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Re-Engineering Curriculum for Proactive Response to the Fourth Industrial Revolution in Nigeria

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Abstract
What was once science fiction is now a reality. The fourth industrial revolution (4IR) has ushered the world into industry 4.0, where artificial intelligence, internet of things, 3D printing, biotechnology, nanotechnology are driving economic and social innovations. Countries at the centre of innovation are enhancing productivity and driving technological advances. This paper explores how curriculum in Nigerian education could be reengineered to respond to the myriad of changes occasioned by the 4IR. The theoretical paper considered higher education and the 4IR, reengineering curriculum, curriculum and the 4IR as well as policy recommendations for the federal government. The paper concludes that the 4IR presents Nigeria with an opportunity to reform its educational system, beginning with the reengineering of its curriculum in the wake of the 4IR. Countries that will make the most of these opportunities are those with responsive curriculum and willingness to implement the curriculum.

Keywords: curriculum responsiveness, higher education, Fourth Industrial Revolution (4IR), science and engineering curriculum, industry 4.0

Introduction

The world is in the midst of a transformational change. The changes are rapid- economic, social and technological transformations. These transformations and in particular, the impact of the fourth industrial revolution driven by digital technologies, have increased demand for higher order skills, competencies and knowledge. According to Ndung'u and Landry(2020), the Fourth Industrial Revolution (4IR)- characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilization of new technologies such as artificial intelligence (AI), cloud computing, robotics, 3D printing, the Internet of Things, and advanced wireless technologies, among others—has ushered in a new era of economic disruption with uncertain socio-economic consequences for Africa.

As Spöttl and Windelband (2021) stated, the 4th Industrial revolution is one of the most widely discussed technological and socioeconomic developments of the modern world with a deep impact on the agenda of education policies and strategies. While there is rather widespread agreement that the 4th Industrial revolution will have a substantial impact on education and training, still comparatively little attention is being paid to the exploration of the current and potential implications of the 4th industrial revolution for the key processes of education and training, and, in particular, for their curricular development.

The implications of the AI revolution for business, industry and daily life remain to some extent in the realm of speculation, but have nevertheless been discussed widely. The most obvious matters are those that relate to the ways in which the nature of work and the job market are changing – and will continue to change at an increasing pace. Apart from the nature of work, there is considerable disagreement as to whether or not the Fourth Industrial Revolution will create more employment or result in the loss of work opportunities.

Just what it might mean for education has had less attention, although the implications are extensive – both in terms of what universities can (or should) contribute to the advance of AI and its applications and how curricula and learning will need to change. The challenge of responding to the myriad of changes occasioned by the drivers of industry 4.0 is not the same for all countries. For least developed countries, like Nigeria, where training institutions and skills policies are not fully developed, this represents a particularly difficult process. In these countries, high levels of informality, or a lack of legal framework to enforce certain training standards usually characterizes training systems. For them, a revision of the curriculum of training systems and the skills delivered through these establishments is essential for adaptation.

Higher Education and the 4IR

Education in the 4IR (HE 4.0) is a complex, dialectical, and exciting opportunity that can potentially transform society for the better. The 4IR has different implications for many other sectors of life. As such, it holds both opportunities and challenges for education. Through the use of different components of the 4IR, such as IoT, 3D printing, quantum computing, and AI, the education sector could be transformed completely to offer solutions to new challenges.

The educational and institutional implication that arises from the application of the fourth industrial revolution is conceptualized in two ways. Firstly, researchers in relevant disciplines face the challenge of making industry 4.0 and its associated technologies increasingly more sophisticated and useful, not just in manufacturing or planning but also in the direct service of society. The 4IR while primarily being explored from a technical point of view has strong social implications. Increasing digitization, however, will not only have an enormous impact on machines, factories and business models, it will fundamentally redefine societies and its relations. 4IR is also a driver of social innovation and should be applied as such by researchers. The concept of social innovation signifies a novel solution to societal challenges that is more effective, sustainable and more equitable than existing practices (Phills, Deiglmeier & Miller, 2008). With Industry 4.0, this becomes the goal, the diffusion and spread of the 4IR is expected to be distributed amongst as many people across societies as possible. Given the diffusion of the 4IR, Marwala (2018) pointed out that the work of scientists, policymakers, social workers, educationists and many others whose duty of care it is to aim for the achievement of the 17 Sustainable Development Goals can all benefit from sophisticated AI applications. Whether the goal is quality education, decent work, climate action, affordable and clean energy or sustainable cities, there are already AI options of value and importance, yet more can and should be developed (Marwala, 2018).

The second implication as opined by Butler-Adam (2018) is closely related to curricula, teaching and learning – rather than about robotic tutors. To succeed as a member of society, and as an employee, in the era of the Fourth Industrial Revolution, numeracy, literacy and an understanding of how the world operates are all essential. Students studying the basic and applied sciences need also to understand the political and social natures of the world in which they live. For the same reasons, students who study the humanities and social sciences need to understand at least the foundations on which AI is based and operates. This is a different kind of decolonisation of curricula – even requiring, perhaps, some of the elements of the kind of education provided (at least at first-year level) by liberal arts colleges.

The second implication has further requirements: people must have the skills required to implement, manage and work with the new technology, and with one another. And, not least, to be problem solvers, to be adaptable, and to be able to express themselves in both the written and spoken word – and to make the kinds of ethical and moral decisions that are not ever likely to become successful elements of AI. This challenge is one to which educators will have to rise (Butler-Adam, 2018).

Conceptualization of the Curriculum

Conceptualizations of curriculum have evolved over time, driven mainly by contextual factors and by intellectual perspectives. The new concept of curriculum is broad based, consisting of the totality of experience that students receive through the manifold activities that goes on in the school, in classroom, library, laboratory, workshop , social settings and in the numerous contacts between the teachers and students. Marope (2017) classifies the curriculum concept into two understandings. First, curriculum is a document, a codified form of educational intentions. Second, curriculum is the totality of (planned) activities influencing the teaching and training process. Curriculum in education and training is viewed as the structural basis for the organization and implementation of education and training as well as for achieving the intended learning outcomes. The curriculum defines:

1. Objectives, outcomes and contents of education and training,
2. Processes and activities necessary for their achievement and implementation (organizational forms, strategies, models and methods of teaching and learning),

3. Ways of assessment and criteria for the assessment of achievement.

A sound curriculum is the basis for remodeling education in Nigeria in the light of sweeping fourth industrial technological changes. The nature and practice of education needs to change in accordance with global/industry demands. The demands today are for smart and articulate workers who possess higher-order skills, are creative and can solve problems(Caleb, 2019).The curriculum is a microcosm of the wider society outside school. It constitutes what a society elects to remember about its past, what it believes about its present, and what it hopes and desires for the future. It is both retrospective and prospective, and it encourages learners to look back at the past and look forward to the future in particular ways. The design of a curriculum shapes the minds and mentalities of young people and encourages them to understand and act in society in particular approved ways. As a result, the local detail of all curriculum reform needs to be understood and grounded in long waves of societal change that are pursued from the past into the present and from there projected into the future (Ryan, 2010).

Current conceptualizations of the curriculum have been on how the curriculum might be redesigned and reformed in the perceived context of the digital age. This is hinged on the premise of constantly changing technologies, accompanied by complex, long waves of social and technological change in the economic, political, and cultural dimensions of existence (Caleb & Israel, 2021).

The identified drivers of curriculum change as identified by Bughin et al. (2018) is the associated technologies of the 4IR.

Whether people are prepared for it or not, much of the future economy will rely on increased automation and machine learning. Advanced technological skills in the new workforce require a deep understanding of how machines use data and pattern recognition to improve the algorithms they use to solve problems. The education system can address these new areas by teaching the building blocks of computational thinking, the fundamentals of artificial intelligence, and the discipline of computer science, including coding. It is not enough to understand what machines can do for humans or what jobs they may replace. Students need to understand how machines work and how to program them to solve the problems that matter. These new fundamental competencies can no longer be ignored or made available to only a privileged few (South, et al., 2020).A sweeping curriculum reforms in Nigeria must imbibe machine learning for all science related disciplines. The key to meeting the challenges of the 4IR is a responsive curriculum.

Curriculum responsiveness is the ability of curricula taught in schools or universities to address student needs as well as societal circumstances (Moll, 2004). Curriculum to achieve responsiveness, goes beyond simply meeting the needs of students. Fomunyam(2020) averred that it has to consider the effects it will have on the well-being of society in general. Thus, curriculum responsiveness implies the ability of the African curriculum to become responsive to the demands

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of the Fourth Industrial Revolution. The 4IR. Though at its early stages, has been disruptive and quite penetrating. The impacts have been far-reaching- from introducing new occupations, to ushering new ways of doing old things, skills and innovation are fuelling new work patterns in industries. This makes it imperative that the African curriculum respond to the changes, in preparation for what lies ahead for students in Africa. For African higher education to achieve full responsiveness, it has to become economically, culturally, disciplinarily, and learning responsive (Fomunyam, 2020).

Economic responsiveness to a curriculum is concerned with the ability of a curriculum to train skilled and capable professionals in the various sectors of the economy (Fomunyam & Teferra, 2017). Thus, a curriculum is economically responsive to this era when the curriculum has the ability to produce graduates able to cope with the digitization of the organisational workspace. An economically responsive curriculum will groom students that have the skills and know-how to create, develop, and nurture long-lasting solutions to organisational problems in this era of globalization. An economically responsive curriculum will therefore produce students that will find solutions not to only current organisational problems, but also to future organisational problems. The 4IR will comprise organisations preferring tech-savvy graduates to non-tech-savvy graduates.

4IR and Re-Engineering of Curriculum

The world is grappling with the diffusion and spread of a technological revolution that is fundamentally altering not just the nature of work and occupations, but social relations as well. The fourth industrial revolution (4IR) is multidimensional-technological, economic, social, cultural, political and geopolitical. Disruptive in nature, dynamic in unfolding, the fourth industrial revolution, 4IR or industry 4.0, is ushering the world into an exciting unknown. Technology that was once confined to science fiction is now an integral part of everyday life. The 4IR is characterized by a range of new technologies that are blending the physical, digital and biological worlds(Usoro, Caleb & Ojobah, 2021) The Fourth Industrial Revolution is characterized by the convergence of breakthrough technologies such as advanced robotics, artificial intelligence, the internet of things, virtual and augmented reality, biotechnology and genomics as well as advanced manufacturing. These are transforming productions processes and business models across different industries (Schwab, 2016). The Inclusive Growth Forum (2015) defines the 4IR ‘as the advent of “cyber-physical systems (CPS)” involving entirely new capabilities for people and machines’. Educational institutions have to adapt their technological curricula to prepare students with skills for the changing technological environment. The purpose of the curriculum aims to bridge the expectations of the labour market and the competencies of graduates to ensure employability.

Iscoop (2017) explain that, the 4IR and its associated technologies are CPS-based, with capacity to fuse virtual (e.g. cyber space, knowledge, information, cyber-social world, cloud…)

and physical (e.g. smart devices, sensors, actuators, computers, physical assets, including biological, customers) systems to create integrated, intelligent, and safe, high performance automation systems in different socio-economic fields. This is quite a radical change and disruptive for science and engineering disciplines. For engineering and science based disciplines, Crawley,et al. (2007) emphasized the need to have skills in a particular industry to carry out practical implementation in industrial and social contexts in addition to competencies in different industrial fields. Therefore, 4IR, though multidisciplinary, requires engineers to have competencies in a specific field of 4IR technologies.

The 4IR is characterized by artificial intelligence, Internet-of-Things, big data, biotechnology, nanotechnology, 3D printing and digital technologies cooperating with each other and with humans in integrated systems that impacts on how societies live and work. In addition to the competencies identified in this study, researchers (Hecklau, et al., 2016; National Academies of Sciences, Engineering, and Medicine, 2016; Passow & Passow, 2017) further identified key criteria of integrating knowledge across a range of industries. Thus, science and engineering training as well as all disciplines, should develop multi-functional people with personal and social competencies. They should have interdisciplinary and system knowledge, competencies of creativity and entrepreneurship, lifelong learning, be able to solve complex problems and make decisions based on big data. It is also very important that students are trained in social emotional competencies in which, they have the ability to collaborate and communicate beyond technology requirements. In addition to project management skills that will allow workers interphase with others from other fields, coordinating multiple competencies to accomplish a goal as a crucial skill for engineers. This includes demand in for the general competencies of collaboration, lifelong learning, creativity and entrepreneurship (Passow & Passow, 2017).

The fourth industrial revolution (4IR) changed the way the world operates and caused changes in the skills demanded (Al-Htaybat et al.,2018:334). In this regard, different skills will be required for current graduates to remain successful and to sustain the profession. Curricula have important effects on students' professional skills (Carter, et al., 2016). Curriculum development goes through a process, following scientific guidelines. Whatever process that is taken to develop the curriculum, often involves the designing and implementation stages. Explaining further, Lieu et al (2018) stated that the result of the first stage is a curriculum framework with identification of student learning outcomes that meet social and economic development requirements. The learning outcomes involve student competencies developed during the instructional processes, involving activities, in and outside the classroom. Curriculum frameworks as an academic plan contains a number of elements, including philosophy; learning outcomes, models; organization and structure; teaching, learning and assessment strategies; module design. These elements are appropriate to the outcomes and a set of instructional techniques and learning aids to help learners achieve the goals, and measure these intended outcomes (O'Neill, 2015). The World economic forum is advocating for countries to use new training approaches and new education curricula to develop their future workforce (WEF & Kearney, 2018). Notably, traditional system of higher education in incapable of tackling coverage the myriad of changes, skills training required for adoption of the 4IR. The traditional curricula are criticized for lacking integration of disciplines, focusing almost exclusively on theory and single subject teaching and learning (Crawley, et al., 2007). This form of information transfer according to Lieu et al (2018), does not equip students with the cognitive skills, let alone content skills, necessary for the 4IR economy. meeting the 4IR skills demands that the emphasis should be on general and professional skills, broadened instructional methodologies, interdisciplinary and transdisciplinary teaching and learning as well as research-led project-based learning needs to be integrated into higher education science and engineering pedagogy. Importantly for 4IR competencies virtual laboratory practices need to be developed, and co-curricular activities and experiential learning need to be better funded and integrated (Carter, et al., 2016; Gleason, 2018).

In the twenty-first century, with increasing systems complexity, the curriculum should be interdisciplinary and transdisciplinary(Lieu, et al, 2018). In an interdisciplinary curriculum, several disciplines are merged into a subject area and interdisciplinary connections and methods are deployed among curriculum elements (Crawley, et al., 2007; O'Neill, 2015). Transdisciplinary curriculum merges different disciplinary areas. For example, CPS education has a multidisciplinary nature drawing from several academic disciplines due to the complexity of the systems (Törngren, et al., 2015). AI, big data, IoT have an inter-disciplinary nature as well and they are sometimes combined with other disciplines to form new technology fields (Ergezer, et al., 2018; Molluzzo & Lawler, 2015; Wyatt, 2000).

In responding to the demands on the curriculum, the Massachusetts Institute of Technology (MIT) developed the Conceive - Design - Implement - Operate (CDIO) approach to teaching engineering. The CDIO is an interdisciplinary curriculum with four discipline blocks: 1) general courses that equip students with general competencies, 2) professional core and 3) specialization courses, and 4) elective courses; practicum/professional application is incorporated in professional courses to equip students with necessary competencies for their job(Lieu, et al 2018).

Policy Implications for Reengineering Curriculum in the Age of the Fourth Industrial Revolution

Evidently, there is need for radical change on how the development of 4IR technology and skills may be achieved through curricula. Curricular is best envisioned as designed to enable learning and how these skills may be appropriated for multiple uses, flexibly, and readily extrapolated to diverse, future and perhaps even unknown contexts. This is essential, as the 4IR ushers us into an exciting unknown. Hence, the following policy recommendations are made

1) For the development of industry 4.0 skills and training, the national universities commission (NUC) should apply the CDIO approach which envisions an inter- and trans-disciplinary curriculum, with a core 4IR technology major and integrate other disciplines. Developed by the MIT, the CDIO combines with co-curricula pedagogies of practical experience in problem-based learning for better developing students' general competencies.
2) Create special post-doctoral and PhD level funding mechanisms to either send students abroad or educate them in country, in order to develop high quality teacher scholars who can teach and research in these fields.
3) Universities should embed general/introduction 4IR courses in other non-engineering curricula such as vocational technical education, to equip learners with general knowledge about the 4IR for better cooperation among engineers and experts from other fields in the 4IR context.
4) It will serve the country a lot of good if they could develop a long-term policy on the 4IR. Such a policy document should encompass skills, technology, training and national objectives with measureable goals. It should cover what technologies the country would like to pursue and develop and human capacity development as well as product development strategies.

Conclusion

In conclusion, digital and advanced technologies in the 4IR have become essential tools for social and economic development as well as the material well-being of individuals in the emerging digital economy. It also presents Nigeria with an opportunity to reform its educational system, beginning with the reengineering of its curriculum in the wake of the 4IR. Countries that will make the most of these opportunities are those with responsive curriculum and willingness to implement the curriculum.

References

Al-Htaybat, K., von Alberti-Alhtaybat, L. & Alhatabat, Z. 2018. Educating digital natives for the future: accounting educators' evaluation of the accounting curriculum. *Accounting Education*, 27(4),333-357.

Bughin, J. Hazan, E., Lund, S. Dahlström, P. Wiesinger, A. & Subramaniam. A. (2018). *Skill Shift: Automation and the Future of the Workforce*. McKinsey & Company. Available at https://www.mckinsey.com/featured-insights/future-of-work/skill-shift-automation-and-the-future-of-the-workforce.

Butler-Adam, J. (2018).The Fourth Industrial Revolution and education. *South African Journal of science*, 114(5/6), Art. #a0271, 1 page. http://dx.doi.org/10.17159/ sajs.2018/a0271

Caleb, E. & Israel, E.(2021). The Fourth Industrial Technology Driven Curriculum: Drivers of Educational Reforms and Policy Implications for the Nigerian Educational System. *Babcock Unversity Journal of Education* (BUJED),8(1),16-23.

Carter, F. D., Ro, K. H., & Alcott, B. (2016). Co-Curricular Connections: The Role of Undergraduate Research Experiences in Promoting Engineering Students' Communication, Teamwork, and Leadership Skills. Research in Higher Education, 57, 363-393. https://doi.org/10.1007/s11162-015-9386-7.

Crawley, F. E., Malmqvist, J., Ostlund, S., & Brodeur, R. D. (2014). *Rethinking Engineering Education the CDIO Approach* . Springer. NY. https://doi.org/10.1007/978-3-319-05561-9

Ergezer, M., Kucharski, B., & Carpenter, A. (2018). Curriculum Design for a Multidisciplinary Embedded Artificial Intelligence Course. Proceedings of the 49th ACM Technical Symposium on Computer Science Education, 1087-1087.

Fomunyam, K. G. & Teferra, D. (2017). Curriculum responsiveness within the context of decolonisation in South African higher education. *Perspectives in Education, 35*(2), 196-207.http://dx.doi.org/10.18820/2519593X/pie.V35i2.15.

Fomunyam, K.G.(2020).Deterritorialising to Reterritorialising the Curriculum Discourse in African Higher Education in the Era of the Fourth Industrial Revolution. *International Journal of Higher Education*, 9(4),27-34.

Gleason, W. N. (Ed.) (2018). *Higher Education in the Era of the Fourth Industrial Revolution*. Forthcoming Palgrave Press. https://doi.org/10.1007/978-981-13-0194-0.

Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. (2016). Holistic Approach for Human Resource Management in Industry 4.0. *Procedia* CIRP, 54, 1-6.

Inclusive Growth Forum (2015).The Fourth Industrial Revolution Growth and Inequality. Retrieved from https://inclusivegrowthforum.org/the-fourthindustrial-revolution-economic-growth-and-inequality/, on 19/09/2019.

Iscoop (2017). Industry 4.0: The Fourth Industrial Revolution - Guide to Industrie 4.0. retrieved from https://www.i-scoop.eu/industry-4-0/.

Lieu, T. T. B., Duc,N. H., Gleason, N. W., Hai, D. T., & Tam, N. D. (2018). Approaches in Developing Undergraduate IT Engineering Curriculum for the Fourth Industrial Revolution in Malaysia and Vietnam. *Creative Education*, 9, 2752-2772. https://doi.org/10.4236/ce.2018.916207.

Marope, M.(2017). *Reconceptualizing and Repositioning Curriculum in the 21st Century. A Global Paradigm Shift*. International Bureau of Education. Paris: UNESCO.

Marwala T. (2018).Tackling bias in technology requires a new form of activism. Available from: https://www.uj.ac.za/newandevents/Pages/Opinion-Tackling-bias-in-technology-requires-a-new-form-of-activism.aspx.

Moll, I. (2004). *Curriculum responsiveness: The anatomy of a concept.* In H. Griesel (Ed.). Curriculum responsiveness: Case studies in higher education (pp. 1–19). Pretoria: South African Universities Vice-Chancellors Association.

Molluzzo, C. J., & Lawler, P. J. (2015). A Proposed Concentration Curriculum Design forBig Data Analytics for Information Systems Students. *Information Systems Education* Journal, 13, 45-57.

National Academy of Engineering (2017). *Engineering Societies and Undergraduate Engineering Education:* Proceedings of a Workshop. Washington DC: The National Academies Press. https://doi.org/10.17226/2368.

Ndung'u, N. & Landry, S. (2020). The Fourth Industrial Revolution and digitization will transform Africa into a global powerhouse. Foresight Africa. Available at https://www.brookings.edu/wp-content/uploads/2020/01/ForesightAfrica2020_Chapter5_20200110.pdf.

O'Neill, G. (2015). Curriculum Design in Higher Education: Theory to Practice . Dublin:UCD Teaching & Learning. http://researchrepository.ucd.ie/handle/10197/7137.

Passow, J. H., & Passow, C. H. (2017). What Competencies Should Undergraduate Engineering Programs Emphasize? A Systematic Review. *Engineering Education Journal*,106, 475-526. https://doi.org/10.1002/jee.20171

Phills, J. A., Deiglmeier, K., & Miller, D. T. (2008). Rediscovering Social Innovation. *Stanford Social Innovation Review*, 6(4): 34–43.

Schwab, K. (2016).*The Fourth Industrial Revolution*. World Economic Forum: Geneva.

South, J., Olszewski, B. & Ramos, Y.(2020).Reforming Education in Response to the Skill Shifts in the Labor Market:United States. In M.M. Diaz & C. Lee (Eds). *What technology Can and can't do For education. A comparison of 5 stories of success*. (pp. 86-108). Inter-American Development Bank.

Spöttl, G. & Windelband, L. (2021). The 4th industrial revolution – its impact on vocational skills, *Journal of Education and Work*, 34(1), 29-52. https://doi.org/10.1080/13639080.2020.1858230.

Törngren, M., Grimheden, E. M., Gustafsson, J., & Birk, W. (2015). Strategies and Considerationsbin Shaping Cyber-Physical Systems Education. In Workshop on Embedded and Cyber Physical Systems Education. New York: ACM. https://doi.org/10.1145/2829957.2829965.

Usoro, A.D., Caleb E.E. & Ojobah, L.O. (2021).The Fourth Industrial Revolution: Discourse and Contexts Shaping Nigeria's Participation. *American Journal of Education and Information Technology*, 5(2), 106-112.

WEF (World Economic Forum), & Kearney, A. T. (2018). Readiness for the Future of Production Report 2018. World Economic Forum. http://wef.ch/fopreadiness18

Wyatt, R. (2000). Curriculum Descant: Interdisciplinaire AI (p. 11). Retrieved from https://cs.brynmawr.edu/EIAIR/CurriculumDescant/9.html