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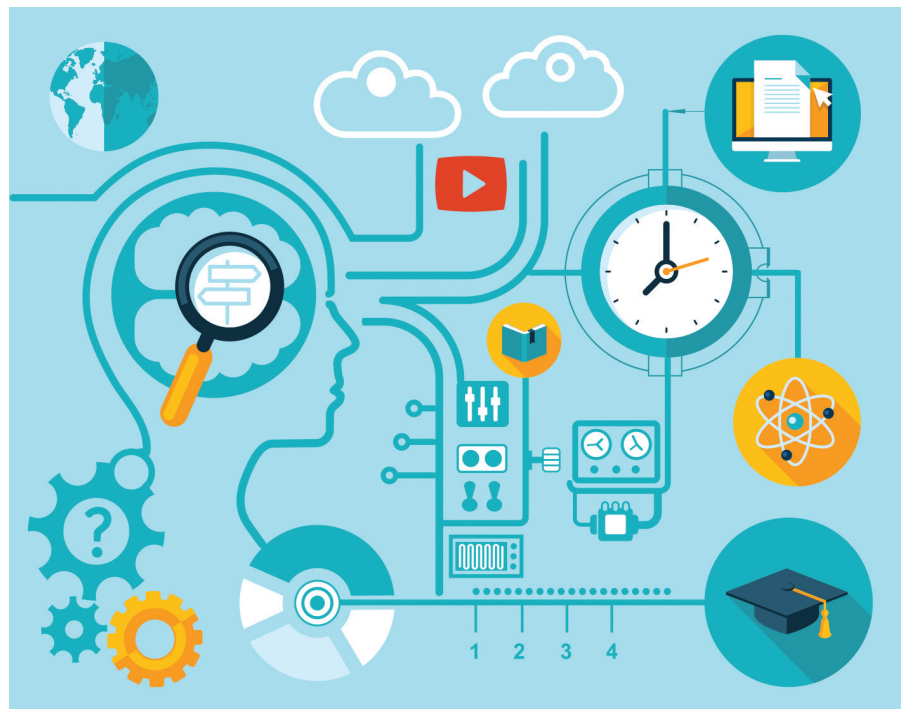
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The Profession of IT Avalanches Are Coming

Computing technology has generated conditions for radical transformations of jobs and professions—including education. How shall we cope?

HAVE YOU NOTICED how profoundly information technology is affecting jobs and professions? Previous waves of technology innovation mostly automated manual work: machines displaced blue-collar workers, leaving relatively untouched the white-collar “knowledge workers” celebrated 50 years ago by Peter Drucker. The current wave of information technology innovation is different. It is automating knowledge work and taking jobs away from the middle class. It is producing the greatest financial returns for the designers and builders of the machines, thus contributing to income inequality that troubles so many people.^{2,6}

Ubiquitous mobile computers deeply connected into vast networks of information efficiently automate cognitive tasks. For example, Apple’s iPhone can talk, answer spoken questions, and recognize fingerprints. Laws in four U.S. states now authorize Google’s driverless car. Google Glass overlays real-time displays onto visual scenes, eerily reminiscent of the Star Trek Borg. Graphics processors make virtual worlds look breathtakingly real. IBM’s Blue beats world chess grandmasters and IBM’s Watson matches natural language patterns faster than the best human “Jeopardy!” players. Supercomputers now pore through huge databases of phone and email metadata to produce detailed reports of any person’s movements—and predict their future movements. Facial recognition software does remarkably



well at identifying persons in surveillance videos. None of these things seemed possible two decades ago.

During the recent period of global recession, many businesses and government agencies turned to computer-driven automation to increase productivity with fewer workers. As the recession receded, these organizations did not rehire many of the workers they laid off because the machines had replaced them.

In past eras, people looked to education to help them past the disruptions caused by technology innovation. Education could help displaced workers learn new skills and enter new profes-

sions. It could help existing professionals stay a step ahead of technology changes. It could channel young people into emerging professions. But now technology advances are disrupting the education system itself. Can the education system help in the current crisis?

I have no answers to these dilemmas. But several new works have looked deeply into these changes and give some insights in ways to cope. These works portray the coming radical transformations as “avalanches,” meaning the conditions are ripe for major disruptions whose timing is totally uncertain. The potential for avalanches creates great uncertainty

because our science and technology cannot predict or control the changes. I will focus here on education, which has historically been the savior during technological transformations.

An Avalanche Is Coming

Michael Barber, Katelyn Donnelly, and Saad Rizvi offer an unsettling assessment of how many familiar aspects of the higher education system may be disrupted by unbundling in the coming years.¹ They begin by noting six big trends: globalization of markets for faculty and students, debt crises causing governments to reduce education subsidies, tuition hyperinflation, falling value of formal degrees (median salaries of bachelor's degree holders are down 15% since 2000), ubiquity of free content, and hot competition (for example, MOOCs). These trends have created a climate for third parties to perform individual, traditional functions of a university at a significantly lower cost.

The result is that the 10 traditional functions of university (see the accompanying table) are being unbundled. A student can assemble a package of unbundled functions to approximate a big university at a fraction of the cost.

The MOOC is a highly visible example of potential disruption. This technology suddenly grabbed attention in 2011 when Stanford University made its artificial intelligence course available tuition-free worldwide, and got 160,000 registrants. Entrepreneurs quickly founded new companies and consortia including Coursera, Udacity, and EdX to offer courses from elite universities tuition-free worldwide. These groups have developed platforms to deliver content, interact with students, assess progress, and provide certificates of completion. The promoters see MOOCs as mass-production machines that automate all the processes of a traditional class and scale them up for tens or hundreds of thousands of students. MOOCs have inspired experiments with new modes of learning such as the “flipped classroom” and the “10-minute video.” At the same time, the early figures raise questions about some of the promoters' claims. For example, MOOCs have experienced attention-grabbing attrition rates in excess of 90%; is the reach of MOOCs

likely to be much less than promoters claim? Many course graduates have already covered the material in another course; are current MOOC offerings too high-level for uneducated people in developing countries? Is it ethical to sell the names of active students to prospective employers? Will the need for faculty and teaching assistants plummet? Are MOOC production studios a good investment?

As interesting as these questions are, MOOCs are a threat in just one of the 10 dimensions. Disruptions are brewing the other nine. Avalanches from other directions are more likely.

Barber et al. argue that universities will have to develop distinctive offers to survive. Few universities fully configured to offer all traditional services will be sustainable. Specialized universities can emerge including elite, mass, niche, local, and lifelong learning. Although the primary goal of education—to transmit a culture to the students—is unchanged, many practices will change.

And Barber et al. argue that the current ranking systems (for example, by *U.S. News and World Report*) are stacked in favor of the elite universities. Only those with large research enterprises and small student-faculty ratios can earn the highest rankings. There is no way to measure excellence in other distinctive categories such as mass education, niches, local service, or continuing education. Barber et al. would like to see that ranking system dismantled.

Surfing Toward the Future

The authors of the surfing report,⁴ which I highlighted in my December

2013 column, devoted a whole section to education. Their concern is that education should help prepare people for a fast-changing world where technology enables radical transformations at an accelerating pace. They argue that the education system must be reformed to live up to this challenge.

The biggest change for education is to prepare people to function well in a world replete with uncertainties. The tradition of scientific and technological knowledge gives the illusion that things follow laws, have predictable paths, and can be controlled. But since technology is embedded in human social systems, and its use depends on unpredictable human actions and declarations, the path of technology itself is unpredictable. Yes, we can see gross trends like Moore's Law in the technology; but we cannot say with any certainty which of many future possibilities will turn out. And often some of those possibilities are radically disruptive and unexpected. The same question challenges many countries: How do we want our education system to prepare our young people for a world full of uncertainties?

The authors argue that two great meta-skills, design and entrepreneurship, give the essence of a new response to this question. Design is concerned with understanding the concerns and issues of a community and making proposals to combine existing technologies and components into a means of dealing with those concerns. Designers perpetually interpret the world; they are exploratory, sensitive to symbolism and identity, respectful of reality,

Functions of a traditional university (adapted from Barber et al.¹).

1. Research	Journal publications, reports, citations, patents.
2. Degrees	Diplomas, certificates, transcripts; brand values.
3. Local connectivity	Economic and social development of region.
4. Faculty	Professors, lecturers, teaching assistants.
5. Students	Full and part time, usually 18–22 years of age.
6. Governance	University leadership, board; processes such as admissions, record keeping, fundraising, alumni services, maintenance.
7. Curriculum	Subject-based courses grouped into degree programs; faculty prepare course content and syllabus; textbooks; reading materials.
8. Pedagogy	Lectures, presentations, seminars, tutorials, project and thesis advising.
9. Assessment	Exams, finals, thesis defenses, project presentations.
10. Experience	Student organizations, co-curricular activities (such as debating or research competitions); extracurricular activities (such as drama, sports), work experience (such as volunteering, internships).

and mindful of ethical consequences of their proposals. Entrepreneurship is concerned with creating offers and transforming markets to take care of concerns. Entrepreneurs also listen for concerns, they create businesses, they build trust, and they are constantly reading the world. Designers and entrepreneurs often work together.

The authors discuss the moods (dispositions) that facilitate the work of designers and entrepreneurs. Topping their list are gratitude for what is already here, care for future generations, and radical hope. Radical hope is a name they borrowed from Jonathan Lear⁵ to cope with disruptive transformations: it is a disposition to accept the change, let go of the identity of the past, and invent new offers in the new world. The authors propose that education institutions learn how to cultivate these dispositions.

The authors also discuss at some length the disillusionment of youth at the current education system. The current system focuses on transmitting knowledge in the form of many facts and processes students must memorize. But, not seeing much of it as useful in the world, students react with boredom and indifference. They do not learn the practices and dispositions that will help them cope with uncertainty.

An example of the disconnect can be seen in the way job interviews now work. A decade ago, the degree certificate and a good résumé were the tickets to employment after graduation. But employers have not found much correlation between degrees and success at work. Instead, they have invented their own performance-based interview processes. You demonstrate your knowledge of programming by solving problems during the interview. Young people are smart: they learn how the companies interview and do their own preparation, often outside of school. They wind up thinking that a lot of school is irrelevant.

How and What to Learn

In recent years, the term “knowledge” has narrowed to mean information—the facts and recorded narratives of a field. The term “body of knowledge,” common in education circles, denotes an organized compendium of the topics to be covered by a curriculum.

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But the wisdom of the ages tells us knowledge is much broader than this. Knowledge also includes the ability to perform skillfully, for example, when we say a taxi driver knows the city or a software engineer knows an operating system. It also includes the ability to know a good direction of movement to achieve a goal. We have terms for these three shades of meaning of knowledge: *descriptive knowledge*, or knowing about; *practices*, or knowing how; and *dispositions*, or knowing which direction to move.

Douglas Thomas and John Seely Brown use the terms *homo sapiens* (one who knows), *homo faber* (one who makes), and *homo ludens* (one who plays or experiments) to refer to personifications of these three kinds of knowledge.³ The latter two are easy to miss since they depend on “tacit knowledge,” which is what we know but cannot put in language how we do it. Thomas and Brown say our education system is based on a philosophy that elevates explicit knowledge to the top priority and gives students little opportunity to become skillful at essential practices or develop useful dispositions. They call for a rebalancing of the system, giving equal emphasis to all three.

Their attention to dispositions is novel. A disposition is a tendency to interpret the world and act in it in a certain way. This kind of knowledge must be cultivated. It cannot be presented as facts or learned through practice. Thomas and Brown say the kinds of dispositions needed in the new world are curiosity, questing, connecting, and reflecting. Their list complements Flores’s list of design, entrepreneur-

ship, gratitude, future caring, and radical hope. Certainly this list is incomplete. A military school might aim to cultivate a warrior disposition; a business school might aim for a marketing disposition. All the authors praise virtual realities, virtual learning communities, and games as spaces that can encourage these dispositions.

Educators do not seem to have spent much time thinking about how to cultivate dispositions, which are often seen as “values” left to extracurricular activities such as clubs.

What It Means for You

Big changes are afoot. Accelerating technology is creating greater uncertainty, and threatens disruptions of familiar institutions. No one knows when or if the disruptions might occur; they can be as sudden and as devastating as an avalanche.

An avalanche can come to your part of the computing profession if your work is of the kind that faster computers and big data processors can automate.

Your best defenses are in education. Pay attention to the knowledge, practices, and dispositions you have. Find mentors to help you learn new practices. Join learning communities to help you foster new dispositions. Spend a lot more time reading to find out what is going on in the world. Take advantage of new education opportunities such as MOOCs. ■

References

1. Barber, M., Donnelly, K., and Rizvi, S. *An Avalanche is Coming: Higher Education and the Revolution Ahead*. <http://www.pearson.com/avalanche>.
2. Brynjolfsson, E. and McAfee, A. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. W.W. Norton, 2014.
3. Douglas, T. and Seely Brown, J. *A New Culture of Learning: Cultivating the Imagination for a World of Constant Change*. Create Space Independent Publishing Platform, 2011.
4. Flores, F. Report of Consejo Nacional de Innovación para la Competitividad. *Surfing Towards the Future: Chile on the 2025 Horizon*. 2013; <http://chile-california.org/surfing-towards-the-future-into-counselor-fernando-flores-vision-for-innovation>.
5. Lear, J. *Radical Hope: Ethics in the Face of Cultural Devastation*. Harvard University Press, 2008.
6. *The Economist*. The future of jobs; Technology and jobs. (Jan. 18, 2014).

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