ROBOT-PROOF

HIGHER EDUCATION
IN THE AGE OF
ARTIFICIAL INTELLIGENCE

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INTRODUCTION

Thousands of years ago, the agricultural revolution led our foraging ancestors to take up the scythe and plough. Hundreds of years ago, the Industrial Revolution pushed farmers out of fields and into factories. Just tens of years ago, the technology revolution ushered many people off the shop floor and into the desk chair and office cube.

Today, we are living through yet another revolution in the way that human beings work for their livelihoods—and once again, this revolution is leaving old certainties scrapped and smoldering on the ash heap of history. Once again, it is being powered by new technologies. But instead of the domesticated grain seed, the cotton gin, or the steam engine, the engine of this revolution is digital and robotic.

We live in a time of technological marvels. Computers continue to speed up while the price of processing power continues to plummet, doubling and redoubling the capabilities of machines. This is driving the advance of machine learning—the ability of computers to learn from data instead of from explicit programming—and the push for artificial intelligence. As economists Erik Brynjolfsson and Andrew McAfee note in their book *The Second Machine Age: Work, Progress, and Prosperity in a Time*

of Brilliant Technologies, we have recently hit an inflection point in which our machines have reached their "full force" to transform the world as comprehensively as James Watt's engine transformed an economy that once trundled along on ox carts.[1] Labor experts are increasingly and justifiably worried that computers are becoming so adept at human capabilities that soon there will be no need for any human input at all.[2]

The evidence for this inflection point is everywhere. Driverless cars are now traversing the streets of Pittsburgh, Pennsylvania, and other cities. New robots can climb stairs and open doors with ease. An advanced computer trounced the human grandmaster of the intricate Chinese strategy game Go. Moreover, it is not only the processing power of machines that has skyrocketed exponentially but also the power of their connectivity, their sensors, their GPS systems, and their gyroscopes. Today, we are giving computers not only artificial intelligence but, in effect, artificial eyes, ears, hands, and feet.

Consequently, these capacities are enabling computers to step into roles—and jobs—once held exclusively by members of our species. Robots now analyze stocks, write in deft and informative prose, and interact with customers.[3] Semi-autonomous machines may soon join soldiers on the battlefield.[4] In China, "co-bots"—machines that can work in factories safely alongside human beings—are upending that country's vaunted manufacturing sector, allowing fewer laborers to be vastly more productive. In 2015, sales of industrial robots around the world increased by 12 percent over the previous year, rising to nearly a quarter of a million units.[5]

At the same time, Big Data is revolutionizing everything from social science to business, with organizations amassing

liberate them from outdated career models and give them ownership of their own futures. They should equip them with the literacies and skills they need to thrive in this new economy defined by technology, as well as continue providing them with access to the learning they need to face the challenges of life in a diverse, global environment. Higher education needs a new model and a new orientation away from its dual focus on undergraduate and graduate students. Universities must broaden their reach to become engines for lifelong learning.

There is a great deal of evidence that we need such an educational shift. An oft-quoted 2013 study from Oxford University found that nearly half of U.S. jobs are at risk of automation within the next twenty years.[10] In many cases, that prediction seems too leisurely. For example, new robotic algorithmic trading platforms are now tearing through the financial industry, with some estimates holding that software will replace between one-third and one-half of all finance jobs in the next decade.[11] A 2015 McKinsey report found that solely by using existing technologies, 45 percent of the work that human beings are paid to do could be automated, obviating the need to pay human employees more than $2 trillion in annual wages in the United States.[12]

This is not the first time we have faced a scenario like this. In past industrial revolutions, the ploughmen and weavers who fell prey to tractors and spinning jennies had to withstand a difficult economic and professional transition. However, with retraining, they could reasonably have expected to find jobs on the new factory floors. Likewise, as the Information Age wiped out large swaths of manufacturing, many people were able to acquire education and training to obtain work in higher-skilled manufacturing, the service sector,

or the office park. Looking ahead, education will remain the ladder by which people ascend to higher economic rungs, even as the jobs landscape grows more complex. And it undoubtedly is getting knottier. One of the reasons for this is that the worldwide supply of labor continues to rise while the net number of high-paying, high-productivity jobs appears to be on the decline.[13] To employ more and more people, we will need to create more and more jobs. It is not clear where we will find them.

Certainly, the emergence of new industries—such as those created in the tech sector—will have to step up if they are going fill this gap. According to the U.S. Bureau of Labor Statistics, the computer and information technology professions are projected to account for a total of 4.4 million jobs by 2024.[14] In the same period, the labor force, aged sixteen and older, is expected to reach 163.7 million. Adding to the disjoint is the remarkable labor efficiency of tech companies. For instance, Google, the standard bearer for the new economy, had 61,814 full-time employees in 2015. At its peak in 1979, in contrast, General Motors counted 600,000 employees on its payroll.[15] To address the deficit, we'll need creative solutions.

Apart from automation, many other factors are stirring the economic pot. Globalization is the most apparent, but environmental unsustainability, demographic change, inequality, and political uncertainty are all having their effects on how we occupy our time, how we earn our daily bread, and how we find fulfillment. Old verities are melting fast. The remedies are not obvious.

Some observers have been encouraged by the growth of the "gig economy," in which people perform freelance tasks, such as driving a car for Uber, moving furniture through TaskRabbit, or typing text

for Amazon Mechanical Turk. But earnings through these platforms are limited. Since 2014, the number of people who earn 50 percent or more of their income from "gig" platforms has actually fallen.[16] In general, these platforms give people a boost to earnings and help to pay the monthly bills. But as an economic engine, they have not emerged as substitutes for full-time jobs.

Of the new full-time jobs that are appearing, many are so-called hybrid jobs that require technological expertise in programming or data analysis alongside broader skills.[17] Fifty years ago, no one could have imagined that user-experience designer would be a legitimate profession, but here we are. Clearly, work is changing. All these factors create a complex and unexplored terrain for job seekers, begging some important questions: How should we be preparing people for this fast-changing world? How should education be used to help people in the professional and economic spheres?

As a university president, this is no small question for me. As a matter of fact, the university I lead, Northeastern, is explicitly concerned with the connections between education and work. As a pioneer in experiential learning, grounded in the co-op model of higher education, Northeastern's mission has always been to prepare students for fulfilling—and successful—roles in the professional world. But lately, as I have observed my students try to puzzle out their career paths, listened to what employers say they are looking for in new employees, and take stock of what I read and hear every day about technology's impact on the world of professional work, I have come to realize that the existing model of higher education has yet to adapt to the seismic shifts rattling the foundations of the global economy.

I believe that college should shape students into professionals but also creators. Creation will be at the base of economic activity and also much of what human beings do in the future. Intelligent machines may liberate millions from routine labor, but there will remain a great deal of work for us to accomplish. Great undertakings like curing disease, healing the environment, and ending poverty will demand all the human talent that the world can muster. Machines will help us explore the universe, but human beings will face the consequences of discovery. Human beings will still read books penned by human authors and be moved by songs and artworks born of human imagination. Human beings will still undertake ethical acts of selflessness or courage and choose to act for the betterment of our world and our species. Human beings will also care for our infants, give comfort to the infirm, cook our favorite dishes, craft our wines, and play our games. There is much for all of us to do.

To that end, this book offers an updated model of higher education—one that will develop and empower a new generation of creators, women and men who can employ all the technological wonders of our age to thrive in an economy and society transformed by intelligent machines. It also envisions a higher education that continues to deliver the fruits of learning to students long after they have begun their working careers, assisting them throughout their lives. In some ways, it may seem like a roadmap for taking higher education in a new direction. However, it does not offer a departure as much as a continuity with the centuries-old purpose of colleges and universities—to equip students for the rigors of an active life within the world as it exists today and will exist in the future. Education has always served the needs of society. It must

do so now, more than ever. That is because higher education is the usher of progress and change. And change is the defining force of our time.

A UNIQUELY HUMAN EDUCATION

Education is its own reward, equipping us with the mental furniture to live a rich, considered existence. However, for most people in an advanced society and economy such as ours, it also is a prerequisite for white-collar employment. Without a college degree, typical employees will struggle to climb the economic ladder and may well find themselves slipping down the rungs.

When the economy changes, so must education. It has happened before. We educate people in the subjects that society deems valuable. As such, in the eighteenth century, colonial colleges taught classics, logic, and rhetoric to cadres of future lawyers and clergymen. In the nineteenth century, scientific and agricultural colleges rose to meet the demands of an industrializing world of steam and steel. In the twentieth century, we saw the ascent of professional degrees suited for office work in the corporate economy.

Today, the colonial age and the industrial age exist only in history books, and even the office age may be fast receding into memory. We live in the digital age, and students face a digital future in which robots, software, and machines powered by artificial intelligence perform an increasing share of the work humans do now. Employment will less often involve the routine application of facts, so education should follow suit. To ensure that graduates are "robot-proof" in the workplace, institutions of higher learning will have to rebalance their curricula.

the strengths of both. Humanics can, in short, be a powerful toolset for humanity.

This book also explores how people grasp these tools. To acquire the cognitive capacities at a high level, students must do more than read about them in the classroom or apply them in case studies or classroom simulations. To cement them in their minds, they need to experience them in the intensity and chaos of real work environments such as co-ops and internships. Just as experiential learning is how toddlers puzzle out the secrets of speech and ambulation, how Montessori students learn to read and count, and how athletes and musicians perfect their jump shots or arpeggios, it also is how college students learn to think differently. This makes it the ideal delivery system for humanics.

A new model of higher education must, however, account for the fact that learning does not end with the receipt of a bachelor's diploma. As machines continue to surpass their old boundaries, human beings must also continue to hone their mental capacities, skills, and technological knowledge. People rarely stay in the same career track they choose when they graduate, so they need the support of lifelong learning. Universities can deliver this by going where these learners are. This means a fundamental shift in our delivery of education but also in our idea of its timing. It no longer is sufficient for universities to focus solely on isolated years of study for undergraduate and graduate students. Higher education must broaden its view of whom to serve and when. It must serve everyone, no matter their stage in life.

By 2025, our planet will count eight billion human inhabitants, all of them with human ambition, intelligence, and potential.[18] Our planet will be more connected and more competitive than the one

we know today. Given the pace of technology's advance, we can predict that computers, robots, and artificial intelligence will be even more intricately intertwined into the fabric of our personal and professional lives. Many of the jobs that exist now will have vanished. Others that will pay handsomely have yet to be invented. The only real certainty is that the world will be different—and with changes come challenges as well as opportunities. In many cases, they are one and the same.

Education is what sets them apart.

1

FEARS OF A ROBOTIC FUTURE

The upshot is simply a question of time, but that the time will come when the machines will hold the real supremacy over the world and its inhabitants is what no person of a truly philosophic mind can for a moment question.

—Samuel Butler, "Darwin among the Machines" (1863)

In 2015, Chapman University published the results of a survey ranking the U.S. public's worst fears. "Man-made disasters" such as terrorism and nuclear attacks stood at the top of the list of popular horrors. But in close second place—even more terrifying than crime, earthquakes, and public speaking—was fear of technology. In fact, technology appears to frighten many of us more than the absolute unknown. According to the survey, Americans fear robots replacing people in the workforce more than they fear death—and by a full seven percentage points.[1]

CHAPTER 1

But it is not paranoia if they really are out to get you. Machines have been replacing human labor ever since a piece of flint proved to be sharper than a fingernail. The history of workplace obsolescence is almost as old as the history of work. As technologies increase our capacity for labor, the nature of labor changes. The question is whether the evolution of work in the twenty-first century is qualitatively different from the evolution of work in the twentieth, the nineteenth, or indeed, the tenth century BCE.

ELEMENTS AND WORK

In physics, work is done when a force is applied to an object, moving it in a direction. This expends energy. In biology, all organisms expend energy to obtain nourishment and to continue the process of living, expending, and feeding.

Throughout history, human beings have spent most of their existence expending energy on work to obtain food. But unlike many other organisms, we have invented ways to amplify that energy by harnessing forces far greater than those available to us in our teeth and musculature. Perhaps as early as a million years ago, our ancestors tamed the element of fire.[2] Controlled fire was among the greatest of all work innovations. By cooking food, our ancestors were able to spend less energy in digestion, allowing us to eat useful plants like wheat and rice, destroying bacteria that taxes our bodies, and reducing the work we spend in chewing and processing. This freed us to expend more energy on evolving our enormous brains.[3]

Much more recently, human beings tamed plants and livestock, vastly increasing the amount of energy we could consume and,

As well as being the legendary home of Robin Hood, the city of Nottingham long had been a center for the manufacture of hosiery. However, by 1812, technological innovations were upending the stocking business as the town's factory owners introduced steam-powered mechanical frames, replacing the labor of skilled artisans. These artisans possessed highly developed—but very particular—skill sets that the marketplace no longer needed. Consequently, desperate to save their livelihoods, the indigent laborers formed secret societies under the banner of an invented character, Ned Ludd—a Robin Hood figure updated for the industrial age. Calling themselves "Luddites," in November 1811, they broke into the hosiery factories and smashed the owners' new machines. The uprising soon spread to surrounding communities, forcing the government to call in the military. At one point, more British soldiers were battling the Luddites than were deployed against the French in the Iberian peninsula.[4]

Lord Byron owned land in Nottinghamshire and had witnessed the violence and disruption firsthand. So when the House of Lords sat to debate whether to make frame-breaking a capital offense, he spoke passionately in defense of the Luddites, arguing that the rioters' "own means of subsistence were cut off, all other employment preoccupied; and their excesses, however to be deplored and condemned, can hardly be subject to surprise."[5] In other words, if machines took the weavers' work, they hardly could be blamed for wanting them smashed.

Byron's eloquence notwithstanding, the act passed. Several days later on March 2, the *London Morning Chronicle* published an anonymous poem titled "Ode to the Framers of the Frame Bill,"

although its authorship by Byron was not hard to figure out. Among its more scathing verses:

Men are more easily made than machinery—
Stockings fetch better prices than lives—
Gibbets on Sherwood will heighten the scenery,
Showing how Commerce, how Liberty thrives![6]

For two hundred years, the Luddites have been a symbol of resistance to technological displacement—and over those two hundred years, there has been a great deal of displacement to symbolize. The invention of the tractor took manual laborers off the land and into factories. The development of automated processes in factories took employees off the assembly lines and into the corporate office park. Karl Marx warned of the effects of automation on the proletariat, and John Maynard Keynes believed that machines would cause "technological unemployment."[7]

By the middle of the twentieth century, people's fear of displacement by machines did not apply just to factory laborers. Even as the postwar economy of the 1940s and 1950s saw a huge shift away from manual work to clerical and professional work, as early as 1964, President Lyndon B. Johnson received an open letter from a group of prominent academics warning of technology's potential to undermine the value of *all* human labor.[8]

When farm laborers left their ploughs for city jobs, they needed new skills to function effectively in industrial workplaces. Generations later, when they abandoned their lathes and welding irons for typewriters and dictation machines, their descendants needed to upskill once more. As a matter of fact, when grappling with technological and social changes, people have always responded by improving their education.

THE ENGINE OF PROGRESS

At its best, higher education does not mirror society from a distance. It is not apart from it but runs like a thread through its fabric, conforming to its patterns. Since the emergence of universities in medieval Europe, their chief purpose has always been to equip students for the economic and professional roles of the day. Before Nicolaus Copernicus and Isaac Newton, universities were largely concerned with training ministers, lawyers, and teachers. The economies of medieval Italy, England, and Spain needed literate individuals to conduct affairs of the soul and the state, to record agreements, and to administrate property and institutions. So that is what the colleges of Bologna, Oxford, and Salamanca produced.

In the 1850s, the United States was mostly rural, agrarian, and unlearned. There was no need for more higher education than what was offered by a handful of colonial colleges dealing in what Cardinal John Henry Newman, the theologian and nineteenth-century intellectual, called "liberal knowledge," the purpose of which was to prepare men "to fill any post with credit, and to master any subject with facility." Moreover, Newman believed that the most valuable education would cultivate a man who "is able to converse ... is able to listen ... can ask a question pertinently ... [is] yet never in the way ... [and has] a sure tact which enables him to trifle with gracefulness and to be serious with effect."[9] In short, the colleges of that age largely prepared men to become gentlemen who would thrive in a technologically undemanding but culturally rich economy and society.

Yet even as Newman wrote, that world was changing. Just as the Industrial Revolution remade society in the image of its machines and companies, it also remade higher education. Less than a hundred years after James Watt fired his engine, the U.S. Congress passed the Morrill Act of 1862, giving public land to endow universities that would train a new generation of technological masters. Their goal was "without excluding other scientific and classical studies and including military tactic, to teach such branches of learning as are related to agriculture and the mechanic arts," the new technologies of the day. They accomplished this by modeling the United States' new colleges and universities on the great German research universities that had emerged after the Napoleonic wars.[10]

The new land grant and research universities evolved past the old liberal arts curricula to focus on nonclassical languages, the newly emerging field of the social sciences, and scientific and technological discovery. Building on scientific principles, new branches of ingenuity shot forth from the laboratories and lecture halls. Disciplines like economics, biology, and engineering coalesced around growing faculties. Instead of teaching knowledge dating back to the Greeks and Romans, higher education began to devote its energies to the active creation of new knowledge. Instead of simply cultivating the individual, universities took on the work of cultivating economic and social progress.[11]

Progress required the individual's participation, so the individual needed the appropriate schooling. As early as the 1830s, educators in the United States were looking overseas to Prussia for ideas on how to formalize a system of education for the nation's children. Reformers such as Horace Mann advocated a form of

schooling that was free, universal, and nonsectarian and that would teach children how to be good citizens and participants in a modern republic.

In 1848, Mann introduced this Prussian model to Massachusetts, establishing the basis for much of the K–12 system that persists to this day. And although it now is fashionable to criticize it as a "factory model" designed to batch-process masses of students to enter roles in an industrial economy—cutting cogs to fit the machine—it successfully educated generations of young Americans for the demands of their times. Until the 1940s, that meant joining a massive migration to urban centers and the rapid mechanization of work.

On June 22, 1944, with American troops still battling through the hedgerows behind Omaha Beach, U.S. higher education undertook its next pivotal transformation. Anticipating the return of millions of veterans into the fold of civic life and the need to integrate them into the economy, Congress passed the Servicemen's Readjustment Act—better known as the G.I. Bill—one of the benefits of which was provision of tuition and living expenses for college attendance.

Not since the land-grant movement of the 1860s had there been such a dramatic widening of access to higher education. The returning veterans flooded in, soon becoming more than 50 percent of the country's college population. By 1956, the G.I. Bill had helped more than 2.2 million Americans attend college.[12] To accommodate these huge numbers of new students, universities needed to expand radically, and they did so through a huge investment to expand state's public higher education systems, including creating a new type of school—the community college.

half of the twentieth century. As companies grew more complex, people needed more training to fill the roles of accountant, lawyer, and manager. There was a clear link between a university degree and an employee's ascent up the corporate ladder. Indeed, the connection between the two remains immutable. The so-called wage premium for having a college degree had risen steadily since the 1960s, eventually reaching a median of about 80 percent higher hourly earnings over people with solely high school diplomas.[18]

A WRENCH IN THE ENGINE

For thousands of years, human beings worked the land. Two hundred years ago, machines displaced farm laborers because they were physically stronger and faster at the grueling tasks demanded by agriculture. Some of these farmers found better lives working in the industrial economy, applying themselves to rote work that required some, but not much, education. In turn, their descendants eventually began to surrender those factory jobs to machines that were more efficient at routine tasks, requiring industrial employees to educate themselves further in order to rise to better positions in corporate offices. Finally, in the late twentieth century, computers began to perform routine cognitive tasks with an efficiency that no human being could match, invading the accountancy office, the call center, and the secretarial pool.

Cycles of automation and disruption generally have led to elevated living standards and economic growth as people found jobs performing work that machines could not. But as machines have sped up, so have the cycles. As computers and advanced machines take the next leap forward and attain high levels of cogni-

tion, they are poised to replace professionals who make decisions based on information: in other words, they are poised to replace thinkers. We now have machines that write news articles, translate foreign languages, and interact pleasantly with customers. We have machines that edit the genomes of the life we know and scan the universe for the life we do not. Machines build our automobiles and will soon drive them. On Wall Street, they are ousting financial analysts by the hundreds, with some observers estimating that between one-third and one-half of all finance employees will be replaced by software within the next ten years.[19] In a few years, they may stand in for human surgeons in performing operations like appendectomies.[20]

Scott Semel, the chief executive officer of "cloud-based Content Collaboration Network" Intralinks, has said that machines are much better than legal associates at scanning and summarizing large numbers of leases or licensing agreements. "The A.I. just does the same thing over and over and over and over again," said Semel. "People get tired. Two different people could read the same contract. Somebody could finish half of it and go home, stay out too late, come back hungover. There are lots of variables around that. And that kind of work, which is summarizing, distilling lots of data into buckets, it's something that machines can do well."[21]

Shelves of recent books have delved into the economic implications of the emergence of intelligent machines. Klaus Schwab, founder of the World Economic Forum, released a title on the subject prior to the group's 2016 annual meeting, where automation was, not coincidentally, at the top of the agenda.[22] Magazines and news sites do a brisk business in headlines forecasting the end