DOI:10.1145/2644230

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The Profession of IT
Learning for the New Digital Age

Digital machines are automating knowledge work at an accelerating pace. How shall we learn and stay relevant?

THE FIRST OF the two accompanying images shows the IBM Blue Gene supercomputer at Argonne Labs. It houses 250,000 processors in 72 cabinets connected by an optical network. It can perform approximately 10^{15} operations per second—a million times faster than the chip in your smartphone. The image on the next page is a beautiful graph of connections between Internet sites. The Internet is a supercomputer grown from a billion machines and several billion people.

The IBM supercomputer is a wholly electronic machine. It uses a robust design first conceived in the 1940s. Its structure is fixed. It is very good at processing large datasets with deterministic algorithms. It has no intelligence.

The Internet is an organic system with humans and machines in a never-ending dance of interaction amplifying each other's capabilities. It is constantly changing its structure and some of the changes are disruptive. It is nondeterministic because there is no way to predict how interactions among so many people and machines will turn out. It has intelligence—the collected, amplified, collaborative intelligence of everyone who participates in it.

The Internet organism is not replacing the machine. It is a new system built on machines, mobile devices, their connections, and their interaction with humans. The network of machines is the infrastructure of the organic system.

The two images represent not only developmental stages of computing, but also different approaches to understanding the world. The machine view represents the advancement of science, which seems poised to know all data, predict what will happen, and enable stabilizing controls over social and economic systems. The organism view exposes an unruly, ever-evolving world, rife in uncertainties, unpredictable events, and disruptions. Our attitudes toward learning new things and staying professionally relevant belong to the age of the machine. What do we need to stay professionally relevant in the age of organism?

IBM Blue Gene supercomputer.

PHOTOGRAPH COURTESY OF ARGONNE NATIONAL LABORATORY

The New Machine Age

Erik Brynjolfsson and Andrew McAfee refer to the new, organic era as the second machine age.[1] Computers are automating knowledge work just as engines began automating manual work two centuries ago.

Historians put the beginning of the previous machine age at the invention of the steam engine by James Watt around 1781. Many say engines were the moving force behind the Industrial Revolution. By automating manual work, engines increased productivity and opened new markets for factory-manufactured goods, creating widespread prosperity and many new jobs. By the early 1900s, machine-based factory operations were so well understood that Frederick Taylor, a mechanical engineer, formulated the famous theory of scientific management, which allowed many factories and businesses to be optimized for maximal production.

In the 1960s, management guru Peter Drucker coined the term "knowledge worker" for workers who depended on their minds rather than manual labor to produce value. Until that time, much knowledge work had been spared the ravages of automation. Because knowledge work was an ever-increasing portion of the labor market, Drucker considered knowledge worker productivity to be the next frontier of management. He foresaw that computers would play an increasing role in automating knowledge work.

IBM, founded in 1924, was one of the first companies to apply computing machines to business data processing, an early form of knowledge work. IBM's

machines sorted and arranged punched cards representing inventories and customers. They enabled the growth of large corporations with worldwide operations. When it introduced the first hard disk, RAMAC, in 1956, IBM said the new machine could condense an entire warehouse of file cabinets onto a single disk and automate all the clerical functions of storing, retrieving, and analyzing files.

Since that time, the computing power of chips, storage, and networks has grown exponentially. We are digitizing everything and can manipulate the digital representations of almost anything. We can connect with almost anybody. These factors foster new waves of innovation. An example of a wave is the world of "apps"—small software programs with tightly focused functions that customize our mobile devices into personalized extensions of ourselves. App development is unlike any previous manufacturing world. New apps can be produced cheaply, copied any number of times perfectly, distributed at near-zero cost, and sold at low prices. Network-connected apps deliver amazing new capabilities that were considered impossible just 10 years ago. Apps craft our personal spaces, see and manipulate our environments, interface to large systems, and even lift our spirits and our hearts. The Apple and Android stores offer over 700,000 apps.

Automation and Jobs

Brynjolfsson and McAfee argue that digital machines are displacing less productive workers in a large number of job categories. In the Great Recession beginning in 2008, employers downsized labor forces and automated functions previously done by human workers; as the recession slowly ended, they did not rehire many displaced workers. Job growth has since been slow because the displaced workers do not have the new skill sets needed in the rapidly growing digital high technology sectors. There are few education programs to help them make the transition.

Disparity of wealth increases in the wake of digital automation. The relatively few designers and engineers who build the new technologies are well paid in salaries and in capital gains (for example, stock options); their technologies can displace relatively many workers. Although wealth spreads are a normal feature of technology expansion, they are worrisome when they get large enough to create social tensions. Examples are the resentments of the 1% who hold 99% of wealth, the gap between CEO and worker pay, and of soaring rents in San Francisco driven by the influx of high-tech industry workers and executives.

Automation may not be the only factor impeding job growth. John Dearie and Courtney Geduldig argue that, in the U.S. at least, almost all *new* jobs are created by businesses less than five years old, but recent restrictions from government regulations and tax structures have caused a sharp drop in new-company formation.[2] They propose regulatory and tax reforms that exempt new businesses from much of the regulatory and tax burden, allowing entrepreneurs access to the capital they need to get started. Human capital expert Edward Gordon has similar proposals and strongly endorses education as a way to help overcome persistent joblessness.[4]

Whatever the correct explanation, almost everyone agrees that education is a powerful means to increase mobility of workers and reduce the spread between high and low incomes.

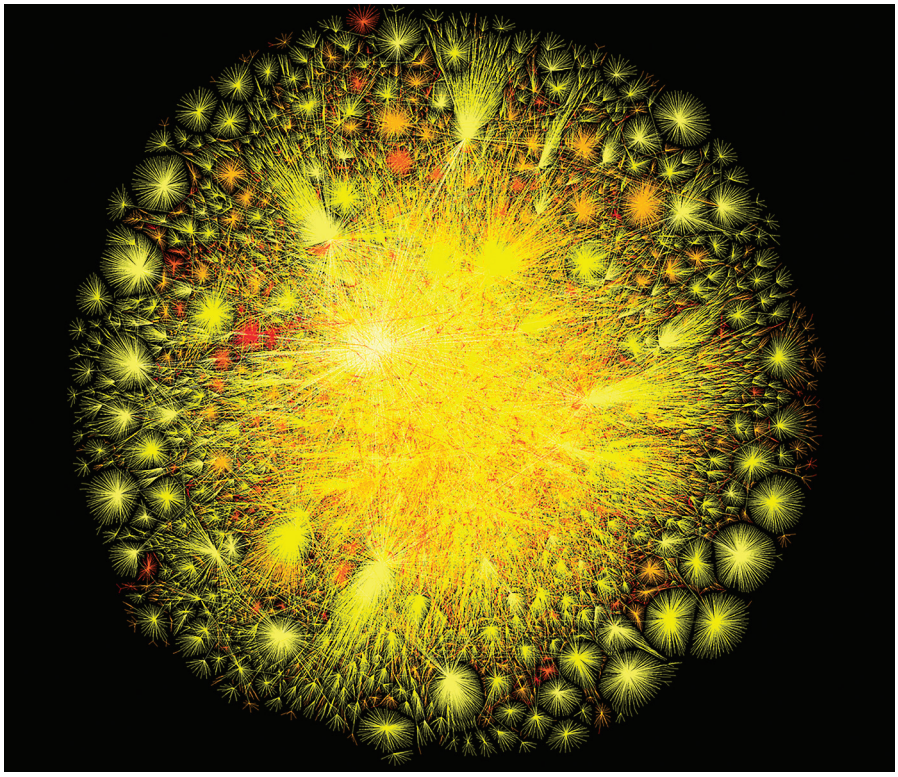
Still, Brynjolfsson and McAffee are optimistic we can design new education programs that help workers move into new areas. They believe the process of automation displacing workers is likely to be gradual and that the secret to success will be to show people how to generate new value from the machines—to race "with" the machines instead of "against" them.

What to Learn?

Two excellent analyses of what education can do to help professionals keep up with accelerating changes in the job markets can be found in the Chile report *Surfing Towards the Future*[3] and in the book *A New Culture of Learning* by Douglas Thomas and John Seely Brown.[5]

Both books observe that our current school systems are structured around assumptions that are becoming less and less tenable. The bodies of knowledge of many technical fields are changing more rapidly than curricula; a degree may be obsolete before its holder graduates. A graduation certificate is less valuable than demonstrated ability to perform, adapt to accelerating changes, and mobilize networks to get jobs done. The Chile report discusses three dimensions of education for this world.

Pragmatics. This has two aspects.



An Internet graph rendered using Border Gateway Protocol data points circa 2010.

IMAGE COURTESY OF BARRETT LYON/OPTE.ORG

One is the learning of skills for competent performance in your domain or profession. The other is learning social interaction skills in communication, coordination, identity, listening, trust, making history, cultivating pluralistic networks, and more. As a professional, you need both kinds of skills to function well.

Coping with accelerating change. Changes in our social systems always happen as historical emergences—responses to events and concerns at a particular time. Professionals need the skills of designers and entrepreneurs to lead and manage the changes, to deal with the moods and emotions of those affected by the changes, and to deal with the economic and social consequences of changes. Professionals also need to be able to cope with disruptions and help others to cope. Disruptions can be large, for example when societies or businesses undergo sharp change; and they can be highly personal, such as a death or illness in a family or loss of a job. They can be relatively slow declines, such as the obsolescence of an industry, rather than cataclysms. Whether large or small, if a disruptive event hits you, you may suddenly find that your skills and practices are no longer of value. The source of your professional identity is gone. You must learn how to detach, let go, and invent new offers for the world that you now find yourself in. This is very difficult but it is essential.

Mentoring. Mentoring is the central skill powering learning networks. It means more-experienced people help less-experienced people learn new skills and form new networks and communities. It means mobilizing networks to get particular jobs done. It means cultivating design and entrepreneurial dispositions such as listening, proposing, experimenting, questing, inquiring, reflecting, and caring for future generations and the planet.

These three dimensions do not exist in the current formal educational system. A new kind of education system is likely to form, whose professionals are skilled mentors. They will integrate many traditional technology fields, such as engineering and computing, with development fields including somatics, coaching, language-action, and social networking. However, you cannot wait for someone to do this for you. You need to find existing communities in the Internet that enable you to learn in these dimensions.

Our attitudes toward learning new things and staying professionally relevant belong to the age of the machine.

Thomas and Seely Brown argue that you can access this kind of learning through numerous learning communities already existing in the Internet.[5] In a learning network the participants become immersed in conversations and actions together. There are tasks for members at all levels of skill, and the more experienced mentor the less experienced. For example, the Faulkes Telescope project (http://www.faulkes-telescope.com/) allows middle and high school students to schedule time on a robotic telescope, take pictures, and process the pictures with a library of image software. They interact with professional astronomers as they share, evaluate, and interpret their pictures.

Learning networks are ubiquitous. People with illnesses share their experiences about their therapies and support each other. Technical support discussion groups are far better at troubleshooting modern computers and networks than manuals and technical support phones. Crowdsourcing services mobilize many strangers to find solutions of problems posted by sponsors, and pay the winners for their time. Even online games such as World of Warcraft have been cited in business journals as learning networks for certain kinds of leadership skills.

Learning networks differ in at least six ways from traditional schools:

- There is no authority figure such as the "teacher"; anyone can be a mentor if they know something, can listen, and motivate.
- Participants can be involved at different levels: passive observing (hanging out), scattered experimentation (messing around), and serious projects (geeking).
- Some learning communities cultivate tolerance of pluralistic views and willingness to cooperate with people of different cultures.
- The network encourages experimenting.
- The network cultivates important dispositions such as questing and inquiry.
- Networks can operate as loose collectives or as tight-knit communities.

Over time, there will be more of these networks, they will be easier to find, and they may eventually converge with formal schools. Learning networks are excellent at coping with accelerating change and, in a growing number of cases, they are leading change.

What Can You Do?

If you are reading this, you are most likely a member of the computing field and are less likely to be one of the displaced workers. I hope you will reach out to people in other fields, who may be in the process of being displaced by your work, and help them find education programs and learning networks so that they may find new work. You also need to pay attention to your own professional health, especially if you are in an area where automation is possible. Find ways to learn social interaction pragmatics, coping with changes, and mentoring. Constantly focus not on fighting machines but using them to to increase your own productivity and value. Find and participate in learning networks on topics of interest or concern to you. C

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