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The Fourth Industrial Revolution: Technology and Education

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Abstract[1]

The convergence of data, computation, and globalization in education has far-reaching consequences for educational stakeholders, institutions, and learners. Terms such as the Fourth Industrial Revolution, artificial intelligence (AI), exponential technology, deep learning, personalized competency-based learning, and distributed ledger technology networks (DLTNs) are indicators of the changing dialogue between education stakeholders, businesses, and government aspirations on a global scale. Location-independent virtual environments promise an exponential expansion that goes beyond brick-and-mortar schools, colleges, and universities. AI and intelligent systems are poised to become global change agents in education, ushering in profound changes in administrative functions, strategic planning, data aggregation, student acquisition and retention, and alternative currencies, as well as curriculum design, assessment, personal learning networks, and global competitiveness generally of both institutions and their graduates. The quality of the education a nation's schools, educational institutions, and teachers provide, along with investments in science, technology engineering, and mathematics education, directly impact economic prosperity and global competitiveness.

This paper explores some of the interdependencies that arise from supercharged technological advances such as AI augmented reality digital technologies (ARDTs) and DLTNs and their possible impact on education, educators, learners, and society. In addition, it unbundles the meaning and use cases of AI, ARDTs, and DLTNs in education.

Keywords: *Fourth Industrial Revolution, Artificial Intelligence, Exponential Technology, Deep Learning, Personalized Competency-based Learning, Natural Language Processing and Distributed Ledger Technology Networks*

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1. Education and Globalization

This paper explores interdependencies related to education, shifts in institutional visions and missions, and evolving systems supercharged by technological advances, such as artificial intelligence (AI), augmented reality digital technologies (ARDTs), and distributed ledger technology networks (DLTNs). The future of education and work is set against a fluid background of volatility, uncertainty, complexity, and ambiguity (VUCA). In the late 1980s, the U.S. Army War College coined this term to describe the post-Cold War world. VUCA captures the essence of the soon-to-be dominant Fourth Industrial Revolution (4IR).

The 4IR was first identified by Klaus Schwab, the founder and executive chairman of the World Economic Forum. 4IR, also called Industry 4.0, is built "on the widespread availability of digital technologies that were the result of the Third Industrial, or Digital Revolution, the Fourth Industrial Revolution will be driven largely by the convergence of digital, biological, and physical innovations" (Schwab, 2021). The continued competitiveness and relevance of education depend on educational institutions, service providers, and learners in synthesizing and adapting to the trends of the 4IR. Social stability, economic growth, and sustainability can only be supported in the twenty-first century through systems that anticipate the coming socio-cultural and global changes. The educational quality of a nation's schools, educational institutions, and educators coupled with investments in science, technology, engineering, and mathematics education directly impacts a country's economic prosperity, workforce employability, and global competitiveness.

Educators, educational institutions, corporations, and countries must prepare for adaptations in their organizational structures and content delivery for the generations iGen and Gen Z. These hyperconnected learners, born between 1995 and 2012, are at home in ARDTs and familiar with DLTNs. However, fundamental questions concerning the nature of global education still center around the five Ws: what is taught, by whom it is taught, and how, where, and why it is taught.

2. Business of Education: Resources, Processes, and Priorities

The scholar Clayton Christensen founded the study of resources, processes, and priorities (RPP) in his 2006 Harvard Business Review article,*"Assessing Your Company's Capabilities: Resources, Processes, and Priorities."* These RPPs are those necessary for a company to get work done (Christensen, 2006). Although RPPs are part of the analysis of business models, they can be applied to education and educational organizations through analysis, synthesis, and alignment of institutional and instructional structures and technology resources.

Successful Edtech integration must be implemented with deliberate strategy rather than reactive resource allocation. In education, resources are the tangible and intangible assets that an educational institution uses to support its faculty and learners. The resources are people, facilities, equipment, technology, curricula, money, endowments, and relationships with communities, learners, businesses, and governments. Because educational resources are easy to identify and realign, they are often the focus of far-reaching decisions. Initial e-learning processes at institutions are often grafted as add-ons or additional services without strategic long-term planning or robust discussion of the concepts of instruction, teaching, and learning as means of education and workforce preparation. However, innovation always involves risk and "is fraught with challenges. Leaders need to understand that simply buying the latest technology or giving schools freedom to experiment may do little to help leaders consistently improve student outcomes." (Freeland Fisher, 2017, p. 4)

Educational processes include the ways in which programs and departments are developed or created or that services are offered to learners, faculty, and communities. Such processes also include the methods through which procurement, research, budgeting, faculty and staff development, and resource allocation are performed. The integration of DLTNs such as blockchain or holochain could soon further streamline administrative procedures and processes by tackling credentialing and international transcript transfers. The Digital Credentials collaboration and other partnerships are working with

universities and governments to create a shared infrastructure for digital academic credentials. In addition, DLTNs are capable of tracking intellectual property, use verified sovereign identities for student identification, and employ immutable certificates coupled with micro-credentialing.

Educational priorities emerge from institutional missions and visions reflecting board, council, faculty senate, or trustee decisions to fund new programs or departments or to discontinue program majors. In addition, priorities in educational institutions include local and global academic ranking and standing in key academic areas, strategic academic and financial investments, a distinctive institutional culture with a sense of community, and the successful placement of graduates in colleges or the workforce.

3. Education, Instruction, and Skills

Mere information delivery is not education. A closer look at the historical concepts of education and instruction is warranted. We begin with a foray into the Latin roots of these words. The Latin *educatus* is the past participle of *educare*, which means to bring up or train or nourish a child, physically or mentally. It can also mean to rear, educate, or train a person in a field of skill or art (Wiktionary, 2021), but it refers more frequently to the mind. Etymologically, the words 'instruction' and 'instructor' derive from the Latin *īnstrūctus*, which has the root meaning of instructing, arranging, furnishing, or providing. Then *informare*, the source of the word 'inform,' means to shape, mold, or develop (Wiktionary, 2021).

The contemporary use of the words 'inform' and 'information' often reduces this complex connotation to the simple acquisition of facts. However, the deeper meaning here is of a process of shaping and developing the minds of learners. Basil Lanneau Gildersleeve (1831–1924), a highly regarded American scholar of the classics, in his essay "Limits of Culture," called for a sharp distinction between education and instruction. He defined education as "the normal development of the powers that lie in man's nature and [...] not to be confounded with

instruction, which merely furnishes the means and appliances of education" (Gildersleeve, 1890, p. 13)

Table 1: Kolb's Four Stages of Learning (McLeod, 2017)

Education	Instruction	Processes	Kolb's Four Stages
Mindfulness	Learning to know	Cognitive processes: memory, learning, language use, problem-solving, decision making, reasoning	Concrete experience
Curiosity	Learning to do	Stages of the learning process: unconscious incompetence , conscious incompetence , conscious competence, unconscious competence (Maya, 2007)	Reflective observation
Meta-awareness	Learning to live together	Interpersonal processes: expectancies, attribution, personal relationships, and group dynamics	Abstract conceptualization
Meta-cognition	Learning to be	Intrapersonal processes: internal vocalization, reflective thinking	Active experimentation

4. Date, Computation, and Globalization

The convergence of data, computation, and globalization in education is changing the way knowledge is generated, disseminated, and transformed into products and services for educational institutions, educators, learners, and employers. Big data and human and technological networks span the globe. Looking forward, educational institutions that offer a menu of established disciplines and degrees in brick-and- mortar buildings may no longer be an ideal, desirable, or sustainable model.

Clay Christensen also developed a theory of disruptive innovation, a pivotal twenty-first-century business idea. Here, disruptive innovations "are NOT breakthrough technologies that make good products better; rather they are innovations that make products and services more accessible and affordable, thereby making them available to a larger population" (Clayton Christensen Institute, 2021). Thus, massive open online courses are not a break- through innovation, as the ability to watch televised or videotaped lectures predates them; instead they make an already available product, distance education, more accessible to a global group of learners.

5. Terminology, Vocabulary, and Acronyms

New terminology is a constant presence in educational conference presentations, articles, discussions, Zoom meetings, webinars, and academic papers that explore the meaning and concepts of the 4IR. Novel acronyms, used with knowledgeably raised eyebrows and infused with sophisticated-sounding vocabulary are used to impress audiences. However, the concepts behind the terminology and acronyms are as new to the general public and educators as the concepts and vocabulary of the First Industrial Revolution were to their contemporaries. The primary feature of the First Industrial Revolution was mechanization, which introduced the vocabulary and concepts of steam engines and factories. The vocabulary of the 4IR describes the fluid boundaries between the physical, digital, and biological worlds. "It's a fusion of advances in artificial intelligence (AI), robotics, the Internet of Things (IoT), 3D printing, genetic engineering, quantum computing, and other technologies. It's the collective force behind many products and services that are fast becoming indispensable to modern life" (McGinnis, 2020).

Exponential technologies are those that allow change at an accelerated speed (Bree, 2020). Today, there are three main exponential technologies: AI, machine learning, and deep learning. AI "refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions" (Chaitanya, 2020). Machine learning is a type of AI, and deep learning is a particularly complex category of machine

learning (Wolfewicz, 2021). Deloitte defines exponential technology as "innovations progressing at a pace with or exceeding Moore's Law" that "evidence a renaissance of innovation, invention, and discovery…[and] have the potential to positively affect billions of lives" (Deloitte, 2016).

Intelligent automation is a combination of robotic process automation and AI technologies. It uses cognitive technologies such as computer vision, natural language processing (NLP), and fuzzy logic that arches across the entire automation process (Automation Anywhere, 2021).

DLTNs, including the peer-to-peer networks of blockchain and holochain, encompass multiple capabilities such as the linking or encrypting of records, an important new frontier for educational globalization, as it opens the door to transcript referencing and possible global degree acceptance. In addition, cryptocurrencies use DLTNs.

ARDTs are computer-generated interactive experiences generated in simulated environments. "Augmented reality is an interactive experience of a real-world environment where objects residing in the real world are enhanced by computer-generated perceptual information, sometimes through multiple sensory modalities" (Bree, 2020).

All of these technologies are nested within the Internet of Things, the interconnection of physical devices and objects through the Internet (Bree, 2020). The complex concepts behind the terminology are indicators of the urgent need to support dialogue between the educational leadership and educational stakeholders in the face of far-reaching changes confronting educational stakeholders, their constituencies, and their national interests.

6. Educational Technology: The Promised Land?

Learning centers are being transformed by computer- based intelligent systems. Algorithmic approaches to decision making are beginning to permeate both the institutional and personal domains in the form of decision-support systems. In education, AI and other intelligent systems are poised to trigger large-scale change with profound impact on administrative

functions, organizational planning, data aggregation, degree viability, curriculum design, meaningful learning outcomes and competencies for graduates, and personal learning networks. These VUCA changes are the background for distance learning, the global competitiveness of educational institutions, and the viability of their degrees and their graduates.

AI-enabled hyperpersonalization is an interesting example of automating student-centered learning. This is personalized competency-based learning that is unfolding in iGen/Gen Z schooling. Here, an AI develops a custom learning profile with individual learning paths aligned to the specific needs of each learner. Generations iGen and Gen Z. are already hyperconnected learners who have mastered different platforms and learning environments. Among the macrotrends for this generation are the need for flexibility, personalization, and hyperconnectedness. How will these technologies change iGen/Gen Z graduates' abilities not only as learners but as explorers of life? Terms such as customer learning profile indicate the planned uses of data aggregated during learning sessions. The use of labels matters. In medicine, patients became clients. The term client invokes someone who receives a service for payment, but a patient is a sick person in need of care. These are two very different ways of seeing the same person.

NLP is another example of a disruptive technology. NLP can be defined as the automatic manipulation of natural language, whether speech or text, by software (Brownlee, 2019). Google Translate features Word Lens, a program that enables users to hold their phone up to a sign or printed text for instantaneous translation into 27 languages. Users now have instant access to multiple languages. For educators in the field of Teaching English as a Second Language (TESOL) and other language professionals, this technology will eventually change the face of language education.

7. Conclusion: Creativity, Collaboration and Communication

What are the implications for education, both for learners and educators and for educational systems? Christensen's theory of disruptive innovation identifies two categories of people that can be expected to give such

innovations their initial foothold: the least-demanding consumers and nonconsumers.

The least-demanding consumers are learners with access to mainstream options such as public schools or colleges who are overserved by those options. If given the choice, these learners will trade away core functionality for other benefits, such as affordability, convenience, or customizability. Examples of these types of service are fully online programs such as those of the University of Phoenix or Southern New Hampshire University. These are accredited institutions that feature affordable, accessible degree programs to thousands of learners fully online. In the K–12 arena, the "least-demanding consumers are students and families who are willing to give up some aspects of a conventional K–12 school experience in order to gain greater flexibility or customizability" (Arnett, 2021). Nonconsumers are rare in the US education system, but in countries such as Mali, Burkina Faso, Burundi, Chad, and Yemen, there are still countless school non-completers, despite obligatory school requirements. Many students hover at the margins of dropping out or become nonconsumers due to food insecurity, insufficient transportation, and high- intensity conflicts among other issues. Here disruptive innovation in educational technology could bring lasting positive changes to learners and their communities.

Technology will never replace great teachers, but in the hands of a great teacher, technology can be transformational (Couros, 2021). Education and meta-education ask for educating the educators within continuous self-educational processes, thus increasing their effectiveness of the education they are providing. However, AI, ARDTs, and DLTNs should not be confused with or replace educators' empathy and loving-kindness or the learner's creative spirit. Instead, an integrated vision is needed that can cover instruction, teaching, and learning in education to strengthen access and equity in education through technology while bearing in mind educators' sacred responsibility to remain true to their calling to *educare*, cultivate and nurture their learners' spirits.

AI, ARDTs, and DLTNs will provide access to personalized quality education, training for future skillsets, and a global portability of

educational credentials, tempering the birth of a new useless class (Harari, 2017). However, it is unclear how AI, with its intelligent tutors and cognitive agents such as chatbots will foster intellectual curiosity, in-depth synthesized reasoning, and productive academic behavior. Sequential learning types, such as continuous student progress tracking, and next-step hints coupled with selected practice problems might not lend themselves to desirable twenty-first-century skills such as creativity, collaboration, and communication.

AI processes cannot nurture intrinsic greatness residing within those learners harboring a Gutenberg leap, the beauty of Beethoven's Ninth Symphony, or da Vinci's genius. Richard Wagner's tetralogy *Der Ring des Nibelungen* explores in opera an allegory of the emergence of humanity from the state of nature and the growth of moral consciousness. From this rises the ascendance of a mature morality rooted in empathy and love between living beings. This author believes that humanity's greatness lies in its immense creative potential often inspired through the individual struggle from night to light from "All that is and all that was, Future, Present and the Past" (Cowin, 2018, p. 9).

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