

Why AI could destroy more jobs than it creates, and how to save them

Automation may be destroying jobs faster than it's creating new ones, but all hope isn't lost. TechRepublic spoke to Erik Brynjolfsson on changing the course of the future.

Erik Brynjolfsson has a dream of the future. Or perhaps more accurately, a nightmare.

A vision of a world where computers entrench the power of a wealthy elite and push the majority into poverty. A world where the rising tide of technology doesn't lift all boats, but sucks under all but the biggest ships.

Brynjolfsson is an economist at the Massachusetts Institute of Technology (MIT) and co-author of [The Second Machine Age](#), a book that asks what jobs will be left once software has perfected the art of driving cars, translating speech and other tasks once considered the domain of humans.

Dystopia is only one outcome foreseen by Brynjolfsson, but why does he even think it's a possibility?

New technology has upended industries for millennia. But the advent of the power loom or steam engine didn't permanently rob men of labour. So what makes today different? For Brynjolfsson it is the pace at which digital technologies grow in power, together with signs that computers are already diminishing the role of human labour.

The exponential rise in the capabilities of computer chips was famously noted by Intel co-founder Gordon Moore, who spotted that the number of transistors packed into a chip doubles about every 18 months. In the 40-plus years since he made that observation the transistor count of computer processors has climbed from 2,300 to more than four billion, and with each doubling comes a leap in the sophistication of the logic the chip can handle.

"The accumulated doubling of Moore's Law, and the ample doubling still to come, gives us a world where supercomputer power becomes available to toys in just a few years, where ever-cheaper sensors enable inexpensive solutions to previously intractable problems, and where science fiction keeps becoming reality," Brynjolfsson and Andrew McAfee, associate director of the Center for Digital Business at MIT, write in the book.

"Sometimes a difference in degree (in other words, more of the same) becomes a difference in kind (in other words, different than anything else). The story of the second half of the chessboard alerts us that we should be aware that enough exponential progress can take us to astonishing places," the book continues.



Baxter is a robot made for manufacturing environments that can perform a variety of repetitive tasks.

Image: Rethink Robotics

Brynjolfsson identifies various astonishing technologies lining up to encroach on human labour. Take Rethink Robotics' [Baxter](#), a robotic humanoid torso complete with arms, claw-like grips and a head with an LCD face. Baxter is designed to replace factory line workers employed in repetitive but as-yet-unautomated tasks, such as inserting large components into circuit boards. Baxter can be trained to carry out new jobs far more simply than its robotic predecessors, primarily by taking its arm and guiding it to where it needs to pick up and drop items. His 'hands' can be swapped out for suction cups or different grippers to allow him to take on different tasks. That flexibility and rapid retraining, together with Baxter's low price relative to other industrial robots, opens up the possibility of automating a swathe of new roles.

However, Baxter is but one mechanised usurper Brynjolfsson sees waiting in the wings. In the warehouse there are [Kiva Systems'](#) knee-high bots designed to lift items from shelving, in the office the [Double telepresence robot](#), and of course the superstars of advanced computing, Google's self-driving car, and [IBM's quiz-showing winning Watson](#).

Brynjolfsson points out that the rate of technological change is of a different order in the information age to the industrial revolution.

"I think it's going to require a similar level of overall change but it's probably going to have to happen faster. The steam engine was a remarkable breakthrough and really set off the industrial revolution, but as we say in the book it doubled in power and efficiency approximately once every 70 years and quadrupled after 140 years," he said.

"The computer processor doubles in power every 18 months, 10 times greater every five years, it's a very different scale of advancement and it's affecting a broader set of the economy than the steam

engine did, in terms of all the cognitive tasks. It's happening a lot faster and more pervasively than before."

But is it correct to link the rate of societal change, and of advances in artificial intelligence, to the breakneck pace at which processors are becoming more powerful? Not everyone agrees.

"Unlike much of the 20th century we're now seeing a falling ratio of employment to population." Erik Brynjolfsson

Nick Jennings, professor of Computer Science at Southampton University has years of experience working with agent-based computing and intelligent systems. He doesn't foresee runaway advances in the field of AI that will reverberate throughout the rest of society.

"[I don't see] major shifts, no," said Jennings. "I see a gradual increase in automation and a gradual increase in the software tools that people have to support them in their day-to-day work. I don't see any non-linearities, I see processing getting better, speeds getting better, more data becoming available and us running more complicated algorithms on that data. I don't see anything that is going to cause a phase change or a disjunction in one go.

"Barring a quantum computing appearing, something that really would change the game for everything. I think standard breakthroughs that everyone is going to see, steady, inexorable progress," he added.

Are people already losing out to tech in the workplace?

Even with computing technologies improving at that "steady, inexorable" rate, jobs may be being destroyed faster than they are created.

For most of the second half of the twentieth century the economic value generated in the US - the country's productivity - grew hand-in-hand with the number of workers. But in 2000 the two measures began to diverge. From the turn of the century a gap opened up between productivity and total employment. By 2011, that delta had widened significantly, reflecting continued economic growth but no associated increase in job creation.

FIGURE 11.1 Labor Productivity and Private Employment



Image: Erik Brynjolfsson/Andrew McAfee - The Second Machine Age. Jared Bernstein/Center on Budget and Policy Priorities

"Unlike much of the 20th century we're now seeing a falling ratio of employment to population and that's something that concerns us. We don't think it's inevitable but we do think that many of the underlying trends in technology are likely to accelerate this so it's something we need to pay some serious attention to," said Brynjolfsson.

That schism manifests in other disparities. Over the past quarter of a century the income gap between the richest and the poorest in OECD countries has continued to widen. Today the average income of the richest in these countries is nine times that of the poorest.

And it's not the only stat that spotlights the widening inequality. For the first time since the Great Depression, over half the total income in the United States went to the top 10 percent of Americans in 2012. On top of that, between 1973 and 2011 the median hourly wage in the US barely changed, growing by just 0.1 percent per year.

This wealth gap isn't restricted to America. In Sweden, Finland and Germany, income inequality has grown more quickly over the past 20 to 30 years than in the US.

The book states:

"Production in the second machine age depends less on physical equipment and structures and more on the four categories of intangible assets: intellectual property, organizational capital, user-generated content, and human capital," the book states, going on to point out that in the US, the share of GDP going to labor has declined over the past decade, falling to its lowest point in the third quarter of 2010, 57.8 percent.

"As The Nobel Prize-winning economist Wassily Leontief agreed, stating definitively in 1983 that 'the role of humans as the most important factor of production is bound to diminish in the same way that the role of horses in agricultural production was first diminished and then eliminated by the introduction of tractors'."

FIGURE 9.1 Real GDP vs. Median Income per Capita

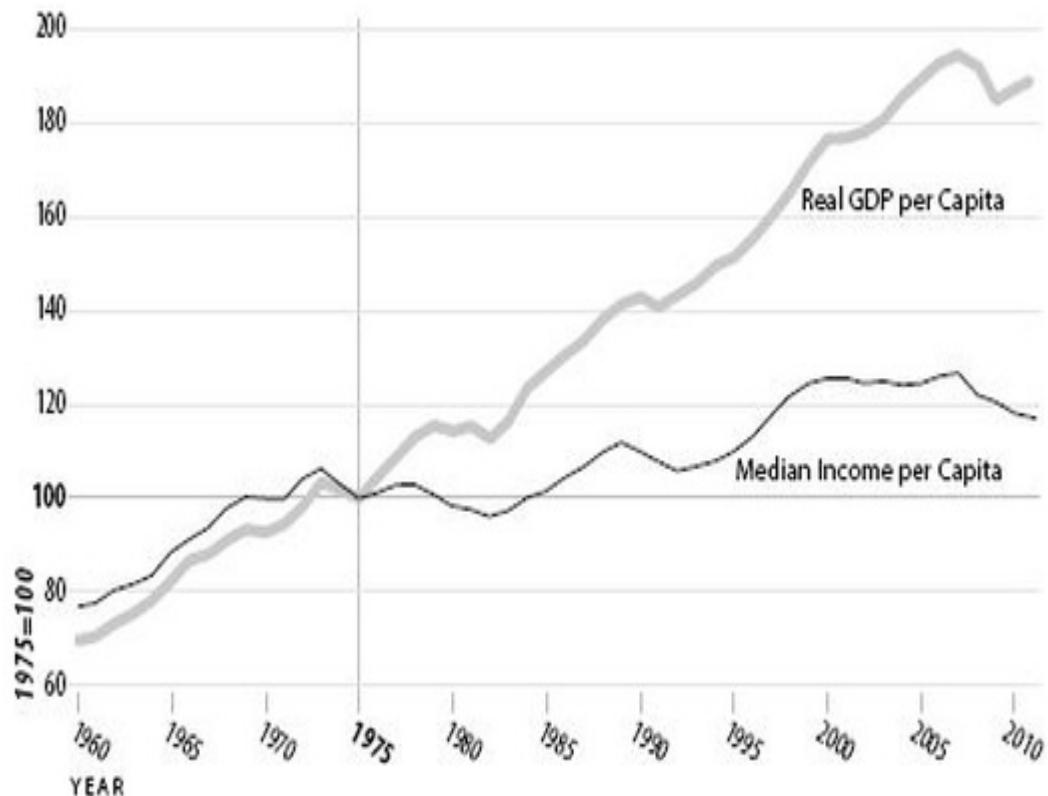


Image: Erik Brynjolfsson/Andrew McAfee - The Second Machine Age

The prediction that society is heading towards a period of technological unemployment was made decades ago by John Maynard Keynes, who forecast it as an inevitable outcome of society discovering ways to make labour more efficient more rapidly than finding new uses for labour.

"There's no economic law that says 'You will always create enough jobs or the balance will always be even', it's possible for a technology to dramatically favour one group and to hurt another group, and the net of that might be that you have fewer jobs," said Brynjolfsson.

Which jobs are at risk?

So what sort of jobs does Brynjolfsson think will fall before software automation and [the ability of computer systems to spot patterns in vast stores of data](#)? Unsurprisingly, it's those tasks that are routine and easily defined.

"These middle-skilled structured tasks, routine information processing tasks will continue to be under a lot of pressure: bookkeepers, travel agents, legal aids — maybe not lawyers or attorneys but the first level associates. I already talked to one big law firm and they said they're not hiring as many of those sorts of people because a machine can scan through hundreds of thousands or millions of documents and find the relevant information for a case or a trial much more quickly and accurately than a human can," said Brynjolfsson.

Beyond these roles Brynjolfsson pictures call centre operators gradually being replaced by question-answering, automated systems - born of a marriage between IBM's [Jeopardy-winning system Watson](#) and Apple's Siri virtual assistant. He also foresees some driving roles being reduced to babysitting a computer that controls the vehicle for the majority of the journey — freeing up the human driver to complete other tasks.

Brynjolfsson is talking about the near future, but wind forward a couple of decades and the successors to the deep learning and other artificial intelligence techniques of today could have automated away half of the jobs that exist in the US today.

That's the prediction of Carl Benedikt Frey and Michael A. Osborne from Oxford Martin School & Faculty of Philosophy in the UK.

"According to our estimate, 47 percent of total US employment is in the high risk category, meaning that associated occupations are potentially automatable over some unspecified number of years, perhaps a decade or two," they predict in the report *The Future of Employment*.

During the coming decades they forecast two "waves of computerisation" during which different categories of jobs will be washed away, with no field of employment left untouched.

"In the first wave, we find that most workers in transportation and logistics occupations, together with the bulk of office and administrative support workers, and labour in production occupations, are likely to be substituted by computer capital.

"According to our estimate, 47 percent of total US employment is in the high risk category, meaning that associated occupations are potentially automatable" Carl Benedikt Frey and Michael A. Osborne

"As computerised cars are already being developed and the declining cost of sensors makes augmenting vehicles with advanced sensors increasingly cost-effective, the automation of transportation and logistics occupations is in line with the technological developments documented in the literature.

"Furthermore, algorithms for big data are already rapidly entering domains reliant upon storing or accessing information, making it equally intuitive that office and administrative support occupations will be subject to computerisation.

"The computerisation of production occupations simply suggests a continuation of a trend that has been observed over the past decades, with industrial robots taking on the routine tasks of most operatives in manufacturing. As industrial robots are becoming more advanced, with enhanced senses and dexterity, they will be able to perform a wider scope of non-routine manual tasks. From a technological capabilities point of view, the vast remainder of employment in production occupations is thus likely to diminish over the next decade."

They also predict disruption to jobs in services industries from personal and household services robots, automation of more routine sales roles, such as cashier and telemarketers, and from prefabrication of buildings to construction jobs.

Even qualities held up as intrinsically human, such as aspects of creativity, may not always remain beyond the capacity of machines. In the 1950s a young chess prodigy performed a chess move feted as a feat of exceptional human ingenuity during a match dubbed [The Game of the Century](#). Yet, as Brynjolfsson points out in the book, today that same move will be carried out by any run of the mill chess program when presented with the same board. As he puts it: "Sometimes, one man's creativity is another machine's brute-force analysis." As computers continue to advance in power, even with the slowing of Moore's Law, brute-force analysis becomes viable for a much wider set of problems.

Digital creation vs destruction

Once a technology can be delivered digitally, it can advance at the heady rate made possible by Moore's Law. When this happens, the chances are its capabilities will increase in leaps and bounds while its costs fall in tandem.

Brynjolfsson explores the idea that digital technology can drastically reduce the cost of technologies, as well as the infrastructure and people needed to support them.

Take digital photography. As Brynjolfsson and McAfee point out, in an age where our photos sit on hard drives rather than in ring-bound albums, the need for a large number of workers disappears.

"These photos are all digital, so hundreds of thousands of people who used to work making photography chemicals and paper are no longer needed. In a digital age, they need to find some other way to support themselves," they write.

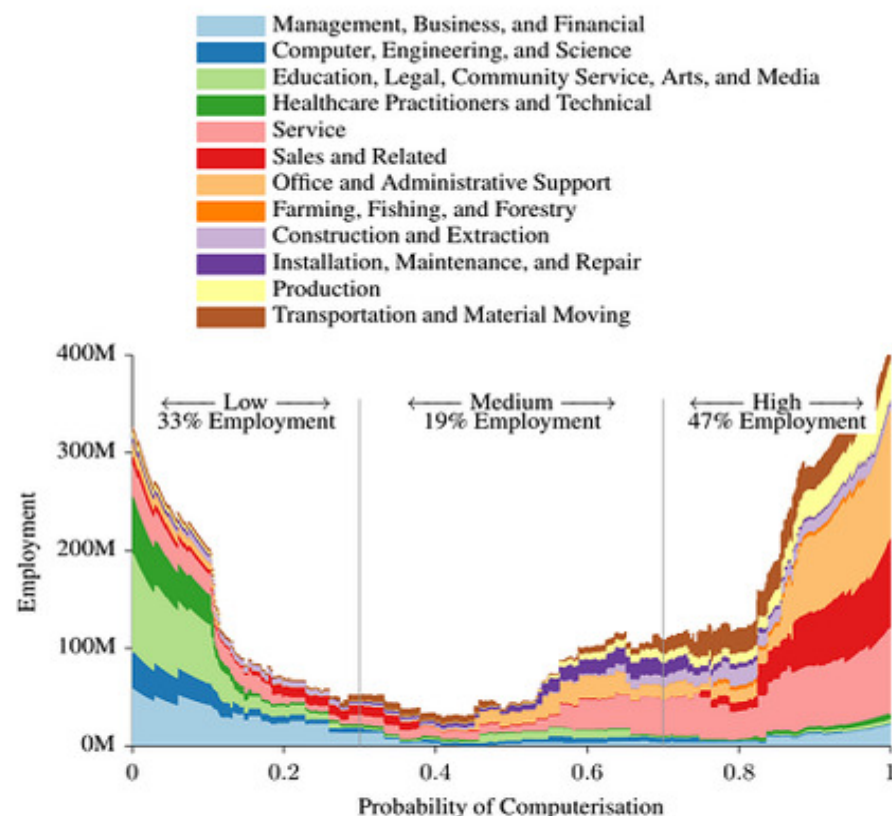


Figure 1. Employment Affected by Computerisation.

Image: Oxford Martin School & Faculty of Philosophy

"Companies like Instagram and Facebook employ a tiny fraction of the people that were needed at Kodak. Nonetheless, Facebook has a market value several times greater than Kodak ever did and has created at least seven billionaires."

This hollowing out of supporting infrastructure can be seen repeated in multiple industries.

"Once the algorithms are digitised they can replicated and delivered to millions of users at almost zero cost."

The authors also see this journey to near-free delivery as a positive — reducing the cost of using that technology to the point where it is accessible to much larger numbers of people, empowering them to build new businesses. Look at how the web led to an explosion in online companies. Or look at how it

has led to an explosion of courses taught by some of the world's most prestigious institutions and now freely available online.

However, this technological bounty, as Brynjolfsson calls it, may not be sufficient to offset increases in the cost of living. While the cost of taking photos may have plummeted the same cannot be said of many essentials people need to survive — food, drink and fuel. The book cites research by Jared Bernstein, who compared increases in median family income in the US between 1990 and 2008 with changes in the cost of housing, healthcare, and college. He found that while family income grew by around 20 percent during that time, prices for housing and college grew by about 50 percent, and health care by more than 150 percent.

Which roles could flourish in the age of machines?

Job prospects are not equally gloomy for every profession according to Brynjolfsson as well as the study by Oxford Martin School & Faculty of Philosophy.

They identify three broad areas of human endeavour that will be resilient to automation in the short to medium term.

"There's no economic law that says 'You will always create enough jobs or the balance will always be even.'"Erik

Brynjolfsson

Manual roles

Despite many manual roles being low-paid, this type of work is likely to remain surprisingly resistant to automation. Some of the jobs that are poorly compensated today remain exceptionally tricky for robots, as even simple manual tasks like walking over uneven terrain are beyond the capabilities of most modern bots. The phenomenon is known as Moravec's Paradox, an observation by leading AI researchers in the 1980s that computers found hard the tasks we found easy and vice versa. While it might take a human seconds to fold a towel, a [robot made to carry out the task in 2010 took nearly 25 minutes](#).

As the book points out: "Results like these indicate that cooks, gardeners, repairmen, carpenters, dentists, and home health aides are not about to be replaced by machines in the short term. All of these professions involve a lot of sensorimotor work, and many of them also require the skills of ideation, large-frame pattern recognition, and complex communication."

"Machines are very clumsy when you think about it. They don't have the agility, and few if any robots could pick up a dime that's on a desk, even though a two or three-year-old person could do that," said Brynjolfsson.

Creative

"Digital technologies are in many ways complements, not substitutes for, creativity," said Brynjolfsson.

"If somebody comes up with a new song, a video, or piece of software there's no better time in history to be a creative person who wants to reach not just hundreds or thousands, but millions and billions of potential customers.

"That's great news for a lot of people who are becoming millionaires or even billionaires by using their creativity to create new products and services that can be digitised," he added.

Interpersonal

"Machines are not very good at motivating, nurturing, caring and comforting people. Human interactions are something that are important but, so far at least, machines are wholly inadequate for those kind[s] of tasks."

The stunted social skills of machines should mean that salespeople, managers and entrepreneurs have a reasonably bright future, as will nurses, kindergarten teachers and home help aids, he said.

Better together

A more optimistic outcome than automation leading to mass unemployment is to see these technologies as a tool that will allow people to achieve more.

Just as no one laments electronic word processors meaning no longer having to retype a document from scratch, so we'd likely welcome the ability for real-time speech recognition and translation.

Brynjolfsson explores this idea of people cooperating with machines, rather than competing against them, and achieving more than either one could individually.

The power of human-machine collaboration was demonstrated by two unranked amateur chess players in 2005, says Brynjolfsson and McAfee in the book. The pair of chess enthusiasts took part in a Playchess.com freestyle chess tournament, where individuals can team up with other people or computers. Despite going up against several grandmasters and a supercomputer named Hydra the pair of amateurs were able to win the contest, using custom chess software running on three laptops to analyse the boards and guide their play.

"This is a real frontier for entrepreneurs to develop new ways of what we call 'Racing with machines', combining machines and humans in new ways to allow them to do tasks they previously couldn't have done," said Brynjolfsson.

"I think that's very exciting and it's very poorly understood. For example, I could imagine augmented reality helping people. Imagine you are a home help aid or a nurse and you see an unusual mole or a lesion and are not quite sure what it is, you could use augmented reality glasses or other tools to send a photograph of that growth to a human expert or even an expert system, a decision-making system that analyses the shape and contours of that lesion and gives advice on whether you need to bring that person in for treatment," he added.

Similarly, AR glasses could overlay useful information for mechanics, surgeons, chefs to "help them with the parts of the jobs they wouldn't otherwise know how to do", he added.

"[There are] many other kinds of tasks where you combine the technology with human skills, so even middle-skilled workers could accomplish tasks that previously they couldn't have done," Brynjolfsson said.

The book repeats something that could turn out to be useful career advice in future: "The career advice that Google chief economist Hal Varian frequently gives: seek to be an indispensable complement to something that's getting cheap and plentiful."

Southampton University's Professor Jennings sees a role for AI in teaching people skills needed for new roles.

"You could see the AI as a system and repository for corporate knowledge," Jennings said. "You can embody much of that in the software. Having the software system act as a corporate memory could make it easier to do medium skilled jobs. It could aid skill transfer and fluidity of people [to move between jobs]."

Having software agents able to feed workers relevant data and crunching records in a fraction of the time it would take a person may be essential if digital data continues to grow at its current exponential pace.



The IBM supercomputer Watson defeated Jeopardy champion Ken Jennings (left) in 2011.

Image: IBM

"As we get ever more data and information available it gets increasingly hard for humans to be able to take account of that," said Jennings. "I see the machine stepping up and providing clever amalgamations of that data and working on it with the humans."

He gave the example of how IBM's Watson system could aid doctors by making suggestions based on research from the latest medical journals. The system is already being trialled at the Maine Center for Cancer Medicine and Westmed Medical Group in New York, where it is recommending lung cancer treatments.

From his knowledge of the way AI systems work today, Jennings finds it difficult to conceive of a system that can replace a person's entire set of skills.

"AI software tends to be very deep and very narrow," he said. "A lot of more professional jobs or tasks just require that broader base of expertise and experience that AI struggles to codify."

Instead Jennings see systems that rely upon AI routines gradually taking a larger and larger role in helping people do their jobs.

"Where it will start to happen is in narrow tasks. It will start with the computer making suggestions and if gradually all you ever do is press 'Yes' then gradually your trust in what the software can do will increase," he said. "That to me is a better model for take-up then 'Right we're going to develop some swanky software and sack all these people'."

Will the displaced find new roles?

The first machine age — the Industrial Revolution — may have destroyed the livelihoods of many artisan tradesmen but it did not have a lasting negative impact on the number of jobs in industrialised nations.

History teaches us that labour markets are able to recover from the changes wrought upon them by technological change, said Alan Manning, professor of economics at the London School of Economics.

"If I take an historical perspective then technical change has always destroyed some jobs and created others, and this would in some sense be no different from that," Manning said. "There will be some people who have spent 20 or 30 years specialised in a job and suddenly there is no demand for that. They suffer big losses but in the long run that washes out, no young people go into those jobs and they go into something else and there is always something else to go into."

The second machine age has undoubtedly created swathes of jobs that would have seemed baffling just a few decades back. Just travel back to the late 90s and try to explain what it is to be a [YouTube Let's Player](#) or to the early 80s and tell someone you're an SEO Expert.

Being a YouTube Let's Player is just one of the roles made possible by the services that have grown up on the web.

Image: Nick Heath/YouTube

But Brynjolfsson says society shouldn't expect that people will simply adapt to the employment opportunities afforded to them by new technologies. To adjust to the labour upheaval that followed the industrial revolution required a long-term overhaul of education systems, he said, an approach that may need to be repeated.

"If you look back to the first machine age the vast majority of Americans worked in agriculture. Now it's less than two percent," he said. "Those people [working in agriculture] didn't simply become unemployed, they reskilled. One of the best ideas that America had was mass primary education. That's one of the reasons it became an economic leader and other countries also adopted this model of mass education, where people paid not only for their own children but other people's children to go to school."

More legislation followed and by the 1950s laws were in place supporting widespread high school and college education in the US.

"We put a lot of effort into reskilling people in these earlier eras. It was very costly and not simple, but ultimately it was successful," said Brynjolfsson.

That commitment to education needs to continue says Brynjolfsson, who argues that lifelong learning will be essential for people to keep pace with the changing demands of roles constantly being reshaped by technology.

"We have to reinvent education and reskilling, and people are going to have to take it upon themselves to more aggressively learn these skills. Because the technology is changing more rapidly, it's going to be a case of lifelong learning and continuously reskilling."

Of course education is still expensive and difficult, but Brynjolfsson believes teaching could become far more accessible in future with the advent of universities like Stanford making entire courses freely available online, and online teaching sites such as [Khan Academy](#).

"Courses online can help tremendously. Education has been a laggard in using digital technologies but that makes me optimistic because there's a lot of room for improvement of doing a better job and I think that will happen in the coming years," he said.

Better education, doesn't mean continuing to teach the same subjects in the same way, and certainly not focusing primarily on the three Rs — reading, writing, and arithmetic — which still are the cornerstones of the classroom in many parts of the world.

"AI software tends to be very deep and very narrow." Nick Jennings

"The three Rs were once the skills that workers needed to contribute to the most advanced economy of the time. As Mitra points out, the educational system of Victorian England was designed quite well for its time and place. But that time and place are no longer ours," according to the book.

To remain valuable knowledge workers in this latest machine age, Brynjolfsson and McAfee say people will need to focus on learning skills that are tricky for computers, such as ideation (the creation of new ideas), large-frame pattern recognition, and complex communication.

Changing national education policy isn't going to happen overnight, and, in part, Brynjolfsson sees the book as a wake-up call, as a reminder that if technologies are leading us down the wrong path, then we as individuals need to do something about it.

"One of the reasons we wrote the book was to get people to change the conversation, to pay attention to these issues and take them on head on," he said. "What we have to do is understand that, as we say in the last line of the book, 'Technology is not destiny, we shape our destiny.' If we do take an active role I think we can come out on the other side much wealthier and with more shared prosperity than ever before, but it's certainly not inevitable."

Cover image: Mike Rubenstein and Science/AAAS



About Nick Heath

Nick Heath is chief reporter for TechRepublic UK. He writes about the technology that IT-decision makers need to know about, and the latest happenings in the European tech scene.

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