

Dewey emphasizes the importance of experience and community in the learning process.[26] While he champions education as a means for democratic participation, he critiques the notion that knowledge alone can incite change. Instead, he argues that change occurs through social engagement and active participation in community life, highlighting the contextual dependencies of educational impact on societal change. This suggests that without proper application frameworks, education might only produce well-informed individuals, rather than igniting social reform.

In her exploration of critical pedagogy, Hooks highlights the importance of addressing cultural contexts and power dynamics in education and argues that such critical pedagogy can only be enacted by humans, not through technological means.[27] She posits that teaching must confront systemic inequalities and empower marginalized voices to foster true change.

Zinn and Macedo argue that the educational system often reflects and reinforces societal inequalities rather than challenging them. They critique educational institutions for often being complicit in reinforcing the status quo. Zinn's perspective serves as a reminder that education alone does not guarantee positive change; educators must actively work to counter entrenched social injustices to alter the narrative of social inequity genuinely.[28]

Gruwell discusses an approach that underscores the transformative potential of education and emphasizes the need for proactive measures beyond traditional curricula.[29] While Gruwell's insights implicitly challenge the notion that mere educational access equates to societal change without an accompanying call to action, they also highlight the importance of empowering students to become active participants in their own education and in their communities. Gruwell's approach illustrates that education should not only focus on academic achievement but also foster critical thinking and social responsibility. Students need tools to question societal norms, understand their own identities, and recognize their potential impact on the world. This calls for educators to go beyond traditional teaching methods, fostering environments where diverse voices are heard and validated despite technological advancements and AI in the education space.[30]

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[23] H. A. Giroux, " Rethinking Education as the Practice of Freedom: Paulo Freire and the Promise of Critical Pedagogy," *Policy Futures in Education* 8, no. 6 (2010): 715–21.

[24] Peter Jarvis, *Twentieth Century Thinkers in Adult and Continuing Education* (Psychology Press, 2001).

[25] Jarvis, *Twentieth Century Thinkers in Adult and Continuing Education*.

[26] J Dewey, "Democracy and Educational Administration," *School and Society* 45 (1937).

[27] Bell Hooks, "Transformative Pedagogy and Multiculturalism," in *Freedom's Plow* (Routledge, 2013), 91–97.

[28] H. Zinn and D. Macedo, *Howard Zinn on Democratic Education* (London: Routledge, 2016).

[29] Erin Gruwell, *Teaching Hope: Stories from the Freedom Writer Teachers and Erin Gruwell* (Crown Publishers, 2009).

[30] C. Wang et al., "Education Reform and Change Driven by Digital Technology: A Bibliometric Study from a Global Perspective," *Humanities and Social Sciences Communications* 11, no. 1 (2024): 1–17.

THEORETICAL FRAMEWORK

The theoretical framework for this study is entrenched in the intersection of educational technology, workforce development, and the transformative impact of the 4IR on learning environments.[31] It emphasizes the rapid evolution of technologies such as AI, robotics, and the IoT, which have fundamentally altered educational practices, necessitating curricular adaptations to prepare students for a technology-driven workforce.[32] As highlighted by Yusuf et al., education systems must function as labs for innovation, fostering critical thinking and adaptability to effectively equip students for an economy marked by automation and AI.[33] Additionally, drawing on Penprase's analysis, the framework advocates responsive curriculum development that reflects the complexities of modern job markets while addressing pressing issues such as inequality and climate change.[34] Marwala's concept of disruptive technologies underscores the immediate socio-economic ramifications of such integration, especially in the African context, where equitable access and ethical considerations must be considered.[35] These technologies have already permeated the workspace; hence, it is pivotal that they be used ethically to preserve academic rigor while intentionally enhancing the educational outlook. Resultantly, *Parker v Forsyth NO and Others* addresses the growing challenge posed by artificial intelligence in legal practice and underscores legal practitioners' ethical obligations to ensure the accuracy of legal authorities presented to courts. The court faced a situation in which attorneys relied on legal authorities generated by ChatGPT that did not exist. The court held that legal practitioners cannot unquestioningly rely on AI-generated research and must independently verify all authorities before doing so. Although the court found no deliberate intention to mislead, it criticised the attorneys for their carelessness and emphasised that professional competence requires independent legal verification.[36]

The central argument emerging from both cases is that technological innovation cannot replace professional judgment. While AI may assist legal research, the responsibility for accuracy, integrity, and compliance with ethical duties remains firmly with legal practitioners. Together, these cases establish that the misuse of AI threatens the administration of justice and that courts will increasingly hold practitioners accountable for presenting fictitious, misleading, or unverified legal authorities. This reflects a broader judicial commitment to safeguarding the integrity of the legal profession and maintaining public confidence in the justice system.

Finally, this framework stresses the importance of aligning educational practices with workforce readiness to ensure that current labour forces are prepared for the evolving landscape. It highlights the need for ongoing professional development to keep pace with technological advancements.

METHODOLOGY

This paper adopted a doctrinal approach to explore and engage with the existing literature on disruptive technologies and their impact on teaching and learning in the twenty-first century. By focusing on a rich array of esteemed scholarly works, insightful articles, and comprehensive reports, the analysis sought to illustrate how to navigate the challenges of digital teaching and learning competencies.[37] Technologies can enhance pedagogies in education. The term "doctrinal approach" in this context refers to a method of analysis and interpretation that emphasizes established educational theories, legal frameworks, and pedagogical principles for integrating disruptive technologies. This study engaged in a detailed examination of relevant literature, including educational statutes, case studies, and

[31] A., Oke and F. A. P. Fernandes, " Innovations in Teaching and Learning: Exploring the Perceptions of the Education Sector on the 4th Industrial Revolution (4IR).," *Journal of Open Innovation: Technology, Market, and Complexity* 6, no. 2 (2020).
[32] Lizette Wessels, "How South African Universities Can Contribute to Preparing the Future Workforce for the Fourth Industrial Revolution" (Stellenbosch University, 2020).
[33] Yusuf, Walters, and Sailin, "Restructuring Educational Institutions for Growth in the Fourth Industrial Revolution (4IR): A Systematic Review."
[34] Penprase, "The Fourth Industrial Revolution and Higher Education."
[35] Marwala, "UJ's Prof Tshilidzi Marwala Stresses the Need to Invest in Human Capital to Build 4IR Infrastructure."
[36] *Parker v Forsyth NO and Others* (1585/20) [2023] ZAGPRD 1 (29 June 2023).
[37] T., Nyathi and R. M. Joseph, " Empowering South African Educators: Navigating the Challenges of Digital Teaching and Learning Competencies," *SA Journal of Human Resource Management* 22 (2024): 2591.

technological doctrines, to derive informed conclusions and recommendations. Through this approach, the paper seeks to bring clarity and precision in the discourse surrounding the role of disruptive technologies in modern education. By systematically analysing the intersection of technology and pedagogy, this study provides foundational insights into how innovative practices can reshape teaching and learning experiences in contemporary classrooms and the workplace.

DISCUSSION

Benyera discloses that numerous individuals have raised doubts about whether the 4IR constitutes a challenge or a remedy.[38] While the African continent continues to face challenges related to decolonization to eliminate the negative impacts of apartheid, the shift towards digital systems seems to be a formidable obstacle, particularly considering the evident disparities and historical legacies. Nonetheless, despite our apprehensions and the hurdles we encounter as developing and formerly colonized nations, technology and systems are advancing. It is essential to highlight that the South African government, like other nations on the African continent, has been striving to formulate and execute a strategic plan aimed at advancing the country towards its social and economic goals while also ensuring global competitiveness, inclusivity in the shared economy, and being driven by individuals capable of leveraging the Fourth Industrial Revolution.[39]

It is fair to state that innovation, globalization, and technology are transforming society and the workplace. Nevertheless, the effect of this transformation on education remains ambiguous, particularly for the most disadvantaged individuals who lack awareness of contemporary technological advancements. The swiftly evolving 4IR is intensifying the challenges emerging in society and accelerating their escalation. These challenges include conflicts in Ukraine and Russia, climate change, social unrest, economic uncertainty, and more. Such issues generate significant social anxiety, considerable ambiguity, and substantial volatility. This situation is mirrored in the realms of teaching and learning, where numerous changes have occurred recently, including the decolonization of the curriculum and the current acceleration of the 4IR. This environment fosters fear. Furthermore, the 4IR reveals inconsistencies and contradictions. On one hand, the 4IR promotes individualized, tailored, learner-active, and learner-centred educational approaches.[40]

To tackle these inconsistencies and apprehensions, Marr advocates the importance of ongoing education, emphasizing that continuous upgrading is essential for achieving high levels of skill and competitiveness in the 4IR.[41] This perspective needs to be reinforced to enhance teaching and learning, thereby alleviating the insecurities that appear to affect older educators and students.[42] Jackson advocates a pedagogy of confidence, inspires high intellectual performance, and thwarts insecure, threatened learning through technology.[43]

Different generations' perspectives on technology and talents.

Schwab indicates that the Fourth Industrial Revolution necessitates a transformation across education, gender, and employment to enhance talent diversity, underscoring the need to "accelerate workforce reskilling" during this period of change.[44] The expansion of the internet and digital tools should promote students' well-being during their university experience. It is expected to improve student learning and, more significantly, address societal issues. Likewise, these technologies should convert information into knowledge; therefore, students require cross-disciplinary skills. Sekiyama adds:

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[38] E. Benyera, *The Fourth Industrial Revolution and the Recolonisation of Africa: The Coloniality of Data*, 1st Edition (Routledge Contemporary Africa, 2022).

[39] Department of Communications and Digital Technologies, "Gazette Notice 591 of 2020 ," accessed May 18, 2026, https://www.gov.za/documents/report-presidential-commission-4th-industrial-revolution-23-oct-2020-0000.

[40] B. Xing, L. Xing, and T. Xing, "Adopt Fast, Adapt Quick: Adaptive Approaches in the South African Context," in *Higher Education in the Era of the 4th Industrial Revolution* , ed. N. Gleason (Palgrave Macmillan, 2018), 171–206.

[41] B. Marr, *Eight Things Every School Must Do to Prepare for the Fourth Industrial Revolution* (Forbes, 2019).

[42] Y. Jackson, *The Pedagogy of Confidence: Inspiring High Intellectual Performance in Urban Schools* (Teachers College Press, 2015).

[43] Schwab, " The Fourth Industrial Revolution."

[44] Schwab, " The Fourth Industrial Revolution."

> Universities are required to provide graduates with "cross-skills," encompassing non-cognitive abilities such as communication, translating technology into practice, empathy, and critical thinking.[45]

However, the emergence and acceleration of technology are significant concerns of social injustice, first for the Luddites and the aging and older students. Second, those left behind in the technology transformation worry about losing their jobs. Thompson and Mayhorn describe this as technostress.[46] Many employers may look for loopholes and employ unfair dismissal tactics, such as incapacity. Yang argues that these social changes must be treated with sensitivity; however, he notes that they are not discussed in detail to calm people's worries.[47] This author agrees with this assertion, simply because while people think there is an attitude and/or inability in some older generation, it may be because there is no transparency or a lack of upskilling of employees and older students. When there is little or no human capital development, worries and uncertainty prevail. Yang asserts, "In this era of transformation, there is insufficient dialogue linking the challenges and opportunities presented by technological advancements, the changes in human resources due to an aging population, and the significance of adult and continuing education in retaining older workers within the labour market."[48] Essentially, there is a strong need for a clearer link between the technology the opportunity offers and the challenges that must be addressed to address concerns. Disruptive technologies are transforming traditional pedagogical approaches into productive, high-quality classroom experiences that encourage interaction, provide opportunities for self-expression, and promote the development of critical skills. This shift rejects the predominance of 'face-to-face' instruction, a conventional teaching and learning methodology. The competitive environment drives learning. Biesta contends that this perspective on learning marginalizes teaching and educators, relies on an input-output framework, and diverts the pedagogical emphasis from the intricacies of knowledge and skill transfer and acquisition.

The 4IR creates fundamental conditions that significantly influence the teaching, research, and economic contributions of our institutions, as well as their impact on employment and society. Kupe asserts that this requires a strategic approach to leverage and reposition universities effectively, enabling the maximization of roles in reshaping the future of South Africa and the related development and employment environment. [49] This extraordinary phenomenon has triggered substantial transformations in individuals' everyday lives, particularly within the education sector; thus, these technologies are indeed disruptive. Moreover, these technological innovations have emerged as the primary source of apprehension about change among educators and learners from older generations. Given this understanding, it is crucial that, while all HEIs focus on enhancing their infrastructure to achieve positive outcomes, authorities integrate learning with a sense of humanity. Education is a basic human right, as is the development of human capital.

Harnessing Traditional Pedagogies in Teaching and Learning for the Fourth Industrial Revolution.

The Constitution ensures that every individual has the right to education. All South Africans must acknowledge this right, regardless of their socio-economic challenges and the historical impacts of apartheid. Education serves as a fundamental catalyst for contemporary development. As a result, educators hold a vital position in molding both the young and the old into citizens who can effectively

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[45] T. Sekiyama, "The Impact of the Fourth Industrial Revolution on Student Mobility from the Perspective of Education Economics," *Creative Education* 11, no. 04 (2020): 435.

[46] L. F. Thompson and C. B. Mayhorn, " Aging Workers and Technology," in *Oxford Handbook of Work and Aging*, ed. J.W. Hedge and W. C. Borman (New York: Oxford University Press, 2012). Anxiety, tension, or distress caused when a person is overwhelmed by new technology. It occurs when they are unable to adapt and learn to use technology in a healthy, productive way

[47] Chaewon Yang, "The Fourth Industrial Revolution, Aging Workers, Older Learners, and Lifelong Learning," Adult Education Research Conference, 2019, https://newprairiepress.org/aerc/2019/papers/35.

[48] Yang, "The Fourth Industrial Revolution, Aging Workers, Older Learners, and Lifelong Learning."

[49] T. Kupe, "Universities Are Key to 4IR Employment," *Mail & Guardian*, July 19, 2019, https://mg.co.za/article/2019-07-19-00-universities-are-key-to-4ir-employment/.

contribute to the economy.[50] Sulaiman has given his approval. He reiterates that educators serve as role models in cultivating skilled professionals who advance the national economy.[51] Siyam agrees and proposes that all elements impacting all stakeholders be considered to enhance the future in this age of the Fourth Industrial Revolution.[52] In this age of advanced technology, conventional face-to-face education must adapt and respond to the current requirements of employment and business. This evolution involves both educators and learners, as the philosophy of Ubuntu has traditionally guided South Africans in their teaching and learning practices. In transitioning fully into the digital era, it is anticipated that the core values of education that promote interdependence will be retained. Govender posits that future-readiness is essential across all educational systems if the younger generation is to thrive in this period marked by the integration of disruptive technologies.[53] She believes that, given the rapid evolution of knowledge and skill sets, there is an urgent requirement for critical foresight to tackle the challenges that will inevitably arise with the Fourth Industrial Revolution.

In the realm of education, where traditional in-person instruction was prevalent, the abrupt emergence of COVID-19 necessitated a significant transition to enhance the utilization of technology. Takalani contends that this substantial deviation from conventional methods allows students to engage with the course material at their convenience, rather than being restricted to scheduled class sessions.[54] Similarly, Kupe contends that one of the responsibilities of academic institutions is to contribute not only to global socio-economic development but also to advancing South Africa's technology. He states, "there is a necessity to support teaching and learning strategies that cultivate well-educated, socially aware citizens who possess the skills required for their time, specifically in the context of the 4IR."[55] World Economic Forum (WEF) President Klaus Schwab predicted the 4IR formulations:

> We are on the verge of a technological revolution that will fundamentally change how we live, work, and interact with one another. This transformation will be unprecedented in its scale, scope, and complexity, surpassing anything humanity has encountered before. Although the exact course of this evolution remains uncertain, one fact is evident: our response must be holistic and inclusive, engaging all participants in the global community, including the public and private sectors, academia, and civil society.[56]

The COVID-19 pandemic's hard lockdowns presented no choice, but Schwab's predictions have become a current reality. Frankly, there is no going back to pre-COVID life; it's about embracing the present and the future. As work evolves faster across sectors, including Higher Education, locations, activities, and skill requirements, many workers will need assistance with adjusting. AI is here to stay; workers must embrace and complement it by upskilling and reskilling themselves with the latest technology. As Manyika et al. assert, "unlocking the potential of the Internet of Things, we can thrive in this digital era by leveraging our conventional teaching methods."[57]

Impact of Intellectual Pursuits at the age of 4IR: Disruptions or Conformity?

Historically, traditional pedagogical methods for teaching and learning have largely excluded the intensive technologies that have only recently proven effective. These educational practices incorporated Africanism by contextualizing and interpreting teaching within an African framework;

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[50] Ong Choon Hee et al., "Factors Influencing Teacher Job Satisfaction in Malaysia," *International Journal of Academic Research in Business and Social Sciences* 9, no. 1 (February 4, 2019), https://doi.org/10.6007/IJARBSS/v9-i1/5628.

[51] T. Sulaiman, S.N. Hamzah, and S.S.S. Rahim, "The Relationship between Readiness and Teachers' Competency towards Creativity in Teaching among Trainee Teachers," *International Journal of Social Science and Humanity* 7 (2017): 10–13.

[52] Nur Siyam, "Factors Impacting Special Education Teachers' Acceptance and Actual Use of Technology," *.." Education and Information Technologies* 24, no. 3 (2019): 2035-2057.

[53] M. Sikhakhane, S. Govender, and M.C. Maphalala, "The Extent of South African Schools' Preparedness to Counteract 4IR Challenges: Learners' Perspectives," *Journal of E-Learning and Knowledge Society* 17, no. 1 (2012): 1–9.

[54] Tshisikhawe Takalani, "Barriers to E-Learning amongst Postgraduate Black Students in Higher Education in South Africa" (Stellenbosch University, 2008).

[55] Kupe, "Universities Are Key to 4IR Employment."

[56] Klaus Schwab, "The Fourth Industrial Revolution: What It Means, How to Respond," Technological Innovation, January 14, 2016, https://www.weforum.org/stories/technological-innovation/the-fourth-industrial-revolution-what-it-means-and-how-to-respond.

[57] James Manyika et al., "Unlocking the Potential of the Internet of Things," McKinsey Global Institute, June 1, 2015, https://www.mckinsey.com/capabilities/tech-and-ai/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world.

nevertheless, South Africa, like other African nations, has struggled with the remnants of colonialism, and its infrastructure has not been as technologically advanced as it is becoming in response to the demands of the Fourth Industrial Revolution. In summary, educational practices have consistently been shaped and guided by demographic factors, including reactions to the methodologies that have been effective. Educators fulfilled their academic responsibilities through in-person instruction, evaluation, and supervision, among other tasks. However, technology intensification has been somewhat interfering with and breaking that chain, leading to rapid, significant change. Another worrying trend with these technologies is a decline in human engagement in mentoring, which may impede skill transfer.

Based on these arguments, technological advancement may affect students' intellectual engagement at both the undergraduate and postgraduate levels if transitions are not carefully managed. Technology makes things faster, which ought to be a boon for bulk work production.

However, the greatest worry is that technology might undermine intellectual engagement and dialogue; the opposite is anticipated. To foster robust scholarly engagement among our students, who are now exposed to widespread technology use, Higher Education Institutions must provide robust mechanisms to enhance students' experiences and encourage lifelong learning. Although many individuals express doubts about the quality of education considering technological advancements and the industrial revolution, the younger generation is well-adapted to the rapid access to vast amounts of information. Sekiyama expresses that "the WEF, a primary advocate for the Fourth Industrial Revolution, asserts that educational frameworks must align with the necessity for lifelong learning to assist individuals in adapting to technological and societal transformations." [58] Although these advancements are thrilling, students must be motivated to prioritize continuous learning.

Effects of digitalisation on teachers and Students on academic performance.

The current technological landscape has sparked anxiety about academic achievement, particularly in previously colonized and rural educational institutions, due to socio-economic disparities. While these technological advancements must occur due to demand, scholars argue that these processes must be central to student learning and prepare students for the future.[59] Consequently, apprehensions regarding the preparedness of the South African education system for the Fourth Industrial Revolution have escalated, especially considering the abrupt onset of COVID-19 in March 2020. Accordingly, Mhlanga and Moloi contend that the infrastructure associated with the Fourth Industrial Revolution has introduced substantial changes and created challenges that have affected most public schools in South Africa, particularly those in townships and rural areas.[60] These challenges have resulted in inadequate performance and negative consequences. Mhlanga and Moloi assert that this is expected to be a common situation across the African continent, attributed to challenges with infrastructure, the availability of broadband, and the costs of data. They suggest a blended learning approach and argue that, for it to be successful, it is critical to have a policy platform that addresses inequality, skills deficits, and the vast digital divide.[61] Butler-Adam acknowledges: "The 4IR has numerous implications for various aspects of life. Consequently, it offers both opportunities and challenges for the education system." Schwab noted that "in terms of its magnitude, breadth, and intricacy, the transformation will be unprecedented in human history."[62] This has emerged, and it is changing lives.

Strengthening Education and Training with the Fourth Industrial Revolution.

The expansion of moral and intellectual foundations necessitates closing all gaps to enhance and elevate the quality of teaching and learning in higher education, thereby equipping graduates to be fully employable and thoroughly empowered for the digital era. Nwosu et al. emphasize the need for

[58] Sekiyama, "The Impact of the Fourth Industrial Revolution on Student Mobility from the Perspective of Education Economics."
[59] Jeanette La Fleur and Reuben Dlamini, "Towards Learner-Centric Pedagogies: Technology-Enhanced Teaching and Learning in the 21st Century Classroom," *Journal of Education*, no. 88 (October 27, 2022): 1–17, https://doi.org/10.17159/2520-9868/i88a01.
[60] David Mhlanga and Tankiso Moloi, "COVID-19 and the Digital Transformation of Education: What Are We Learning on 4IR in South Africa?," *Education Sciences* 10, no. 7 (July 9, 2020): 180, https://doi.org/10.3390/educsci10070180.
[61] Mhlanga and Moloi, "COVID-19 and the Digital Transformation of Education: What Are We Learning on 4IR in South Africa?"
[62] Schwab, "The Fourth Industrial Revolution: What It Means, How to Respond."

educational institutions to adopt advances in digital technology and remain aligned with the requirements of the 21st century. Furthermore, it is expected that e-learning will supplant conventional classroom teaching in higher education.[63] In any case, for HEIs to prosper in the modern era, it is essential to implement rigorous measures that guarantee the integrity of education is upheld during both formative and summative assessments. As students acquire critical and advanced skills necessary for managing technology and enhancing their competitiveness in the job market, there is a risk that they may exploit loopholes in the system, thereby endangering and undermining throughput standards. Reliable digital monitoring tools should be employed. Gibbs observes that the global landscape and the markets demanding essential digital skills have changed significantly due to advances in digital technology. King concurs that "one of the most crucial elements of technology in education is its capacity to equalize opportunities for students. Nevertheless, King believes this can only be achieved through full citizenship.[64]

Gray asserts, "Change will not pause for us: business leaders, educators, and governments must take the initiative in upskilling and retraining individuals so that all can reap the benefits of the Fourth Industrial Revolution."[65] Horch also suggests that students must possess a profound understanding of how to relate, practice, and disseminate various interpretations of expanded frameworks, as well as their implications.[66] This understanding can foster collaborations across different subjects to create 'something' that connects with the real world, leading us to an important conclusion: students must engage in project-based work, which will require them to collaborate with their peers, instructors, and the external environment. Furthermore, referencing Hillier, Aboginjie emphasized that 'universities, in general, serve as a vehicle for economic success, which is facilitated by digitization, thereby increasing students' access to higher education.[67] Al-Rodhan stated that disruptive revolutions also transform the operational dynamics of businesses, create new marketplaces, and clearly define new products. Consequently, the World Economic Forum in Davos recognized the Fourth Industrial Revolution as emerging in the 21st century, a groundbreaking era characterized by the ubiquitous mobile internet, affordable, compact, and resilient sensors, and the integration of artificial intelligence into education.[68] Yun describes 4IR as a significant transformation that occurs when information technology proliferates across all sectors, including primary, secondary, and higher education institutions; thus, it is a result of the swift advancement of information technology.[69]

The 4IR has ushered in a profound transformation across multiple facets of society and the global economy, presenting both opportunities and challenges. On one hand, technological advancements—ranging from artificial intelligence to robotics—serve as formidable catalysts for growth and innovation, promising enhanced productivity and improved quality of life. These innovations are paving the way for new markets and previously unimaginable efficiencies. However, with this transformative shift comes a wave of uncertainty as individuals grapple with the potential consequences of rapid technological change. Concerns about job displacement in sectors vulnerable to automation highlight the urgent need for proactive measures to mitigate socio-economic challenges.

Moreover, the rise of technostress adds a layer of complexity, as many workers struggle to adapt to new technologies while managing the pressures they entail. This underscores the importance of fostering workforce resilience through collaborative strategies among policymakers, educators, and business leaders. Investments in retraining and upskilling initiatives are critical to empowering employees and ensuring they remain competitive in a continually evolving job market. The skill sets

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[63] Sakhiseni Joseph Yende, "A Transition towards the Fourth Industrial Revolution (4IR) in the South African Education Sector: A Perspective from Rural-Based Higher Education," *African Journal of Development Studies* 11, no. 2 (2021): 55.

[64] Digital Citizenship can be defined as the safe, ethical responsible, and informed use of technology. This concept- encompasses a range of skills and literacies that can include internet safety, privacy, and security. Cyberbullying, online reputation management, communication skills, information literacy, and creative credit copyright. These can be termed as non-cognitive skills.

[65] Gray A, "The 10 Skills You Need to Thrive in the Fourth Industrial Revolution," *World Economic Forum*, 2016.

[66] D. Horch, "Promise or Peril: Decoding the Future of Work," 2017, https://www.weforum.org/agenda/2017/01/promise-or-peril-decoding-the-future-of-work/.

[67] Ademilade Aboginije, "Harnessing Fourth Industrial Revolution (4IR) for Improving Poor Universities Infrastructure in Developing Countries-A Review," *10th IEOM Conference*, 2020.

[68] Schwab, "The Fourth Industrial Revolution: What It Means, How to Respond."

[69] JinHyo Joseph Yun, *Business Model Design Compass* (Springer, 2017).

required for success are shifting, with an increasing emphasis on digital literacy, critical thinking, and creativity poised to replace more traditional competencies. It is therefore essential to explore innovative pedagogical approaches that cater to the unique needs of 21st-century learners. Equally important is addressing the digital divide that persists across generations. At the same time, younger individuals might quickly adapt to new technologies, but older populations often face barriers due to limited resources and training opportunities. Bridging this gap is crucial to fostering an inclusive environment where all members of society can take advantage of the opportunities the Fourth Industrial Revolution offers.

Ultimately, while the 4IR heralds significant prospects for growth and development, it also necessitates careful navigation of the associated risks. Achieving a balance between reaping the benefits of technological advancements and protecting individuals and communities requires a concerted effort from all sectors of society. By prioritizing education, skills development, and inclusivity, stakeholders can shape a future that not only embraces the transformative power of technology but also safeguards against its potential pitfalls. Together, a resilient, adaptable workforce must be built, ready to thrive in this new era.

RECOMMENDATIONS

The following strategies are recommended to enhance the educational ecosystem to build future-ready academics and graduates in the era of high use of technology:

1. Enhance Digital Infrastructure in Rural HEIs

Invest significantly in upgrading and expanding digital infrastructure in rural HEIs to ensure reliable internet access and modern technological resources. This includes equipping campuses with high-speed internet, providing updated hardware and software, and creating digital learning spaces that foster collaboration and innovation.

2. Implement Comprehensive AI and Digital Literacy Training

Develop a robust curriculum that includes not only foundational digital literacy skills but also advanced training in AI and data analytics. This program should be integrated across all disciplines and offered in various formats, including online courses and workshops, to ensure that all students, regardless of their major, are prepared for a tech-driven job market.

3. Promote Flexible and Blended Learning Models

Encourage the adoption of blended learning models that combine online and in-person instruction. This approach provides flexibility, caters to diverse learning preferences, and uses technology to enhance educational experiences. Furthermore, institutions should facilitate educator training to ensure effective implementation of these models.

4. Address Digital Inequality Proactively

Create targeted initiatives to close the digital divide by providing resources and support to marginalised and underrepresented communities. This could include scholarships for technology purchases, community workshops, and partnerships with local organisations to improve access to digital tools and training.

5. Develop Comprehensive Mental Health Support for Technostress

Establish mental health support systems specifically designed to combat technostress. This can include counselling services, stress management workshops, and resources for coping strategies. Institutions should also promote a culture that emphasizes work-life balance and mental well-being in digital learning environments.

6. Encourage Interdisciplinary Collaboration
Foster partnerships between different academic departments to create interdisciplinary programs that prepare students for multifaceted challenges presented by the Fourth Industrial Revolution. Such collaboration can lead to innovative problem-solving approaches and equip students with a broader skill set.

7. Cultivate Industry Partnerships for Real-World Experience
Forge strong collaborations with industry stakeholders to provide students with opportunities for internships, mentorships, and project-based learning experiences. Engaging with real-world challenges will allow students to apply their skills in practical settings and enhance their employability.

8. Continuous Evaluation and Adaptation of Curriculum
Regularly review and adapt the curriculum to keep pace with evolving technological landscapes and job market demands. Incorporate feedback from students, alumni, and industry experts to ensure that educational offerings are relevant, forward-thinking, and effectively prepare graduates for future challenges.

CONCLUSION

This study has rigorously examined the impact of rapid technological advancements, particularly those associated with the Fourth Industrial Revolution and Artificial Intelligence, on the educational landscape. The findings reveal a pronounced divide between younger and older educators in their acceptance and adaptation to these transformative technologies. Younger educators tend to be more open to innovation, while older educators often express apprehension about the potential erosion of intellectual discourse quality. Interestingly, traditional teaching methods, though perceived as slower, have demonstrated a capacity to foster deeper understanding among students. In contrast, modern digital tools, while beneficial in some contexts, may inadvertently encourage superficial engagement with the material. This research enriches the existing body of scholarship by linking emerging technologies directly to educational practices, emphasizing the crucial need for sustained intellectual engagement in our increasingly digital age. Furthermore, it calls for a balanced pedagogical approach that harmoniously integrates technology with traditional teaching methods, enhancing the educational experience without compromising academic integrity. The implications for higher education policy and pedagogy are considerable. Institutions must prioritize fostering constructive dialogue between technology and instructional practices, ensuring educators receive adequate training to navigate this evolving landscape effectively. By championing strategies that carefully balance technological integration with the preservation of scholarly engagement, colleges and universities can better prepare both educators and students to thrive in an increasingly competitive global environment. This proactive stance will not only enhance educational outcomes but also ensure the continued relevance of intellectual rigor in our rapidly changing world. As technology in education continues to grow rapidly, rethinking educators' roles to transform the education space includes innovative approaches to digitization.

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