CHAPTER 1

Introduction

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Introduction

In a July 2017 piece in *Inside Higher Ed*, Joshua Kim asked: "Why is it that books about technological-induced economic change tend to focus on every other information industry except for higher education?"[1] The answer is because no one knows quite what is happening yet. It is too new. The automation economy, resulting from the technologies of the fourth industrial revolution (4IR), is changing the way we live and work. Information transfer is no longer the sole purview of institutions of higher education (HE). Information is everywhere and the collection of big data means we have brand new kinds of information. Several good books have already been released on what needs to change in HE, but they lack a detailed perspective on how some elements of HE—liberal arts, youth themselves, and libraries—are already changing, as well as what nations are doing to adapt their HE institutions. HE is changing around the world

[1] Joshua Kim, "'The Fourth Industrial Revolution' and the Future of Higher Ed," *Inside Higher Ed*, July 10, 2017, https://www.insidehighered.com/blogs/technology-and-learning/fourth-industrial-revolution-and-future-higher-ed.

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already as a result of the fast-shifting global economy and the types of employees and thinkers it demands. This book offers a first glimpse at new global trends in HE, and how nations around the world are responding in their national HE systems in order to provide readers insights into how that is already happening on the ground and what is likely to come next. HE will have to change, quickly, in collaboration with governments and industry to respond to the automation of knowledge and production.

The Fourth Industrial Revolution

What is the phenomenon we are now experiencing? The first industrial revolution emerged in the 1780s with steam power, making humans more productive. Then in the 1870s the second industrial revolution emerged with the development of mass production and electrical energy. The third industrial revolution emerged with the development of IT and electronics, which enabled more efficient production. We are now in a new phase where the fusion of several technologies is not only automating production, but also knowledge. There are many working to classify and name the phenomenon we are all experiencing. Talk of "Industry 4.0" emerged from Germany's manufacturing industry in the early 2000s. The changes that are occurring are happening now because humans have finally developed the computing capacity to store massive amounts of data, which in turn can enable machine learning. The outcome of this is the development of what are called cyber-physical systems (CPSs). The term cyber-physical systems was coined by the US National Science Foundation in 2006 with the hosting of several workshops on artificial intelligence and robotics and the declaration that CPS would henceforth be a major area of research. Ragunathan Rajkumar et al. provide a useful explanation of what these complex systems are and their broader implications:

> Cyber-physical systems (CPS) are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. Just as the internet transformed how humans interact with one another, cyber-physical systems will transform how we interact with the physical world around us. Many grand challenges await in the economically vital domains of transportation, health-care, manufacturing, agriculture, energy, defense, aerospace and buildings. The design, construction and verification of cyber-physical systems pose a

multitude of technical challenges that must be addressed by a cross-disciplinary community of researchers and educators.[2]

Erik Brynjolfsson and Andrew McAfee of MIT outlined what they call the dawn of the *Second Machine Age* (2MA), which classifies a shift to the automation of knowledge. Their argument follows that the first machine age was about the automation of manual labor and physical strength. In the 2MA, the technological progress in digital hardware, software, and networks is about the automation of knowledge. This is underpinned by:

1. "exponential growth of Moore's law yielding a new regime of computing;
2. the digitization of everything; and
3. the emergence of an infinite number of combinatorial possibilities for innovation between the two."[3]

In 2016, economist and Executive Chairman of the World Economic Forum (WEF) Klaus Schwab published a book and launched WEF efforts in the area of what he called the 4IR.[4] Klaus Schwab's WEF 2016 theme, which coincided with his book, *The Fourth Industrial Revolution* officially sounded the alarm that labor costs were about to be disrupted and the way we live and work would be permanently altered by the introduction of CPSs. The world was put on notice that increased economic growth will no longer correspond with increased job growth and discretionary spending.

This volume has adopted the phrase 4IR to describe the phenomenon we are all experiencing because it aptly applies to both the technology shifts of 2MA and how people will live with it. Indeed, we are in the 2MA, but that age represents revolutionary changes to everything. The transition is profound and the pace unprecedented as we learn to harness the massive amounts of data being collected. Like earlier industrial revolutions, the impacts will emerge for years to come. Many nations are now preparing for the shifts coming, and HE is a key player. In 2018, CPS and full artificial intelligence are still, for the most part, in development form,

[2] Rajkumar, Insup Lee, Lui Sha, and John Stankovic, "Cyber-Physical Systems: The Next Computing Revolution," in *Proceedings of the 47th Design Automation Conference* (New York: ACM, 2010), 731.

[3] Brynjolfsson and McAfee, *The Second Machine Age* (New York: W. W. Norton, 2014).

[4] Schwab, *The Fourth Industrial Revolution* (New York: Crown Publishing Group, 2017).

but with significant importance to transportation, manufacturing, health care, energy, and agriculture, they are likely to change our lives over the next ten years. How we live and work is being transformed by CPS and other new technologies such as 3D-printing, the Internet of Things (IoT), blockchain, and artificial intelligence.

What does all this mean in practice? The Mckinsey Global Institute released a 2017 report, *Harnessing Automation for a Future that Works,* which measured the likelihood of automation in 54 countries which covered 78% of the global labor market. What they found reveals the scale of impact of 4IR. Organized by sector, the data collected show that 50% of current jobs in agriculture, forestry, fishing, and hunting, representing 328.9 million employees, are potentially automatable. For manufacturing, 64% of current jobs are automatable, representing 237.4 million current employees. For retail trade, 54% of current jobs, representing some 187.4 million current employees are automatable.[5] When considered by nation rather than industry, we see massive shifts for the world's biggest economies. McKinsey anticipates that for China 395.3 million employees are in potentially automatable jobs, making up 51% of the labor force.[6] In India, 235.1 million employees are working in automatable jobs. And in the United States 60.6 million, or 46% of the workforce, are currently in automatable jobs. Not all these jobs will go away, but all of them will be changed. As has been noted many times now, this is not just about unskilled labor. This is a story of all pattern-based and routine work being replaced. Lawyers, radiologists, architects, and accountants will all see significant changes to how they work and in some areas a much smaller demand for human labor. For example, machine learning will allow architects to deploy techniques that add complexity to the built world without cost, and robots will allow for new methods of design and fabrication doing away with traditional constraints.

Many of the new jobs that will exist even ten years from now, we cannot imagine yet. The well-paying jobs will involve creativity, data analytics, and cyber security, as there is currently a global dearth of talent in this area. What we do know is that the skills needed to take full advantage of the automation economy are different from those that have been emphasized

[5] McKinsey Global Institute, *Harnessing Automation for a Future that Works* (New York: McKinsey Global Institute, 2017).

[6] McKinsey Global Institute, *Harnessing Automation for a Future that Works.*

by HE institutions in the past. According to the WEF "Future of Jobs" report, the top ten skills that will be needed in order of priority by employers by 2020 are: complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation, and cognitive flexibility.[7] The skills that had been identified as needed in 2015 that are no longer included in the top ten list were active listening and quality control. Cognitive flexibility and emotional intelligence were the two new skills added for 2020 to replace them. This is because as work becomes automated, it will also become much more fluid. Employees will need to be agile and able to jump between very different types of tasks and contexts. HE needs to change to better prepare thinkers of the 4IR.

Higher Education

HE has a crucial role to play in shaping the societal transitions necessary to adjust to the 4IR. But today's HE was designed to meet the needs of past industrial revolutions with mass production powered by electricity. Those systems are not suited for the automation economy. Today's students (of all ages) are faced with major challenges in demographics, population (both growing and shrinking ones), global health, literacy, inequality, climate change, nuclear proliferation, and much more. As students today leave university, the 4IR world has significantly different demands on them than have previously existed. Nearly everyone will work with artificial intelligence. What you majored in will not determine your job or your career. The content and a deep understanding of it matter, but it is also about what you are able to do with it.

The goal of most reputable institutions of HE is to develop capacity for academic achievement and retention of knowledge among graduates to prepare them for a productive life. Academic development units, commonly holding a title such as the Centre for Teaching and Learning, are preparing faculty for evidence-based practice in improving learning skills. Institutions of HE are incorporating service to community as part of their learning cultures. For example, Hong Kong Polytechnic requires all

[7] World Economic Forum, "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution," January 2016, http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf.

undergraduates to participate in a credit-bearing service work program. And institutes of HE continue to influence policy with research-based evidence and facts. The good news is that HE has come a long way. The challenge is we have much further to go and shifts caused by climate change and 4IR make adaption imperative.

Thus far the changes in HE have been slow and inadequate, though some are trying to adapt. In the past few decades, HE has generally experienced only small incremental improvements. Better classrooms, better support, and advanced libraries. In many countries, access has widened to underrepresented groups, which offers improved social mobility. Thanks to efforts of the Millennium Development Goals to educate young girls, and better outreach from College Admissions offices, we are seeing much higher enrollment and completion by women as well. HE has also offered more diverse skills with the inclusion of experiential learning and adaptive career offices. These are all important improvements, but the 4IR requires HE institutions to depart from the current 3 or 4 year undergraduate model to prepare for lifelong learners.

Traditional, undergraduate, graduate, and research education will remain important to society, but space must be made for adult learners to continue their learning as well.[8] Institutes of HE, in collaboration with governments and industry, need to prepare lifelong learners together. The concepts, let alone the vernacular, are nearly all new. From micro-credentials, Education 3.0, nano-degrees, adaptive learning, microlearning, upskilling to the idea of preparing for just-in-time education, the message is that we must all keep learning. We must, however, caution from falling back into exclusively vocational skills-based learning through these mini-degrees and credentials. The necessary cognitive flexibility needs to be there first and the education, even if specifically targeted, needs to emphasize cognitive agility.

The response to 4IR should be a combination of liberal arts education and upskilling depending on where you are in your educational journey. Not everyone can attend a liberal arts college. But the techniques and curriculum deployed there can be adapted to a given institution's cultural and financial context. Institutes of HE can work to scaffold in the higher order thinking that is needed in the 4IR.

[8] Joseph E. Aoun, *Robot Proof: Higher Education in the Age of Artificial Intelligence* (MIT Press, 2017), 117.

Bloom's revised taxonomy of higher learning had classified six levels of learning and knowing. They are *remembering*, *understanding*, *applying*, *analyzing*, *evaluating*, and *creating*. Information transfer through the traditional lecture and test format does not get you up very high in the cognitive capacity ranks of higher order thinking. But there is also another dimension to this, what Lorin Anderson et al. in 2001 called the "Knowledge Dimension," which represents a range of knowledge from concrete to abstract.[9] The knowledge dimension is made up of facts, concepts, procedures, and metacognition. Metacognition is important because it is linked to information literacy, an essential element of intelligence in the post-truth era. Joseph E. Aoun, President of Northeastern University, in his recent book *Robot-Proof: Higher Education in the Age of Artificial Intelligence* brings these issues to bear on HE as well, making the case for content combined with cognitive capacities that revolve around systems thinking, entrepreneurship, and cultural agility.[10]

Whatever combination you apply, be it a revised Bloom's model, the WEF skills set, or an approach such as Aoun's, the bottom line is that creativity is the key. Furthermore, the learning cannot stop because the institutional progression does. Whatever was promised before by completing an HE degree is not promised any longer. High school is not enough, undergraduate education is not enough, a master's degree is not enough, and a PhD is not enough. Everyone is now responsible for lifelong learning and upskilling. It is the skills that will carry you through; the content will always be changing.

To develop these skills learning must go way beyond information transfer. HE needs to emphasize pedagogy that is student-centered and individualized. Assessments are most effective when they are grounded in project-based learning and authentic experiences. Team work also goes a long way in developing the emotional skills necessary for twenty-first-century success. Ultimately, if the students have the opportunity to conduct their own independent research through an undergraduate or graduate thesis, this allows them to create new knowledge and develop a deep understanding of how we know what we know. Quality HE in the era of the 4IR needs to incorporate these things.

[9] Lorin W. Anderson, David R. Krathwohl, and Benjamin Samuel Bloom, *Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives Abridged Edition* (Harlow: Longman, 2001).

[10] Aoun, *Robot-Proof*, xix.

Underpinning all of this are the issues surrounding gender. 4IR will impact women and men, boys and girls, differently. Females are less likely to have digital literacy, which means they will be less likely to take advantage of technological opportunities. Even for those who are fortunate enough to be participating in the technology-related workforce, women are significantly underrepresented. The reasons for this are well documented. According to the ISACA Survey, the reasons relate to a lack of mentors, a lack of female role models, gender bias, unequal growth opportunities compared to men, and unequal pay for the same skills.[11] According to the WEF Future of Jobs Survey, assuming that the current gender gap ratios persist through the 2020 period, for men there will be approximately one new STEM job per four jobs lost, but for women, for every single new STEM job created, 20 jobs will be lost.[12] That being said, the disruptions caused by 4IR present an opportunity to break away from the status quo. Throughout this book, consideration for how we can improve gender equality, and address the unique needs of men, women, and those who identify as neither, is important. Organizations like Women 2.0 and Girls Who Code are creating support on the ground in the United States. We need much more of them, and we need similar support networks for male labor groups as well. HE will need to play a role if we are going to adequately address these issues.

This book proceeds with eight chapters. The first three address major cross-cutting issues of HE in the context of 4IR. This includes Pericles Lewis's contribution on the globalization of liberal arts education, which provides an overview of the foundations of liberal arts education and the learning that it is intended to develop. Peidong Yang and Yi'En Cheng in Chapter 3 provide an important discussion of the disparities of opportunity related to HE and youth mobility. They suggest that current preoccupations with 4IR's impact on HE is colored by technocratic discourses that ignore "on the ground" experiences of the disadvantaged and marginalized. The final chapter in this section, by Lorcan Dempsey and Constance Malpas, discusses the future of the academic library in the context of electronic resources. They find that academic libraries will diverge,

[11] "ISACA Survey Identifies Five Biggest Barriers Faced by Women in Tech," ISACA, March 6, 2017, http://www.isaca.org/About-ISACA/Press-room/News-Releases/2017/Pages/ISACA-Survey-Identifies-Five-Biggest-Barriers-Faced-by-Women-in-Tech.aspx.

[12] World Economic Forum, *Future of Jobs Survey* (Geneva: World Economic Forum, 2017).

with different service bundles depending on the type of educational institution they serve. This means that the model of excellence for libraries will need to be plural, based on strategic fit to the needs of the institution they serve and not on collection size or gate count. Libraries will support research, student success and retention, community engagement, preservation of the scholarly record, and so on. But their profiles will be different depending on the particular strategic needs of their institutions.

The following four chapters look at how HE has already begun to be adapted in China, Costa Rica, Singapore, and South Africa. Rosaline May Lee and Yanyue Selena Yuan describe the state of current higher educational reform efforts in China that support innovation. They explore the obstacles facing far-reaching reform, offer a view about the likelihood of success and the potential emergence of a "Chinese model" for innovation. May and Yuan use their own experience, introducing and teaching "Design Thinking" to STEM students at a Chinese university as a case study to explore how best to develop critical thinking skills in the automation context.

Eduard Müller looks at HE through an environmental lens, applying the case study of Costa Rica's experience with learning and sustainable development. He advocates for a regenerative development approach to HE. Müller discusses three urgent challenges: the need to move from disciplinary approaches to holistic ones; adapting to disruptive technological advancements; and identifying what is truly important for survival of our civilization.

Reviewing the exciting opportunities in South Africa, Bo Xing, Lufuno Marwala, and Tshilidzi Marwala make the case for an Adopt Fast and Adapt Quick strategy for HE. Their case study presents evidence from a "smart mining" case in South Africa as implemented by the University of Johannesburg. Findings detail an adaptive solution to new demands in the HE arena, which address issues of accessibility, digital literacy, acceleration, pan-regionalization, transformation, inclusiveness, vision, and engagement of students.

Reviewing Singapore's HE systems and close government support of preparing lifelong learners, Nancy Gleason provides a detailed review of replicable policies and programs to prepare 4IR-ready citizens. Gleason details three education-based initiatives in Singapore: Smart Nation Singapore, SkillsFuture, and the creation of three new universities, in preparation for the automation economy. She details how these education-based initiatives are intended to address employment challenges in the era

of the 4IR. Developing the skills and mindset for lifelong learning is essential to making a smoother transition to the automation economy and Singapore has developed practical large-scale policies for how to do this.

The book concludes with a chapter by Bryan Penprase on the evolution of HE in the context of 4IR in the United States and around the world. He emphasizes the importance of new STEM instruction that develops technical capacities in emerging technologies in active and project-based settings. Penprase argues that a rapid adjustment of on-campus curriculum is needed. He calls for expanding STEM's capacity to accommodate the rapid acquisition of new knowledge by students, faculty, and alumni, with new modalities of instruction that leverage the digital advances from the third industrial revolution.

Evidence-based research on how we learn and new research on what skills are needed in the automation economy come together in this book. We know how to create critical thinkers, but it is not easy and it is often expensive. This book provides insights into how this is already being done in the context of 4IR around the world. We can learn from initial efforts, adapt them, improve them, and keep pushing the boundaries of learning. The automation of knowledge may be upon us, but the value of emotional intelligence combined with creativity, and working with artificial intelligence, is limitless. This is the capacity we need to foster.

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