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4TH IR – IMPLICATIONS FOR HIGHER EDUCATION

Abstract:

During the 4th industrial revolution (4th IR) the world will see the emergence of a new form of institutions of higher learning. These institutions will have no classrooms, no library and no onsite lecturers. The institutions will be inter-disciplinary, will have virtual classrooms and laboratories, the library will be online and the lecturers will either be virtual or can sit anywhere in the world. Higher Education in the 4Th IR is creating an exciting but complex opportunity which has the opportunity to transform the society for the better. Artificial intelligence is driving the 4th IR and the needs of the workplace will be transformed from a task-based characteristics to human-centred characteristics. Due to the merging of "man" and machine, the distance between social sciences and humanities as well as between technology and science will be reduced. This will necessarily require more interdisciplinary teaching, research and innovation. All the components of the "new" higher education system will be inter-dependable of each other but will also be independent of each other. This paper looks at the impact of the 4th IR on the mission of higher education institutions.

Keywords:

4th IR, 4th industrial revolution, higher education

JEL Classification: A00

Introduction

The Fourth Industrial Revolution (4th IR) is a model that is being discussed widely at places like the World Economic Forum (WEF) at Davos, institutes of learning and by business leadership, how the 4th IR will be shaping the future of education and the workplace and how the 4th IR will require the reskilling of the workforce (World Economic Forum, 2019). The 4th IR as a watchword has its origins in early studies of the evolution of technology where the First Industrial Revolution arose from using water and steam power for manufacturing. The first descriptions of the First Industrial Revolution mention steam engines used in the mining in Cornwall the changes steam power had in the explosion of manufacturing and production. Steam power was defined as "the hub through which the spokes of coal, iron and cotton were linked." (Rosen, 2010). The term industrial revolution can be traced to work done by A Toynbee (1884) in an article called the "Lectures on the Industrial Revolution" he described the industrial revolution as follows: *The expansion of power and mechanical production became a revolution only from its coupling with a "political culture which was receptive to change,"* (Weightman, 2007). One author describes it as, "the Industrial Revolution is not merely an acceleration of economic growth, but an acceleration of growth because of, and through, economic and social transformation." (Eliot, 1869) Educational and Social changes from the first three industrial revolutions provided the starting point in our consideration of the potential changes in higher education arising from the 4IR.

The Educational response to the 1st and 2nd IR

Harvard President, Charles W. Eliot brought forward the idea for a new kind of curriculum with more diverse degree options and new general education programs designed to produce breadth of study through the selection from a variety of elective courses in 1828. This was described by the as "The New Education" and offered a histrionic shift away from the main stream education expressively outlined for the University graduate education within the United States and across the world. The German model for postgraduate research enabled the rise of new research universities within the United States.

The 2nd IR happened during 1860 to 1900, and is linked with new technologies in manufacturing based on electricity,(Netschert & Schurr, 1960) which triggered changes beginning what some have described as a "new economy." The greater access to higher education and the propagation of multiple types of higher education institutions in the United States and Europe produced a surge in discovery and helped consolidate and accelerate the growth brought about by the powerful new technologies. In the United States, the period of the first two industrial revolutions brought a large crop of innovative new educational institutions—founded through both public and private funding. The Morrill Act of 1862, passed in the middle of the Civil War and at the beginning of the Second Industrial Revolution, was intended to open educational opportunity "for the industrial classes" and to enable higher education that is accessible to all. Geiger (2017) wrote that these new types of institutions were envisioned to supply a steady stream of newly trained technicians and engineers trained in the "practical avocations of life" such as agriculture and the mechanic arts. Most of these new institutions of higher education during the period of the 2nd IR were co-ed and helped natured an increased role for women in industrial and academic environment.

It needs to be note that changes in society and education from both industrial revolutions are also difficult to separate from other causes, such as economic cycles and geopolitical shifts of the period like the westward expansion and development of the United States, the rise of industrial Japanese and German states, and large world wars that dislocated economic activity and accelerated the development of science and technology. Some economists have also observed that the cyclic nature of economic activity arises from regular cycles of economic growth and recession (Korotayev & Tsirel, 2010) It has been observed by economists that every time new technologies are introduced into an economy, there is a noteworthy time delay for the technology to be fully used at a level where their impact on productivity could be measured. This delay between technological modernization and growth of productivity has been called a productivity paradox and coupled with the time it takes for training and experimentation with new technology and then be distributed throughout society.

The explosion of new educational institutions and changes in the curricula after the first two industrial revolutions enabled the massive expansion of the economy and manufacturing that arose in the twentieth century. Shifts in US higher education after World War II further advanced the changes made possible through the first two industrial revolutions. This expansion of research followed the publication of the report commissioned by President Truman entitled “Science: The Endless Frontier,”(Bush, 1945) and the creation of the National Science Foundation in 1950, which drastically increased the resources available for university scientists and shifted the incentive structures and curriculum within US higher education for decades to come.

The Educational response to the 3rd IR

The 3rd IR, which is generally credited to the developments in the computers and web-based interconnectivity developed in the 1980s and 1990s, is only now having its effects upon education, economics, society and politics. Within the 3rd IR, access to higher education develop to even greater importance with increased diversity on campuses and the globalization of academic research accelerated by online technologies. An intensified commitment to large-scale higher education across the world has resulted in increasing rates of participation in higher education in India, China as well as the United States.

In 2012 in what was called the “Year of the MOOC” 1 of the largest waves from the 3rd IR was the move toward online education, as massive online open courses which was anticipated to completely displace traditional in-person higher education and increase access to university education to millions of students across the globe. The revolution brought about by online courses is still ongoing. Michael Staton (2012) has suggested a useful framework of breaking up higher education activities between those that are inherently synchronous and personal, such as personal exploration, coaching and mentorship, from those activities that can be easily scaled and shifted online such as content transfer. The era of increasing online content delivery and access to information, the more personal and hands on approach of the traditional educational experience will become more important and will never be replaced by technology.

Online and the availability of online teaching material within universities is enabling universities to more resourceful in teaching students with diverse backgrounds, and to open up their campuses to a more global community of both faculty and students. (LACOL, 2017) Collaboration between online education companies and larger universities are creating innovative and interactive platforms for their online courses and are developing dozens of new “stackable micro-credentials” (Young, 2017). The 3rd IR resulted in that access to information is immediate and free, shifting the focus toward active learning pedagogies that place a premium on teamwork within diverse (Mazur, 2009).

Realities emerging from the 4th IR

The 4th IR is often seen as the integration and compounding effects of multiple "exponential technologies," such as nano-materials, bio-technologies and artificial intelligence (AI). Synthetic organisms (life from DNA created within computers and bio-printed) is an example of the reality within the 4th IR as well as robotic assembly lines in manufacturing using nanomaterials. The 4th IR extends the paradigm of industrial revolution into a future when many of the basics of what we might consider factories, massive labour forces within businesses — will disappear. The best example of exponential technology is the explosive increase in computer power and storage becoming cheaper. The doubling of CPU power every 18–24 months has enabled new supercomputers to reach computation speeds of 300 quadrillion FLOPS (floating operations per second) in the latest supercomputer known as Milky Way 2, an increase in speed of more than a factor of 300,000 in just two decades (Peters, 2017).

At the World Economic Forum (2015) it was discussed that one of these tipping points include the explosion of the 4th IR technologies to levels where they make significant impacts on our lives and require shifts in employment and education. A survey of 800 high-tech experts and executives determined a series of dates by which tipping points would be reached. Examples include implantable cell phones by 2025, 80% of people with a digital presence by 2023, 10% of reading glasses connected to the internet by 2023, 10% of people wearing internet-connected clothes by 2022, 90% of the world population with access to the internet by 2024, 90% of the population using smartphones by 2023, 1 trillion sensors connected to the internet by 2022, over 50% of internet traffic directed to homes and appliances by 2024, and driverless cars comprising 10% of all cars in the United States by 2026. Many other predictions suggest extensive integration of AI in the 4IR workforce, such as AI members of corporate boards of directors, AI auditors and robotic pharmacists, proliferation of bitcoin in the economy, 3D printed cars by 2022, and transplants of 3D printed organs such as livers by 2024.

Philp (2017) has defined the 4^{th} IR as a shift from non-renewable energy resources toward renewable energy enabled by bio-technology breakthroughs. This approach preserves the paradigm of the industrial revolution arising from new energy sources, and makes concrete predictions about the emerging bio-economy that will fuel the future. The 4^{th} IR will enable technological solutions to the environmental threats such as the greenhouse effect from the massive factories arising from our first two industrial revolutions.

The response of higher education to the 4^{th} IR

The impact of the 4^{th} IR technologies on society and the planet are still unknown, but it will bring profound and rapid change. The need for higher education to respond is urgent as the power of the 4^{th} IR for either positive social impacts or devastating environmental damage is upon us, but the dangers also needs to be noted such as the potential for loss of control over networks of AI systems. Extensive changes to the science and technology curriculum will be required to permit students to develop their ability in the rapidly emerging areas of nanomaterials, AI, robotics, data science and genomics. Such a 4^{th} IR STEM curriculum need to reconsider the curriculum within the traditional sciences biology, chemistry and physics and place a higher importance for training in computer science subjects as a form of 4^{th} IR literacy.

For example in biology, a new approach can include a course for example on emerging areas such as synthetic biology and molecular design, (Cyert, 2017) or a new course in engineering biology that allows students to design their own life forms on computers and bio-print them to solve practical problems in medicine, public health and environmental management. Chemistry could include courses and degree programs in “Green” Chemistry, where the blending of chemistry, biology and environmental science allow students to engage on real environmental problems such as synthetic fuels, bioplastics and toxicology, and to equip students with skills to reduce pollution (Mammino & Zunin, 2015). Another response higher education to the 4th IR can require a restructuring of institutions to provide new and innovative science programs and departments in new interdisciplinary fields to provide trained workers to help advance and accelerate the development of sophisticated bio-technology, nanotechnology materials and AI.

Any educational plan for the 4th IR needs to be built upon the outcomes of the 3rd IR as described earlier, with its emerging development of online and in-person instruction, and efficient and unified integration of global video-conferencing and the availability of educational resources. Blended instruction and optimization of flipped and online courses will make more streamlined learning environments adapting for all students. The Future of Education Report at MIT strongly emphasizes the need for leveraging online courses to strengthen the residential education for undergraduates and to also give more flexibility and modularity of courses (MIT, 2013).

Mendez (2014) mentioned that effective blended environments where course material is delivered entirely online with the in-person component focusing on laboratory and maker space time for students to build and test robots, for example the MIT Circuits and Electronics course, which has been offered as an online course for residential students, was found to be less stressful and was appreciated by the ease of scheduling and additional speed for receiving feedback on assignments.

Effective 4th IR education strategy need to include consideration of the human condition, how the new technologies and economic power will impact people of all levels, keeping in mind a world that is increasingly interconnected, and respect human rights. Remember that the development of intercultural and interpersonal skills is a hallmark of the future 4th IR workplace.

The 4th IR and curriculum expansion

The 4th IR and its new technologies for example Artificial Intelligence will challenge some of our expectations on how thing should be. How should liberal arts respond to this new human condition? The social upsets from the 4th IR have to be accounted for within a new 4th IR curriculum. As smart AI-powered machines and other advanced technologies become more common within the work place, this change will be become more urgent. The 4th IR curriculum needs to respond to the changes in die political and the social environment that will accompany the accelerating pace of technological change. Described by Schwabi (2017) in his WEF report, the political effects of the expansion and convergence of the physical, digital and biological worlds will be profound. This development will "enable citizens to engage with governments, voice their opinions, coordinate their efforts, and even circumvent the supervision of public authorities. Simultaneously, governments will gain new technological powers to increase their control over populations."

The evolution of online instruction and expanding uses of AI, will result in the need for new guidelines for the theoretical basis for digital instruction. Jandric (2017) called the old styles of teaching "anthropocentric humanism" and the new types of digital education "critical post-humanism." This approach suggests that digital education is more than a purely technical concern, as online environments change the dynamics of space and time to create new learning cultures that challenge our earlier notions of social interactions. The new curriculum needs to assist students contend with the intricate issues of relationships within online spaces and the logical dimensions of AIs that may approach or even surpass human intelligence. Haraway (2000) has created a "Cyborg Manifesto" to assist in explaining the social reality for a cybernetic organism, which would be a "creature in a post-gender world" where divisions between human and non-human, public and private and nature and culture break down. These humanistic fears are inseparable from technical advancement, and a new 4th IR curriculum will need to reduce the divisions between humanities and STEM to create a more integrated system of education which can explore the newly emerging conceptions of self and identity within the 4th IR.

Higher education in the 4th IR age needs to develop the ability not just for analysing and dividing a scientific or technical problem into its basic parts, but also look the interaction between the biological, chemical, physical and economic extents of the problem. Peters (2017) described it as, "there is a single planetary technical system" in which globally scaled markets enable "hundreds of thousands of transactions and information exchanges take place at the speed of light within the space of a microsecond." This speed can cause volatility and chaos in financial systems, and similar analogs of interconnected complex systems exist in the realms of marine ecology, forest conservation, global climate and the impacts of extinctions on the biosphere, to name a few examples. In all of these systems the rapidity of responses to the system and the larger network of interconnections can easily result in exponential responses to small perturbations, and the 4th IR curriculum needs to train students to recognize and help manage the proliferating numbers of exponentially responding and interconnected systems.

"Re-tooling" of Education to renew skills

The express pace of change within the 4th IR will require development of existing initiatives for updating skills after graduation. Within technical and scientific education and training, we will need to re-educate students in the use of today's most rapidly emerging technologies. It will become imperative for graduates to reengage with their institutions of learning after graduation to provide both updated skills and create a new channel for younger students to engage with the changing realities within the industrial and corporate sectors. Stanford University in the USA started an initiative called the Stanford2025 project which explore new ways to structure higher education, it foresees several mechanisms whereby students can extend their education over longer timeframes. One model is the "open loop university" where students can experience six years of higher education over their entire adult careers that can allow them to blend their learning with life experience and provide value to the campus by returning as expert practitioners over several intervals enabling students to refresh their skills while interacting with the campus community (Stanford2025, 2013). Another model known as the "axis flip" ranks skill development and competency training over content and disciplinary topics, requiring new methods of assessment and a degree known as a skill-print that students would constantly renew and extend through their careers. The hallmark of the 4^{th} IR is exponential growth and rapid change, this forces curriculum to update content on an unparalleled frequency to match the rapid tempo of scientific and technological advances. A more responsive curriculum will place a high premium on curriculum renewal and faculty development, as well as to develop students who can think and reinvent "themselves" within the world they will graduate into. In the future, graduates will never be "done" with their education, but instead will engage constantly with their colleagues and outside experts to renew and update their skills. The 4^{th} IR university needs to become a constantly renewing collaborative hub of activity to maintain itself within the fast-changing environment.

Conclusion

The explosive changes in during the first three industrial revolutions ensured large shifts in education, the economy and the society which caused curricular innovation and the establishment of new educational institutions. The effects of the 4th IR on our society will not be realised for many decades to come, as it happened during the first three industrial revolutions. But, unlike the first three industrial revolutions, the 4th IR features technology that has the capacity for rapid increases in scale and reductions of cost. This advance in technology therefore demands a bigger response from the educational sector than those made by the earlier industrial revolutions.

The impact of the 4th IR technology on the economic and environmental relationships alone will require radical change of the curriculum within higher education to enable students to understand the technology be able to analyse and forecast the development of networked systems of technology and the environment as well as the political structures. The responses to this and the feedback will amplify the pace of change, as has already been seen in for example the context of global climate change. The 4th IR STEM curriculum will need to focus on new technologies such as robotics, nanomaterials, AI and biotech to provide a workforce not only capable of developing new applications and products, but also capable of interpreting the effects of these technologies on their environment and using their expertise to provide sustainable and ethical uses of science and technology. New curriculum needs to assist students to develop the capacity for awareness of human impacts, ethical reasoning and the comprehension of the impact of the 4th IR technologies on daily life, they need to be trained to not only increase the worlds material prosperity but also to improve our social and cultural fabric. Students who are capable of collaborating in diverse teams, navigating through global cultural differences and have creative insights will be at an asset in a workplace where new skills will become more of interpreting rapidly changing information and being able to work with experts and stakeholders toward common understanding of the benefits of sustainable development. While earlier industrial revolutions have immediate needs such as the development of fuel to power the cities and industries of the time, the 4th IR will place an emphasis on intellectual capital and the ability to collective thought. Higher education owes it to students and our future to develop more interactive forms of education to develop curriculum that stresses viewpoints from multiple disciplinary and cultural perspectives. A lot of the new institutions the USA and Asia and some of the new types of curricula are providing useful examples of how to implement this new model of the 4th IR higher education. Higher education needs to recognize the necessity of adapting and developing of these new 4th IR models of education to assure the sustainability of our future. Higher education needs to take its place as a responsive and vital component of society. These new models of 4th IR education will prepare both the universities and the students for their leadership roles in a world of change, with a curriculum that develops both technical mastery and a deep awareness of ethical responsibility toward the human condition.

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