The Economist Intelligence Unit

HUMANS AND MACHINES

The role of people in technology-driven organisations

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Preface

Humans and machines: The role of people in technology-driven organisations is an Economist Intelligence Unit report, sponsored by Ricoh. It explores how the interaction between humans and technology is evolving in businesses and other organisations, and asks whether and how technological progress will continue to be complemented by the influences of human imagination and intuition. The report consists of an introduction and five discrete articles, each examining different areas of human and technology interaction. Four of the articles have a sector focus, exploring the challenges and opportunities in healthcare, financial services, manufacturing and education, while the other addresses decision-making. The Economist Intelligence Unit bears sole responsibility for the content of this report. The findings do not necessarily reflect those of the sponsor.

The analysis in the report is based on a two-pronged research effort:

- The first is a survey of 432 senior executives conducted in November and December 2012. The sample is global, with roughly equal numbers emanating from Europe, North America and Asia-Pacific. All respondents are at a senior level: 50% hold C-suite or board positions. They hail from over 20 different industries, the best represented being financial services, manufacturing, education, and healthcare, biotechnology and pharmaceuticals. Just over half of the firms in the survey (53%) have annual revenue in excess of US$500m, with nearly one in five having US$10bn or more.

- Complementing the survey is a series of 20 in-depth interviews conducted with prominent business and technology thinkers as well senior corporate executives across different sectors. Along with the survey respondents, our thanks are due to all of the below for their time and insights:
  - Kevin Brown, senior inventor, IBM Research
  - Jeff Burnstein, president, Association for Advancing Automation
  - Steve Chilton, ICT director, University Hospital Birmingham
  - Donald Clark, technology entrepreneur, speaker and blogger
  - Mark Coeckelbergh, assistant professor, University of Twente; managing director, 3TU Centre for Ethics and Technology
  - Chun-Yuan Gu, head of discrete automation and motion division, North Asia and China, ABB
  - Kris Hammond, chief technology officer, Narrative Science
  - Oskar Heer, head of labor relations, Daimler
  - Brian Holliday, divisional director— industry automation, Siemens Industry
  - Michael Hsieh, assistant professor, Stanford University School of Medicine
  - George MacGinnis, telehealth expert, PA Consulting
  - Jose Marques, global head of equity electronic trading, Deutsche Bank
  - Brian Millar, director of strategy, Sense Worldwide
  - Rick Robinson, executive architect of smarter cities, IBM
  - Yvonne Rogers, professor, UCL
  - Will Stewart, professor, University of Southampton
  - Eric Topol, professor, Scripps University
  - Wim Westera, professor, Open Universiteit
  - Simon Williams, chief executive officer and co-founder, QuantumBlack
  - Michael Zürn, head of production and material technology, Mercedes-Benz Cars, Daimler

James Watson, Stephen Edwards and Kim Thomas are the authors of this report. Denis McCauley is the editor.

MIND OVER MACHINE

More promise than peril for human imagination and creativity

Type the words "machines are taking over" into your search engine and dozens of pages of almost exact matches are likely to result. In all walks of life, people are clearly apprehensive that computer programmes, robots and other manifestations of modern technology are supplanting the roles that humans have played. In the workplace, job displacement due to automation is perhaps the most emotive fear of all.[1] But short of that, professionals worry that the advent of sophisticated data analysis software or the march of machine-to-machine communications, for example, will circumscribe the salutary influence of human imagination, creativity or intuition on everyday activities and decisions. This is not so much a concern about the nature of the technologies themselves, but rather about humans' continuing ability to influence how they operate to the benefit of the organisation, its customers and other stakeholders.

Humans have grounds to be worried. Many recent technological advances cross over into areas once presumed to be solely the domain of human thought and ability—remaining purely the stuff of science fiction until now. One is the ability to comprehend and respond to natural language. Now popularised through our smartphones with features such as Apple's Siri, computers are increasingly good at understanding what we are saying. In 2011 this capability was shown to great effect when IBM's Watson supercomputer outwitted the best human contestants on a television quiz show.[2] This capability is now being applied in the field of medical diagnosis, to see whether machine learning can outperform humans in a more profound domain.

Machines can now also express themselves in natural language, to the point of proving themselves as journalists capable of reporting financial and even sport news. In 2011 Narrative Science, a US technology firm that has created a platform to automatically generate written stories based on inputted data, wrote about 370,000 Associated Press-style sport reports covering youth baseball games across the US; in 2012 it generated over 2m. Each story is crafted at the standard of a professional journalist, with gripping details of a team's victory over the odds, except for the fact that no journalists are present at the games.

Machines are also increasingly adept at seeing and interpreting our visual environment. Although autopilots have long been a staple of planes and trains, computers have now been shown to drive cars more safely than humans, with rapid progress being made towards driverless vehicles.[3] Thanks to such developments in visual acuity, machines in a range of contexts are performing an increasingly diverse set of tasks, from assembling cars to supporting surgery, disarming bombs and packing groceries.

Hey, big thinker

When it comes to businesses, public sector organisations and the people who work in them, technological progress has always evoked a mix of both fear and optimism. Nearly four in ten executives polled for this report, for example, worry that their organisations will be unable to keep up with technology change and will lose their competitive edge. The articles appearing further on highlight common occurrences in the fields of financial services, healthcare and education, for example, where

1 We considered arguments for and against the likelihood of accelerated job displacement due to technology in our March 2012 report, *Agent of change: The future of technology of disruption in the workplace.*

2 "Computer wins on 'Jeopardy!': Trivial, it's not", *New York Times*, February 16th 2011.

3 "Google's driverless car draws political power", *The Wall Street Journal*, October12th 2012.

employees are unable to master a new application or system, sometimes with grave consequences for their organisations or clients.

The technology advances described above, however, raise specific questions about the role of humans in relation to the machines we are busy developing. In the past, technological progress has typically enabled organisations to eliminate the most menial jobs, allowing humans to focus on what we do best: intellectual and cognitive tasks—deploying our creative abilities and imagination to solve problems of all kinds. It is becoming apparent, however, that technology advances are steadily blurring the lines between mind and machine. Will such developments push humans up the cognitive food chain—empowering us to go further than ever before—or squeeze us out? If humans are no longer needed "in the loop" of some processes, from diagnosing illnesses to trading equities, will we still be required "on the loop", overseeing and controlling such activities?

In exploring such issues, this report finds that while it is easy to worry about the uncertainty ahead, there is a wide-ranging sense of optimism about what technology will mean for our role. There is clear potential for humans to embrace a higher-level, more creative role in the workplace, augmented by increasingly smart systems. Across a diverse set of industries, most executives in our survey agree. Nearly three in four (74%) dispute the notion that technology is making it difficult to be more imaginative or creative, even as they acknowledge a far greater reliance on technology in recent years. And there is less concern that this change is eroding the need for human creativity in their industry.

The survey results do hint at potential problems ahead, however. The vast majority of our respondents (82%) report that the time they spend using e-mail—which some would consider among the more creativity-sapping of work activities—has increased in the past three years, and over half say the increase has been substantial. While acknowledging the hugely beneficial effects technology has had on their employees' productivity, efficiency and communication, little more than one-third say it's freed up employees' time to be more innovative. The concerns also extend to a broader plane: while eight in ten believe that human-technology interaction will prove hugely productive for society, about the same number also insist that it will also pose profound societal questions about their respective roles in the workplace.

The overwhelming spirit coming from the research results, however, is optimism about how people and machines will work together in the coming years. A key ingredient to the achievement of such accord, most of our survey-takers agree, is the processes that people write to connect the two. Technology in isolation, they remind us, without a well-thought-through process to use it, brings little value to anyone.

Human-technology interaction is a big and complex theme. The articles in this report do not pretend to capture all or even most of its dimensions. Instead, they explore some of the trickier (yet also more hopeful) areas of how people and technology interact in selected sectors, including financial services, healthcare, education and manufacturing, and outline challenges facing organisations across all industries as well as, ultimately, societies and governments. The aim in each is not to provide insights into the state of technological development today, or a comprehensive review of any given issue, but rather to share observations on some of the implications of wider progress in each domain—and what they imply for our own roles. The latter, it is apparent from this, will not diminish but evolve, and harmony between human and machine is an eminently achievable goal. ■

SMART SYSTEMS, SMARTER DOCTORS

Humans and machines in healthcare

There are few instances in our lives when we place greater trust in the abilities of our fellow humans than in surgery. Even in relatively safe procedures, invasive surgery carries an inherent degree of risk. From a doctor's perspective, there are specific challenges to overcome in trying to minimise the degree of invasiveness, not the least of which is our basic biological makeup. "The advantage of open surgery is that you [the surgeon] have full use of your wrists and fingers, which means a large degree of freedom and potential articulation," explains Dr Michael Hsieh, a professor at Stanford University School of Medicine in California and an expert in robot-enhanced surgery. "Another advantage is that you have a three-dimensional view, with depth perception," he adds.

It is here that advances in robotics are creating striking new possibilities that augment the capabilities of humans. Dr Hsieh has been conducting so-called multi-port robotic surgery for some time: guiding robotic arms into a patient's body through several tiny incisions about the size of a keyhole. This accelerates recovery times and reduces scarring. The next frontier is the potential for single-port surgery. In certain cases this may enable surgeons to avoid any scarring at all, by entering via the navel, while further speeding recovery.

Such technologies are not supplanting the role, skills or creativity of surgeons; instead, they are augmenting surgeons' abilities, freeing them to make advances that humans cannot accomplish on their own. "Robotic technology is not inhibiting human creativity," agrees Dr Hsieh. "If anything, it has perhaps expanded our horizons by allowing us to conceive of new ways to conduct old operations, or ways to take completely new approaches to disorders. I would say that creativity has been enhanced."

Creativity plus efficiency

Robots in surgery are a dramatic example of how technology can help healthcare professionals become more creative as well as efficient in the effort to improve patient care. And much more efficient they will need to become if healthcare systems are to meet the daunting challenges facing them. In Europe, for example, the costs of providing care to ageing populations are soaring, while governments remain intent on maintaining near-universal levels of provision. To achieve this amidst tight public financing will require vast improvements in efficiency in all facets of healthcare operations. Making better use of the myriad technologies coming available—in areas ranging from diagnostics to telehealth and others—is central to this objective. Nearly nine in ten health executives surveyed for this study agree that there remains enormous room for technology-led efficiency gains in their organisations.

Unfortunately, the ease with which surgeons like Dr Hsieh are interacting with new technologies is less visible elsewhere in the sector. IT—and particularly the types of systems which connect the back office to the hospital floor or doctor's surgery, or provide the information necessary for effective patient care—has made slow inroads in healthcare. The reasons are varied, but human resistance to change and difficulty in adapting to new technologies are prominent among them. Six of ten healthcare respondents—more than in other sectors—say their organisations have become heavily reliant on technology in just the past three years, an indication of how recent significant technology penetration has been in some parts of the sector. Two-thirds report one or more instances of employee failure to learn a new technology in the past six months, suggesting that health employees' interaction with new technologies remains anything but smooth.

Failure to overcome difficulties in how doctors, nurses, administrative and other staff interact with technology can have expensive consequences. A salutary lesson was the 2011 scrapping of the UK's £12.7bn effort to introduce electronic patient records. A range of factors plagued the implementation, but the thorniest was trying to convince doctors to accept and adopt new processes. (Germany, France and the Netherlands have experienced similar failures, although in Denmark such problems appear to have been surmounted.[1]) Beyond resistance to change, problems in connecting systems in different parts of the health service also undoubtedly play a role in such episodes. In our survey, sector executives point to such system disconnects as among the toughest challenges they face with technology. Another major challenge, according to the respondents, is that processes are not being written quickly enough to keep pace with technology advances.

> *"There will always be the need for a human to decide and act in more complex situations."*
>
> Mark Coeckelbergh, assistant professor, University of Twente and managing director, 3TU Centre for Ethics and Technology

Employees' adaptation to new technology will likely improve, and operational and cost efficiency along with it, but will there be a sacrifice in the types of human creativity and imagination needed for truly effective patient care? Our survey-takers are optimistic on this score. Close to 70% believe that increasing technology intensity has made their employees more, not less, creative in developing ideas for new health services and products, and 65% say the same about conceiving ideas to improve processes.

What's my problem, Watson?

A look at medical diagnostics may help explain such optimism. It is an area where technology promises to enhance the abilities of health professionals, improving efficiency in the process. Diagnosis relies on the fundamental human capacity to draw on diverse pieces of information about patients—from how they describe their symptoms, to their prior medical history, to how they physically appear—and make an assessment of their likely condition. The lion's share of our survey respondents (43%) point to diagnostics as the area of healthcare where the retention of human intuition is most critical.

Much work is under way to bring machine learning and computing power to bear in diagnosis, in order to maximise the power of data. The potential is clear: systems such as IBM's Watson supercomputer can "read" a million medical textbooks in just three seconds, while also sucking in diverse other information, from insurance claims to electronic medical records, to enhance its diagnostics calculations. Rick Robinson, an executive architect at IBM, notes that as many as 50,000 papers are published each year in the field of diabetes alone. "No human clinician can keep up with that," he says. The result is inevitable errors. Studies suggest that doctors misdiagnose conditions as much as 10-15% of the time.[2]

There is no suggestion, however, that such systems would fully replace the role of humans in diagnosis. "I think there will always be the need for a human to decide and act in more complex situations," says Mark Coeckelbergh, an assistant professor at the University of Twente (Netherlands) and managing director of the 3TU Centre for Ethics and Technology. More fundamentally, there are wide-ranging challenges to overcome, ranging from issues of accountability to rethinking the fundamental processes of healthcare.

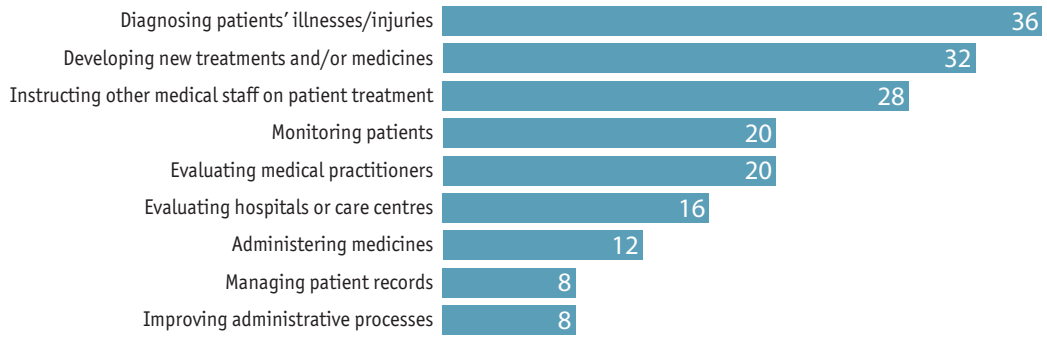
1 *Future-proofing Western Europe's healthcare: A study of five countries*, Economist Intelligence Unit, September 2011.

2 *How doctors think*, Jerome Groopman, 2007.

Which statements best characterise the challenges you face in dealing with technology?
(top responses; % of respondents from healthcare, biotechnology and pharmaceutical industries)

Source: Economist Intelligence Unit survey, December 2012.

In which of the following activities is the need for retaining a role for human imagination or intuition most critical?
(top responses; % of respondents from healthcare, biotechnology and pharmaceutical industries)



Source: Economist Intelligence Unit survey, December 2012.

> *"The demographic challenge is such that the current way of working … is not sustainable."*
>
> George MacGinnis, telehealth expert, PA Consulting

Pressure to automate

While technology may augment human potential in some healthcare domains, in others it is being viewed as a means to free up people to perform other activities. In this context, the case for remote patient monitoring and other elements of "telehealth" is clear. The aim is to free clinicians from the basic and time-consuming manual processing of information so that they can focus on where they are needed most—patient care. "This is not just a financial challenge," explains George MacGinnis, a telehealth expert at PA Consulting, speaking about healthcare organisations in the UK. "The current way of working is not sustainable from a future workforce perspective; there simply aren't going to be enough doctors and nurses either domestically or available to recruit from overseas."

It is also an area where many see less need for human imagination or intuition: less than one-fifth of those polled in the sector think monitoring patients requires these capacities; and only 9% think the same of administering medicines. Both areas are ripe prospects for technology: from scales that monitor patients' weight and flag up possible risk conditions to automated alerts reminding people to take their pills.

Such technologies hold clear potential not only to free up personnel, but also to improve patient outcomes and quality of life. Mr MacGinnis cites the example of patients with certain heart conditions who must weigh themselves daily to look for early signs of

The newly digital doctor

Dr Eric Topol is an American cardiologist, geneticist and researcher. Named "Doctor of the Decade" by the Institute for Scientific Information for his research contributions, he is the author of "The Creative Destruction of Medicine: How the Digital Revolution Will Create Better Health Care".

Q. How will technology change the role of doctors?
Today doctors control everything. They order in the data, the scans and any tests required. But tomorrow, the individual will drive that. Individuals will come to doctors—whether physically or virtually—with information in hand seeking their guidance. Individuals will also have information well beyond what was formally obtainable today—for example, blood pressure readings for every minute of the last two weeks, or glucose levels for every minute of the last month. Those prospects are exciting.

Q. Will a traditional physical exam be replaced?
There will certainly be more data analysis, but a physical exam will still be useful. My physical exam, however, has changed dramatically. Since December 2009 I have not used a stethoscope to listen to a heart. Why would I bother when I can use a high-resolution ultrasound, which is a pocket device in my coat? So the stethoscope will eventually go, but I don't believe technology could ever replace the doctor-patient relationship in terms of empathy, compassion and understanding.

Q. Can technology reduce the pressure on overburdened health systems?
I think so. We are going to level the playing field, and this should mean the demand for doctors lessens. More and more things can be done remotely, or by individuals on their own, as long as there is Internet coverage. There will be times where you need a hospital and the physical presence of a physician, but that need—which puts pressure on health systems—will be dramatically reduced over time.

excess fluid retention. This can be automated with the help of an Internet-enabled scale that alerts doctors of any worrying changes.

Encouragingly, there is little fear in the industry that telehealth would somehow curtail the role of carers or nurses, or lessen their societal value. "There are certain things where you need emotions and where you need improvisation, imagination," explains Mr Coeckelbergh. This is borne out in a variety of specific healthcare implementations, such as wide-ranging work at University Hospital Birmingham (UHB) in the UK to use technology to improve clinical decision support and increase process automation. "Contrary to negative perceptions, we've seen individuals empowered, obtain greater autonomy and achieve greater job satisfaction," says Steve Chilton, UHB's ICT director. He argues that such developments have pushed the role of human workers up the value chain, while new roles have emerged as a result, such as within process analytics. "Technology-led automation and development have freed up creativity," he says.

The pain of disruption

Much of the wrenching change that healthcare organisations are destined to undergo over the next several years will be driven by technology. Robotics in surgery or video consultations between doctors and patients may get the headlines, but less exotic data analysis, knowledge sharing, website management and other systems will be at least as instrumental in creating the efficiencies that must be gained across under-pressure health systems. Technology disruption is part of almost any conceivable scenario for healthcare reform in the coming years.[3]

Pressure on healthcare professionals to adapt to technology change will thus remain relentless. How well they adapt will rely to some extent on the skill (and speed) with which processes are written to guide the interaction. The views of the health practitioners and experts, and the examples, presented in this article, provide grounds for optimism that the frictions which have plagued interaction between people and technology in this sector will be smoothed out, and that human creativity will not be sacrificed in the process. Which is a good thing, because health organisations will need all the creativity their employees can muster to deliver the effective and cost-efficient care their patients will require and their stakeholders will demand. ■

3 A variety of scenarios for how healthcare reform may play out in Europe are presented in *The future of healthcare in Europe*, Economist Intelligence Unit, March 2011.

MONEY, RISK, PEOPLE AND PROCESS

Humans and machines in the financial services industry

August 1st 2012 began as a relatively peaceful day on the New York Stock Exchange (NYSE) trading floor. The latest monetary policy statement from the Federal Reserve was due later that morning, and much of the market was quiet ahead of the news. Then, in a matter of seconds, a surge in trading volume started affecting stock prices. Violent swings of more than 10% within a five-minute period saw many stocks halted by the exchange's circuit breakers. "Stocks are moving all over the place," noted one investor at the time; "it is weird, they are trading millions of shares, 100 shares at a time; something went haywire somewhere."[1]

The source of the chaos was Knight Capital Group, a large trading firm that uses automated high-speed trading to buy and sell shares. The firm told clients it was dealing with a "technical issue" and was forced to turn away customers. It took just 45 minutes for the glitch to wipe out much of the company's capital base, causing a pre-tax loss of US$440m and forcing it to seek new funding to avoid bankruptcy.[2]

For many, the event was yet more evidence of an over-reliance on technology in the financial markets. It is also a dramatic manifestation of what occurs in many parts of the financial sector, including banks and insurers, when something goes wrong in the interaction between information technology and the humans who operate it. Within banks, for example, missed payments, incorrect statements or inefficient responsiveness to customer requests are some of the more everyday problems caused by human-technology mishaps. Others are more consequential: a programming error in June 2012 caused a lengthy outage of Royal Bank of Scotland (RBS) customers' online access to their accounts, costing the bank an estimated £175m in compensation payments.[3]

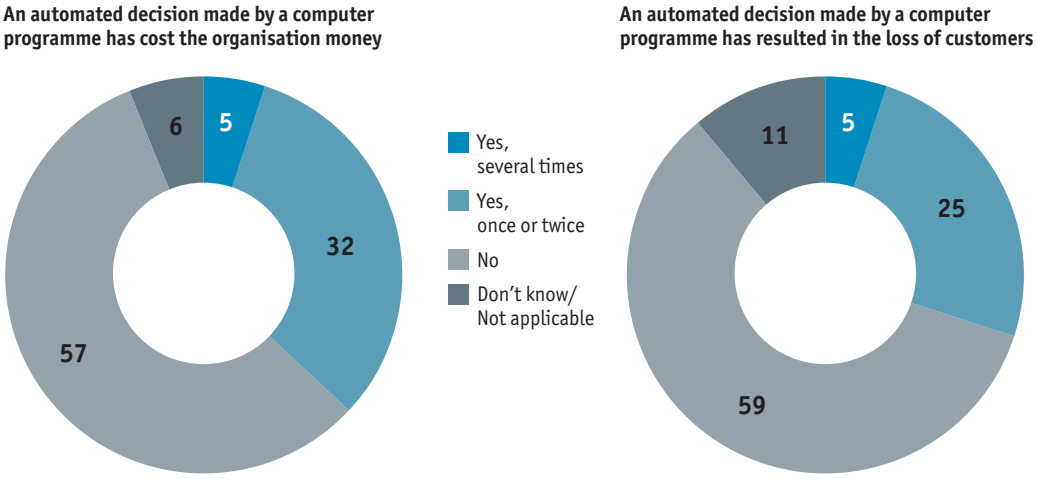
When it comes to suffering material losses, they are not alone. Over one-third (37%) of the financial industry executives surveyed for this report—who include retail bankers, commercial bankers, insurers and others—say that an automated decision made by a computer programme cost their organisation money at least once in the past six months. Nearly one in three (30%) report that such issues have resulted in a loss of customers.

Industry executives are largely positive when asked about the present and future nature of human and technology interaction in their firms, but many nevertheless voice concerns. For example, 43%—more than other sectors in our survey—feel that technology is complicating person-to-person communication more than it is facilitating it. (The substantial increase in time spent using e-mail in the last three years, reported by 45% of respondents, may be partly to blame for this.) And little more than one-quarter believe that technology has freed up people's time to be more innovative. Disconnected systems (for example, between front and back-office functions), and technologies evolving faster than the processes developed to use them, are seen as especially significant challenges finance industry firms face in dealing with technology.

Trading, for example, was a very social, people-driven activity. "Whether it happens upstairs on trading desks or on the floors of exchanges, there has always been human-to-human interaction," explains Jose

1 "New York Stock Exchange's 'weird' glitch causes volatility; some trading halted", *Huffington Post Business*, August 1st 2012.
2 Knight Capital Group Press Release, August 2nd 2012.
3 "Cost of RBS IT glitch grows to £175 million", *Information Age*, November 2nd 2012.

Have you encountered these situations in the past 6 months?
(% of respondents from financial sector)



Source: Economist Intelligence Unit survey, December 2012.

Marques, Deutsche Bank's global head of equity electronic trading. But over the past ten years this has changed dramatically. Today, 73% of all equity orders (by volume) in the US and 40% in Europe are handled by high-frequency trading firms.[4]

Such speed and efficiency have opened up myriad new strategies for traders to exploit, leading to an explosion in market activity. But they have also given rise to the types of risks highlighted at the start of this article. In other parts of the sector, the challenges that arise as technology advances at a rapid pace manifest themselves in different ways.

A matter of trust

Retail banking was once a people-centric business but has become increasingly automated. Systems now make rapid decisions on numerous aspects of personal finance, such as whether customers qualify for a loan or a new credit card. Some start-ups within the sector use this speed as a means of competing against slower, more traditional banks. For example, Wonga.com, a UK firm which provides short-term loans online, not only promises loan decisions in less than half an hour but will also deposit the funds within the customer's account in that time.

One reason why online firms can automate the process of credit checking is that the nature of how applicants' reputations are established and enhanced is fundamentally changing. Where credit managers have traditionally determined whether an individual is creditworthy or not, a host of new variables are now coming into play. These include information aggregated and sold by online data brokers relating to customers' purchasing activities on the web. eBureau, for example, a predictive analytics firm, gathers masses of data about consumers which it uses to calculate "e-scores" of some 20m people each month for banks, insurers and other financial services firms.[5] Another online firm, Movenbank, now even tracks consumers' activity on various social media platforms as an element in determining their financial credibility.[6]

According to Rick Robinson, an executive architect at IBM, the importance of online trust and reputation has risen rapidly in parallel with the growth of peer-to-peer activities, such as choosing to buy from a stranger online. "There has been an evolution in both business models and technologies that aim to provide trust within that online context," says Mr Robinson. "Take the peer-to-peer personal loans market. There are traditional banking processes to give loan providers a reason to trust that their money is reasonably safe. But there are also things like reputation systems, which use online networks to

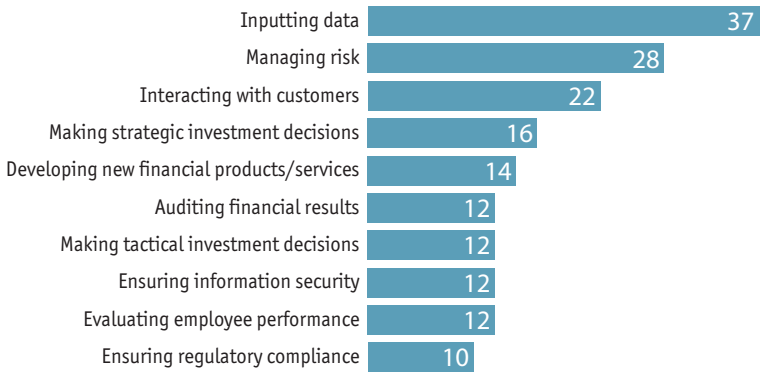
4 "Regulators globally seek to curb supercomputer trading glitches", *Reuters*, August 31st 2012.

5 "Secret e-scores chart consumers' buying power", *New York Times*, 18 August 2012

6 "Is the world ready for social media credit scores", *The Financial Brand*, 14 August 2012

> *Disconnected systems (for example, between front and back-office functions), and technologies evolving faster than the processes developed to use them, are seen as especially significant challenges finance industry firms face in dealing with technology.*

In which of the following activities has the role of human imagination or intuition declined most rapidly in the past five years?
(top responses; % of respondents from financial sector)



Source: Economist Intelligence Unit survey, December 2012.

see who applicants are friends with and how they're connected, all of which provide additional reasons to trust [or not to trust] the applicant."

As is often the case in the financial industry, such technology-based services are developing much faster than the rules governing them, resulting in new risks. When an online credit scoring agency gets it wrong, the lender may not have much recourse when a loan goes bad. (By the same token, borrowers can find it difficult to repair one's reputation.) Fortunately, technology is also allowing third parties to step in and help borrowers and lenders retain some control over these processes. Services such as Reputation.com can help borrowers, for example, to take better control of their online profiles.

Back in the trading sector, banks themselves are developing process improvements and risk controls to help redress imbalances caused by rapid technology advances. Deutsche Bank, for instance, is developing a system to help visualise the logic being deployed within its automated trading systems. "Very few people feel comfortable handing off a very large, important trade to a machine when it's not doing something entirely transparent to the human," explains Mr Marques.

Very few people feel comfortable handing off a very large, important trade to a machine when it's not doing something entirely transparent to the human."

Jose Marques, global head of equity electronic trading, Deutsche Bank

Machine processors and human processes

In general, the positive impact of smart technology on financial services is clearly evident in our study. Nine in ten executives surveyed for this report emphatically deny that technology is usually the single point of failure when things go wrong in their organisations. Indeed, technology is typically at the heart of many of the innovations being made: 41% of financial sector respondents say their team's best innovations of the past three years could not have been delivered without it, and three in ten say they could not even have been conceived without technology. About eight in ten (78%) say it makes them more productive, while three-quarters deny that technology is making it more difficult to be imaginative and creative in their work.

The caveat to this optimism is that the vast majority of those we spoke to believe that human-technology interaction will only add value if humans are more creative with the processes developed to connect the two. Ultimately such innovation should lead to machines and humans working in symphony, but at the moment a large minority (40%) are not confident that the difficulties involved in human-technology interaction will all be ironed out. It is yet another reminder that, in as transaction-intensive an industry as financial services, technology will only be as good as the processes that people develop to guide it.

A case in point is how banks are beginning to use artificial intelligence to gain a better understanding of customers. BBVA Compass, a retail bank, uses web 'robots' to scour the Internet for paragraphs and sentences relating to the bank and its major competitors. The process, known as sentiment analysis, interprets what it finds to give decision-makers insights that would take traditional focus groups and surveys months to uncover.

To properly benefit from this technology banks have to change the way they work, in particular re-thinking their traditional sales, marketing and product development processes. The norm has been a gradual and linear process of research, followed by product development, then annual sales and marketing planning. Today banks like BBVA Compass operate in a more dynamic, fluid and adaptive environment. They can respond in days to new trends, customer concerns and the competition; bad decisions can be immediately identified and reversed, and opportunities can be taken faster than ever before. Without this shift in approach and processes, daily web sentiment analysis has limited value.

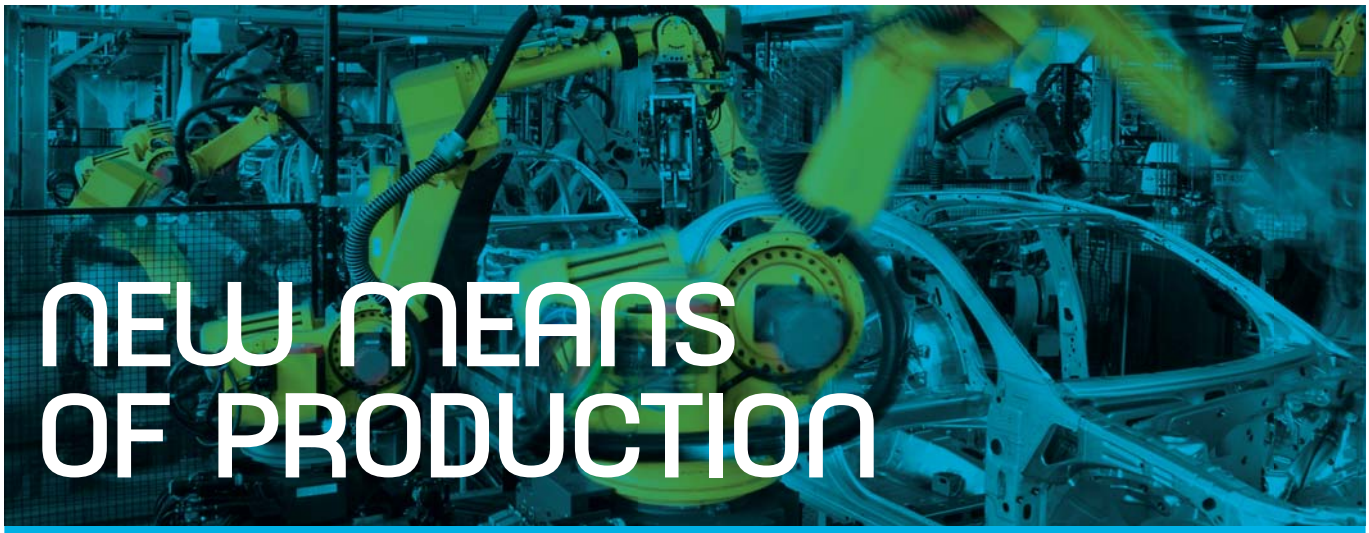
Still a place for the human touch

Beyond making changes to business processes, there is still a vital role to be played by humans in this sphere. Gauging the feelings and emotions of customers from what they write on the Internet is a massive challenge for machines. Here as in loan approvals and credit checking, while the technologies continue to develop from infancy, the information gathered and interpreted by people—such as branch staff talking face-to-face with customers—will remain vital in banking for the foreseeable future.

This is also the case in the investment sector. Says Deutsche Bank's Mr Marques: "One of the things we miss when we are automating social human processes is subtlety. In constructing an asset portfolio, an analyst might meet with the senior management of a portfolio company. They have a conversation, and the firm's management disclose the information that they are legally allowed to disclose. But there are additional data in that conversation, in the body language or the inflection of the voice, which cannot be captured within a quarterly filing or the annual accounts."

Free to think creatively and brainstorm, humans can add value by shaping and optimising whatever technology is helping to enable. "At the end of the day," believes Mr Marques, "we'll end up in a place where man and machine are working together as an integrated system to achieve far better outcomes than we can today."

Technology has revolutionised many aspects of how banks and other financial institutions deal with their customers, and has likewise enabled enormous leaps in their operating efficiency. But as the examples in this article suggest, technology change in this industry is likely to continue at a relentless pace. The risk of sacrificing a degree of human imagination and intuition at the altar of technological progress will thus remain ever present. In finance as everywhere else, that would be an irretrievable loss. ■



NEW MEANS OF PRODUCTION

The challenge for human-machine relationships in manufacturing

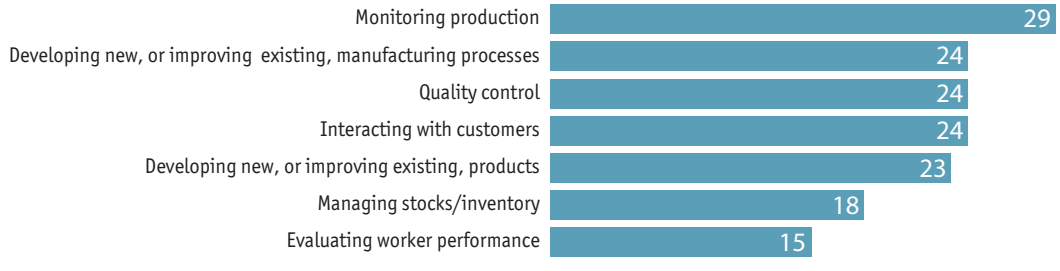
In Roald Dahl's classic children's book, *Charlie and the Chocolate Factory*, things go from bad to worse when Charlie Bucket's father loses his job as a toothpaste cap-screwer. The story does not say whether a machine replaced Mr Bucket, but humans have already been relieved of millions of equally torturous jobs thanks to industrial automation and robotics. Although there has been concern about the loss of jobs ever since the Industrial Revolution, the impact of automation has more often been positive. In many sectors, people have evolved towards more sophisticated roles, raising the average quality of manufacturing jobs while driving down costs and improving both the quality and volume of output.

Technology has wrought enormous change over the past few decades in many aspects of manufacturing, posing tough challenges for the employees operating the machines and devices or utilising the software. The manufacturing executives in our survey are nonetheless positive about the effect that technology has had on the scope for employees to utilise their human aptitudes of creativity and imagination. A majority of manufacturers (57%) insist that increasing technology-intensity has enabled their employees to be more, rather than less, creative in areas such as developing ideas for new products and services and improving business processes. At the same time, many say that the scope for imagination has declined rapidly not just in the more automated areas of monitoring production and quality control but also in new product development and interaction with customers, where the human touch is especially desirous.

Manufacturing employees' ability to cope with the strains posed by technology change are being put to the test anew as the sector undergoes what some are calling a "third industrial revolution". As explained by *The Economist* (our sister company), driving this new phase of disruptive change are recent technology advances in areas such as engineered materials, collaboration software and 3D printing, not to mention robotics.[1] The result will be the enabling

1 "The third industrial revolution," *The Economist*, April 21, 2012.

In which of the following activities has the role of human imagination or intuition declined most rapidly in the past five years?
(top responses; % of respondents from manufacturing sector)



Source: Economist Intelligence Unit survey, December 2012.

of much more economical, smaller scale and more flexible production. In turn this will open up new vistas for efficiency improvement for manufacturers of all sizes; it will create added pressures to boost efficiency as well, as new, often smaller entrants emerge to challenge established producers.

Another effect of these combined developments, *The Economist* maintains, will be that manufacturing jobs of the future will require more skills than they do now, as more jobs move away from the factory floor into design, IT, marketing and other positions. In the meantime, companies and employees will no doubt struggle to find the right balance of human and machine interaction as the new technologies penetrate the sector. A closer look at robotics may provide some hints of how this might be done.

March of the machines

Judging by the available statistics, 2011 was the most successful year ever for industrial robots, with sales up by 38% to some 166,028 units, the highest ever recorded. Estimates by the International Federation of Robotics, an industry body, put the increase in 2012 at about 9%, or 181,000 units, with growth of around 5% per year forecast between 2013 and 2015.[2]

While some of this growth is being driven by the modernisation of factories in developed markets, China is its main engine. Between 2006 and 2011 annual sales of robots quadrupled there. In a half-century history of industrial robots, no other country has adopted automation on such a large scale in such a short period of time. This trend appears set to continue, not least thanks to plans by Foxconn, a major electronics manufacturer, to install more than 1m robots within just three years.

The most frequently cited reason for China's rapid automation is the pressure of rising labour costs. But this is only part of the story. "The challenge with hundreds of people [in a factory] is that it's hard to get them to act consistently. That is where robot automation can add value," explains Chun-yuan Gu, head of ABB's discrete automation and motion division for North Asia and China. Foxconn, with

2 *World Robotics 2012*, IFR Statistical Department, August 2012.

Daimler's new production-floor bosses and assistants

In early December 2012 Daimler, the global car manufacturer, started a pilot project, implementing a new kind of lightweight robot in one of its production processes, with a specific focus on allowing humans and robots to co-operate more closely on vehicle production. Michael Zürn, who oversees production planning, and Oskar Heer, a human resources leader, explain how this is setting a new path for human-machine interaction.

> *"… workers will require the skills needed to handle the robots, to adapt them to new tasks using learning by guidance—essentially to manage them."*
>
> Michael Zürn, head of production and material technology, Mercedes-Benz cars, Daimler; Oskar Heer, head of labor relations, Daimler

Q. What are the benefits you hope to obtain from this new approach?

We see the potential to revolutionise our system of production. We not only want greater flexibility, but also more adaptable production systems. For example, when we improve a vehicle, we want to be able to quickly adapt our production line to launch the necessary changes rapidly, or else to quickly increase the volume of production. When you look at today's production systems, there are two directions—an automated system or a largely manual [human] workplace—and the industry fluctuates between the two. The automated system is highly efficient but rigid, while the manual system is perfectly flexible but in some areas requires greater efficiency. We want to combine the strengths of these approaches to get the benefits of both.

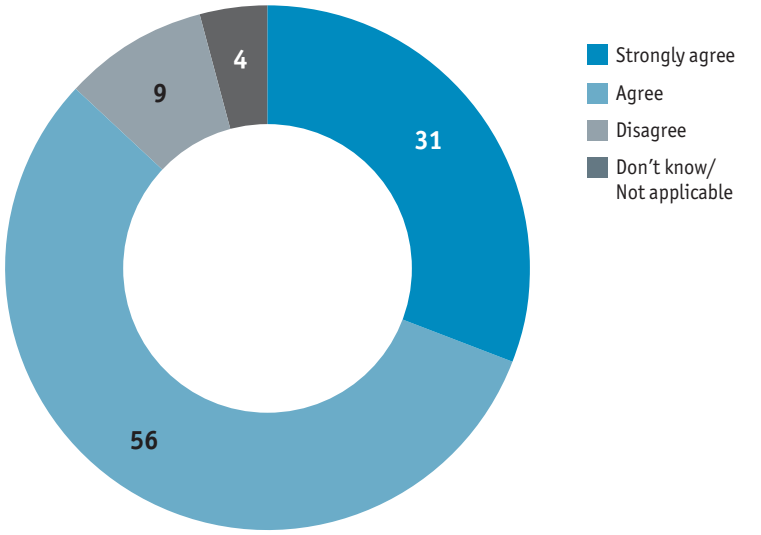
Q. What changes are taking place?

Currently the job is either done by workers or by robots. In the latter case, the job is totally separated from human workers, for safety reasons. Looking ahead, we believe the job will be done mainly by workers, but with robots assisting them. This is completely new. For example, tiring jobs such as handling overhead parts or stepping into a vehicle to do assembly work will be done by these small lightweight robots, but guided by workers. We've called this concept "robot farming": just like a farmer tending sheep, but with workers tending their robots.

Q. What is the reaction of human workers to this change?

We're right at the beginning of this today, but workers will require the skills needed to handle the robots, to adapt them to new tasks using learning by guidance—essentially to manage them. We don't want highly customised robots, but rather ones that can be adapted to a wide range of tasks, whether engine assembly or painting. The workers are very proud of this. They co-operate with the robots, and do not feel that this portends a kind of substitution for them. Instead, the robots assume the most tiring jobs, and improve the workers' productivity. Quite simply, the worker is the boss, and the robot is his assistant.

Do you agree or disagree?
"Human-technology interaction will only add value if we are more creative with the processes we create to connect the two."
(% of respondents from manufacturing sector)



Source: Economist Intelligence Unit survey, December 2012.

1.2m workers in China, understands this more than most. Indeed, quality and consistency are often the main reasons why companies choose robots. And as costs have fallen, they have become more attractive. Such systems also allow companies to react faster to changes in consumer tastes. "In the old days you had 'hard automation', where you had to rip out your machines if you wanted to build something else," says Jeff Burnstein, president of the Association for Advancing Automation, a trade group. "Now you can reprogramme the robot, so it is much more flexible."

One example is Marlin Steel, a US manufacturer of wire products. It was about to go out of business until automation allowed it to create higher-quality products and sell to a different customer base. "They were making very low-quality products, where the only differentiator was price," notes Mr Burnstein. "They couldn't compete on price, but now they were able to make high-quality products with consistency and reliability. And by making them in the US, they could ship them to their customers faster than the competitors could."

The learning process

The manufacturing executives who took our survey are almost uniformly optimistic that human-technology interaction in areas such as this will prove to be hugely productive for their business (the view of 85% of respondents from the sector). Just as uniform, however, is the view (expressed by 87%) that such interaction will only deliver value if humans are more creative with the processes they write to guide such interplay. This applies well beyond production.

Employees of manufacturing firms will, for example, need to master new collaboration technologies, many of which are web-based and which require adapting to unfamiliar practices of sharing product design details with interested third parties. Marketing, design, finance and IT staff alike will be spending considerably more time using sophisticated data analytics tools and manipulating ever larger volumes of data emanating from customers, suppliers and partners. The increasing use of social media will likewise pose new challenges to customer service, marketing and other functions of the production enterprise. Processes will need to be written, and continuously updated, to ensure not only the efficient and cost-effective use of these technologies but also the safeguarding of the information communicated over them.

Creative processes will certainly be necessary to allow robots and humans to work more closely together on the factory floor. Naturally, safety is one area in need of attention. "Today, with machine-safety regulations, robots must be isolated by screening as a basic requirement," says Mr Gu. "We have to design new safety concepts so that robots can be free to work anywhere."

To this end, various companies are developing robots that can work better alongside humans. One example is Baxter, launched in October 2012 by Rethink Robotics.[3] As a two-armed factory robot with a humanoid appearance and an LCD screen "face" as a user interface, it is safe enough to work together with humans. Elastic actuators make it less dangerously rigid than traditional robots, for example. In particular, it is designed to overcome two of the major barriers to the adoption of industrial robots: usability and cost. Instead of hundreds of thousands of dollars, the price tag is US$22,000.[4] And rather than relying on specialist programming, a person with no robotics experience can simply take hold of Baxter's wrist and train it by moving its arms around to show it what to do—a kind of learning by guidance.

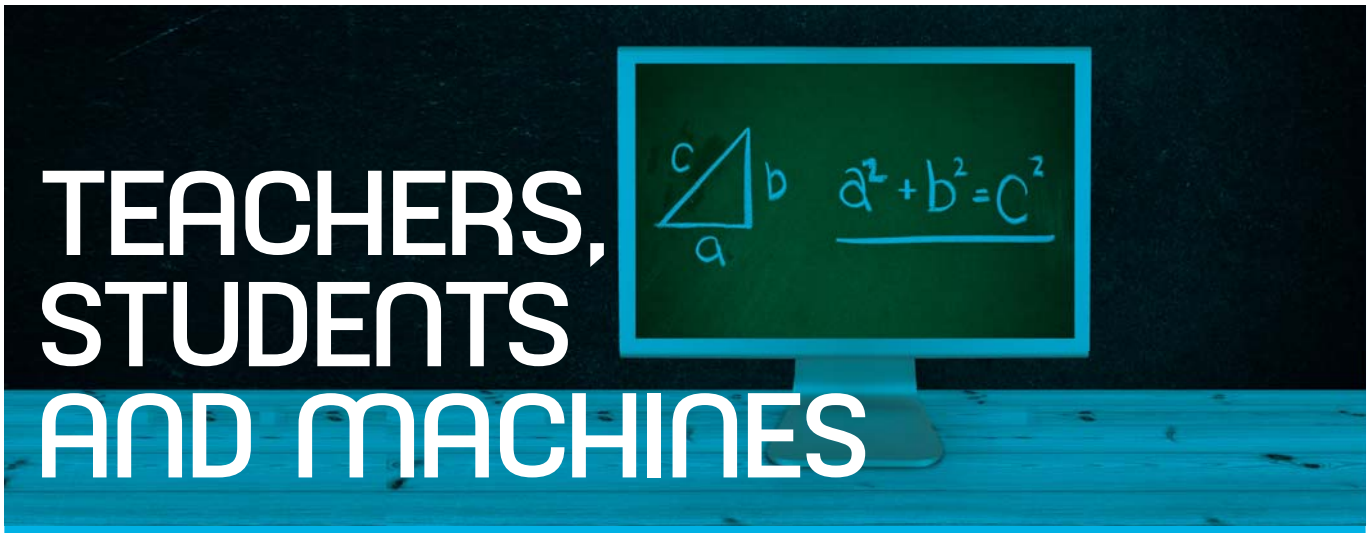
The interface issue is a key one. In our survey, the lion's share of manufacturing executives flag up the need to design intuitive processes as the most difficult issue for the future of human-technology interaction, ahead of all others. "There are a lot of small and medium-sized enterprises where manufacturing batches are not so big. If you use traditional methods you would spend three days programming and testing, run the system for one day and then have to change it all again," explains Mr Gu.

3 Rodney Brooks, founder and chairman of Rethink Robotics, is one of the world's most famous "roboticists". He is the former Panasonic Professor of Robotics at the Massachusetts Institute of Technology (MIT) and previously founded iRobot, maker of the Roomba, one of the world's first robot vacuum cleaners.

4 "How Rethink Robotics built its new Baxter robot worker", *IEEE Spectrum*, October 2012.

In the future, he says, such systems will learn their tasks by themselves.

Collectively, such developments have striking potential. Cheap, easy-to-implement robots could dramatically improve the efficiency of employees, helping to rebalance the cost-effectiveness of manufacturing in the developed world (see box on page 14). More importantly, it highlights the increased importance for humans to focus on what they do best: ideas, designs and engineering. As Mr Burstein puts it: "As robots do more of the dull and dangerous jobs, they free up people to do more of the creative work." They may even do more than this. Their effect, when combined with those of 3D printing and such phenomena as collaborative online production and design communities, all of which are helping to make small-scale production economical and attractive again, may very well be the emergence of a more "human face" to manufacturing. ■



TEACHERS, STUDENTS AND MACHINES

The democratisation of education?

Sebastian Thrun, until recently a professor of artificial intelligence at Stanford University, has several major achievements to his name. These include leading the team that developed Google's driverless car, an invention which looks set to save many lives and disrupt several industries. He is now at the forefront of another revolution, this time in education. In 2011 Mr Thrun and a colleague decided to offer Stanford's artificial intelligence course online. The response was staggering: 160,000 students in 190 countries enrolled, with 23,000 ultimately completing the course.[1]

Massive Open Online Courses, or MOOCs, have the potential to change the face of tertiary and even secondary education. Mr Thrun is now running Udacity, a start-up that offers MOOCs, and plans to make money by matching employers to qualified students. This new model offers the appealing vision of democratised education, bringing learning to millions of people who would never have the opportunity to attend a university such as Stanford.

The first hint of what was to come emerged in 2002, when the Massachusetts Institute of Technology (MIT) started to make its course materials freely available on the web. Many other universities rapidly followed suit. These materials now range from text-based lecture notes to podcasts and vidcasts. The UK's Open University has a free OpenLearn platform that includes social media for students to discuss course content with each other.

The best-known provider of MOOCs is the Khan Academy, which offers 3,400 online videos and tutorials for some 10m students. A 12-year old in India whose parents cannot afford to send her to school but have some means of access to the Internet can now educate herself online. Some go on to gain a university place and obtain a further qualification.

In essence, MOOCs provide a way of learning without a teacher being physically present. As Donald Clark, a technology entrepreneur and blogger, puts it: "We are witnessing the 'Napsterisation' of learning—its democratisation, decentralisation and disintermediation."

Shaking the pillars of learning

Internet-enabled disruption of the type described above is just one factor driving far-reaching, and often unsettling, change across the education sector. Education systems in many parts of the world are coming under pressure from governments and businesses, not to mention citizens, to better prepare students for the workforce. Better performance is being required of teachers in the classroom, of school leaders in teacher and student assessment, of education system leaders in encouraging more cost-efficient school administration, and of all system stakeholders in improving curriculum development and new learning tools. In parallel, greater effectiveness is also required of the "back office" of education—from administrators, IT professionals, bursaries, admissions staff and many others who together create the learning environment.

"Whole system reform" is being pursued at primary, secondary and tertiary levels across the developed and developing world in systems as diverse as those

1 For more, see: "Instruction for masses knocks down campus walls", *New York Times*, March 4th 2012.

in Singapore, Shanghai, Rio de Janeiro, Ontario and New Orleans.[2] As part of these initiatives, instructors, administrators and other staff working in educational institutions are being pressed to integrate new technologies more tightly into the learning and administrative practices they develop. Digitising the supporting business processes of education is also an imperative as many educational institutions become more commercially-minded—partly due to public funding constraints but also to due to greater interest in private schooling. Half of education sector respondents in our survey say their organisation has become heavily reliant on technology in just the past three years—no doubt a reflection of the relatively slow digitisation of schools and other institutions in comparison with that in other sectors.

Given the resistance to change that education systems tend to be famous for, concerns might be expected from educators that technology is constraining the scope for human creativity so necessary for effective learning. The survey suggests otherwise: only a small minority is concerned with a loss of creativity or imagination due to technological progress (although a large number feel that technology stifles open debate and discussion). When it comes to creativity-inducing activities, such as thinking in isolation or brainstorming with colleagues, many more education respondents say that their time spent in these endeavours has increased in the past three years than those who say it has decreased. Almost half—48%, substantially more than other sectors—report that technology has actually freed up their employees' time to be more innovative.

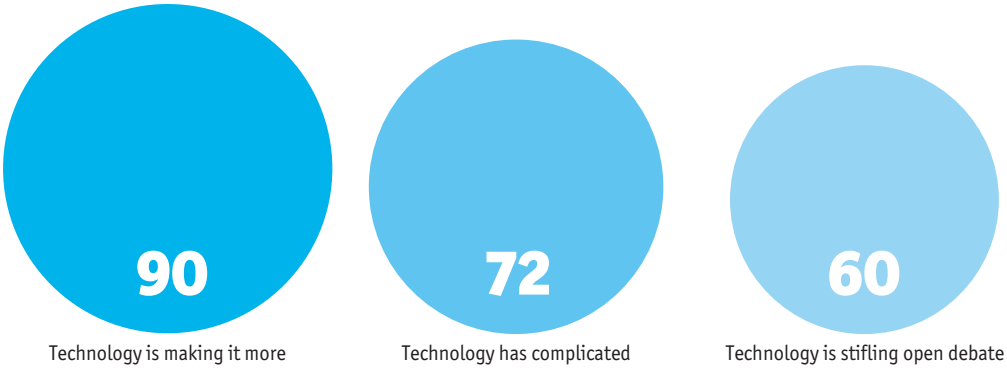
2 For a closer look at the extent of education reform efforts under way in different parts of the world see *How the world's most improved school systems keep getting better*, McKinsey & Co, 2010, and *The Learning Curve*, a Pearson website created by the Economist Intelligence Unit, http://thelearningcurve.pearson.com.

Still, the spectre of classes without teachers, such as raised by the advent of MOOCs, generates opposition from some educators who argue that, in learning, there is no substitute for interaction with a real human being. Indeed, in our survey "teaching classes" tops the list of activities where retaining a role for human imagination and intuition is critical. Developing new teaching materials and practices are also prominent in this list. However, the more likely scenario is that MOOCs, like the emergence of other types of technology-enabled learning, will merely mean that the role of teachers in the classroom will change rather than disappear.

One manifestation of this is the rise of "blended learning", where students use online learning to complement their formal education: if you don't understand what the physics teacher has told you, then you can probably find a Khan Academy video that explains it better. Some teachers now podcast their own lectures, so that students can listen to them outside of class hours. This in turn is leading to a new model, dubbed the "flipped classroom": instead of learning in a classroom or lecture hall, the student watches or listens to a lecture online. The classroom session is then used for what was previously homework: putting what has been learnt into practice, but with the teacher there to help and answer questions.

Some educators are concerned that far from learning becoming more democratic, the opposite is happening. Salman Khan, the founder of the eponymous academy, is a former hedge fund analyst, not an educator, and some worry that the education agenda in future will be set by large corporations, not teachers or experts in pedagogy. Indeed, what is to stop companies like Google offering qualifications to rival those offered by exam boards and universities?

Share of respondents who disagree with the following statements:
(% of respondents from education sector)



Source: Economist Intelligence Unit survey, December 2012.

> *Serious gaming simulations are the richest environments that you can imagine and provide all kinds of mechanisms for optimising learning."*
>
> Wim Westera, professor, Open Universiteit

Others believe such new models of learning are the best defence against "corporatisation". Wim Westera, a Dutch physicist and educational technologist at the Open University of the Netherlands, believes that traditional universities are under threat: "If higher education remains the way it is, with its 19th-century model of lectures, then within ten years we will have Google University and Walt Disney University taking it over."

Digital teachers

Is it possible to remove teachers from the equation even further? One apparent example of this are South Korean schools that have piloted the use of robots to teach English to schoolchildren. However, the "robots" are really telepresence platforms—teachers based in the Philippines, who communicate via a small screen, with microphones and speakers embedded in the robot. It is a clever, cheap way of hiring foreign teachers without paying their living costs, but it is not yet a genuine substitute for human initiative, and it is not entirely clear whether it adds educational value.

Technological development nevertheless has its own momentum. There are some situations where teachers are being displaced because technology does it better— in gaming, for example. One advantage of games is that they allow students to be active learners rather than passive ones. Or, as Mr Westera puts it, they can be used for "mimicking authentic tasks and bridging theory and practice, which is one of the biggest problems in education". He argues that gaming is not a substitute for traditional learning but an improvement on it: "Serious gaming simulations are the richest environments that you can imagine and provide all kinds of mechanisms for optimising learning."

Many educators await with anticipation the coming on stream of other technology applications that will complement the role of humans in learning as well as in making educational institutions more efficient. Examples include cloud-computing-based software to help schools reduce the administrative burden. Likewise, cloud-based servers and advanced analytics software can allow students, sited together or at different campuses, to collaboratively analyse large data sets or work on other complex projects.

All this points to a potential revolution in education. As technology takes centre stage, the power of learners to control their own learning increases. In some areas, the direct role of the teacher may be diminished. On the whole, however, teachers' impact on the lives of their students will remain undiminished, and that of the best teachers—who can also master the technologies coming available—should be vastly amplified. Despite inevitable tensions, all signs point to the various forms of teacher-technology-student interaction becoming enriched rather than diminished. ■

THE FUTURE OF INTUITION

Decision-making in a hyper-connected world

For data geeks, the world of Formula One is a glorious playground to explore. Fans have access to thousands of data points and statistics, accumulating in real-time over the course of every lap. For a team's race manager, there is intense pressure to make strategic race decisions, such as when to call in a pit stop, amid rapidly changing events. In this technology-rich world, there is already a wealth of data—not least from sensors all over the vehicle streaming the current status of things, from tyre pressure and heat to fuel levels and engine performance. But as teams seek out any possible competitive edge, they are drawing on technology to capture even more data. The aim: to track rivals more closely, gain a wider view of events and filter this back into strategic options—all in real-time.

One F1 team (which declined to be named), working with QuantumBlack, a specialist data analytics agency, draws on a range of data inputs, such as timing feeds, GPS, in-car telematics and live television broadcasts, and then uses algorithms to infer a wide range of race information: pit-stop windows, the degree of wear on tyres, driver velocity and so on. All this is fed into a live, visual dashboard that allows the team to constantly review "what-ifs" and adapt its strategy.

This works. Over the course of the 2012 race season the accuracy of pit-stop forecasting, for example, improved by 25%. "Strategy can determine the outcome of the race as much as the driver or the speed of the vehicle, so that's an advantage," explains Simon Williams, QuantumBlack's chief executive. In preparing for the 2013 season the F1 team realised that even before coming up with a new race design, it needed to get its data strategy right. "It's how they manage data that they see themselves gaining a race-winning advantage in the coming seasons," says Mr Williams.

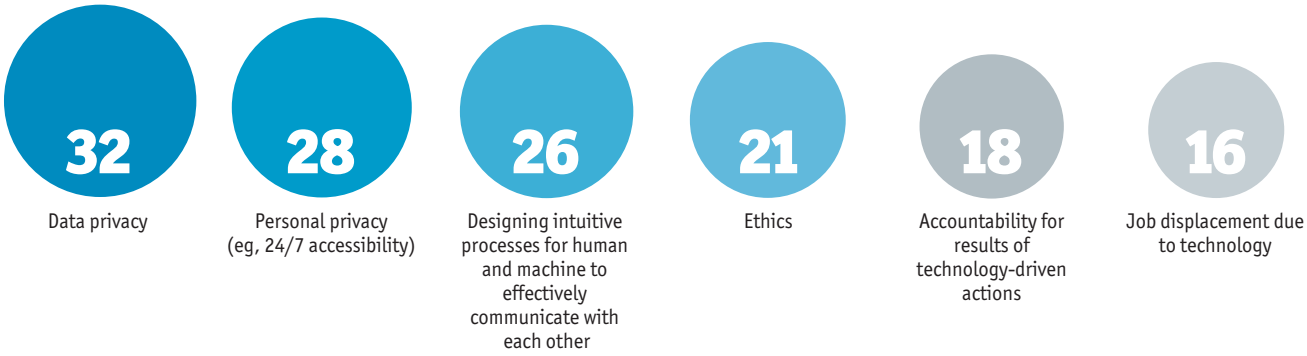
Big or not, data are changing decisions

The F1 example is colourful, but its decision-making lessons can be applied to more traditional businesses as well. Most executives are now well aware that the volumes, forms and sources of data, and the sophistication of data analysis, have changed dramatically in the past few years as machines grow smarter, cheaper and more networked. Half of our surveyed executives believe that increasing technology-intensity, which incorporates new data collection and analysis tools, has made their employees better able to make good business decisions. (No more than 8% say it has weakened decision-making.) And data analytics tops their list of technologies believed most likely to widen the scope for human intuition and imagination in the work environment.

For better or for worse, executives from many industries are grappling with a profound change: from making key decisions with a paucity of data to instead dealing with an abundance of it. "Information overload is a challenge whether you work in a factory [or a services provider]," says Brian Holliday, divisional director of industry automation at Siemens, an engineering firm. The challenge is more cognitive than technical: enabling humans to make sense of it all. This in turn is raising questions about how the nature of decision-making is changing, and the respective roles of humans and machines.

The good news is that systems are available to help humans focus on the bigger, more critical questions which require more creative thinking. For example, software applications can intelligently filter signals

Thinking of the future of human-technology interaction, in what areas do you think the most difficult issues will lie?
(top responses; % of total respondents)



Source: Economist Intelligence Unit survey, December 2012.

amidst the noise. In an industrial environment, says Mr Holliday, it is feasible for hundreds of sensors to raise alarms at a given time, quickly overwhelming a human operator; software programmes, however, can easily categorise and prioritise these. He cites the Buncefield fire, a major 2005 incident at the UK's Hertfordshire oil storage terminal, as an example: "One of the findings [afterwards] was that operators were flooded with information, in excess of their ability to do anything about it," he says. Much of the machine emphasis today is on helping to provide only the most relevant information, to the most relevant person, at the best time.

> *"I think creativity, especially business creativity, comes out of great insight. And obtaining a different level of insights [from data] will be one of the truly powerful opportunities of the next few years."*
>
> Brian Millar, director of strategy, Sense Worldwide

Software is also used to enable more visual or informative decision-making, given the inherent difficulties that people have in rapidly and accurately interpreting large amounts of information. Visual dashboards are cropping up in areas ranging from product development at engine manufacturers to control systems in airports. "What's brilliant about it is that managers are not being overwhelmed with data, but instead having the data presented to them in an incredibly simple way so that they can make the big decisions needed," says Brian Millar, director of strategy at Sense Worldwide, a UK-based consultancy. "I think creativity, especially business creativity, comes out of great insight. And obtaining a different level of insights [from data] will be one of the truly powerful opportunities of the next few years."

Narrative Science, the data start-up cited at the start of this report, provides a compelling example. It works with a large fast-food chain to analyse minute-by-minute sales data from across 14,000 branches, and in turn supplies entirely automated summaries and recommendations that are specifically tailored for each individual branch manager—something entirely unfeasible for human analysts. These alerts—automatically written in the style of a helpful management memo—might note, for instance, that sales of a specific chicken product have increased strongly in all other stores in that region, so a given outlet may want to consider increasing its promotion of this product.

The decision on how to act is left to the store manager, but rather than being swamped with data, he or she gets a concise and filtered view of what matters to that specific store. "We're interested in empowering non-technical people who are making decisions," explains Narrative Science's chief technology officer Kris Hammond. "We have a machine take care of the [underlying complexity] and then communicate the insight it's found directly, in a very natural and human form."

The promise this picture holds for organisations is extremely bright, but the use of data is also among the thorniest issues relating to human and technology interaction that business, governments and wider societies will face in the coming years. Beyond concerns about how organisations use consumers' data, there are also ethical issues to be addressed about the extent to which automated data drives decisions where humans have previously been behind the wheel. Such dilemmas may perhaps be imagined most vividly in the field of healthcare, where a mistaken computer-generated diagnosis based on a faulty reading of data could feasibly result in a patient's death. But our discussion of human-technology difficulties in financial institutions is also a reminder that monumentally bad decisions can also be made by banks' or traders' computerised systems with equally monumental consequences.

Still the gut feel, at least for today

Overall, when it comes to decision-making, the status quo still applies in most organisations. The vast majority of executives that we surveyed acknowledge some degree of help from technology in arriving at their most important decisions, but also that human intuition remains the core basis for this. This applies to 7 in 10 respondents, compared with the 3 in 10 who

believe that the key decisions they are making would be impossible without technology. The question is, which of these two camps will ultimately win out over time, as reliance on technology grows?

As the line between humans and machines becomes more blurred, some expect the role of human imagination and intuition to continuously recede. But although companies have always upped their game by relying on what technology can do to improve their business, there is little suggestion today that they will seek to take humans out of the loop.

"By commodifying a lot of business reasoning and turning it into something a machine can do, this frees up people's time to be able to do the deeper, richer, more creative thinking around business," says Mr Hammond. "We think having humans in the loop isn't going to go away in the near future."

Indeed, the greater (and happier) likelihood is that in decision-making, as in the various other dimensions of organisational activity examined elsewhere in this report, the role of humans will be enriched by technology, and that humans and machines will ultimately work out their optimal "division of labour".

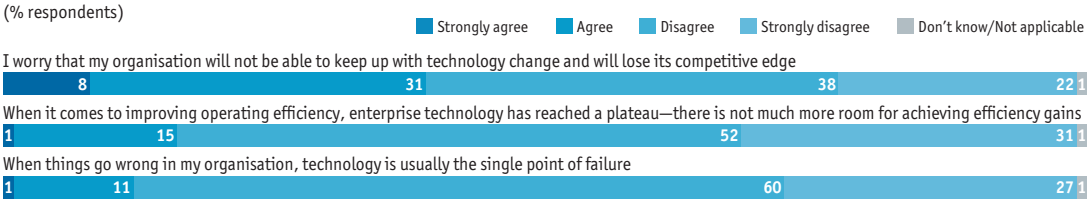
This will not come about of its own accord, however. Lack of attention to the processes involved in governing how employees interact with new systems has frequently proven the latter's graveyard. People will remain "in the loop", and greater workplace harmony between human and machine will be achieved, when guidelines, rules, principles or other forms of governance accompany the implementation of new technologies. When this becomes the norm, humans and the organisations they work in should have nothing at all to fear from technology. ■

Appendix: Survey results

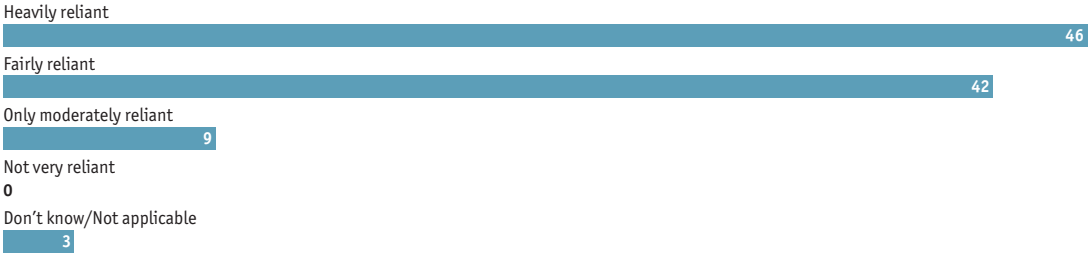
The Economist Intelligence Unit conducted a global survey of 432 executives in November and December 2012. Our sincere thanks go to all those who took part.

Please note that not all answers add up to 100%, either owing to rounding or because respondents were able to provide multiple answers to some questions.

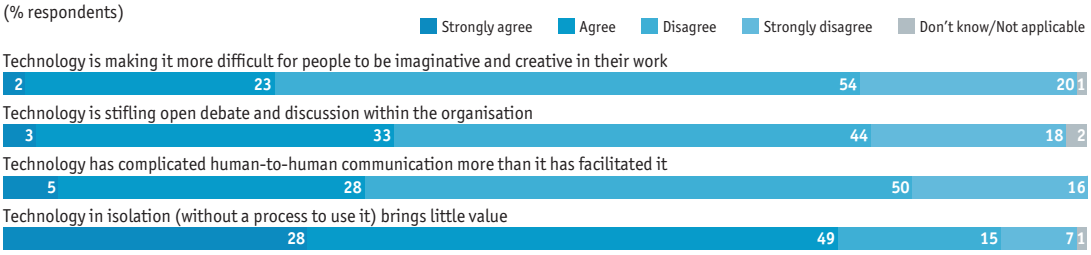
Please state the extent to which you agree with the following statements:
(% respondents)



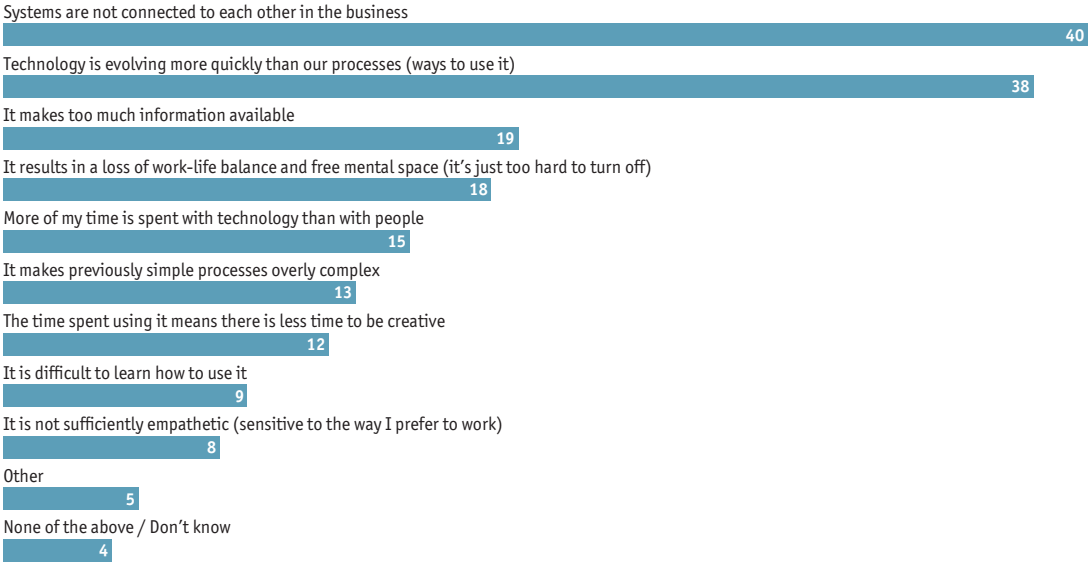
How reliant would you say that your organisation has become on technology over the past three years?
(% respondents)



Please state the extent to which you agree with the following statements:
(% respondents)



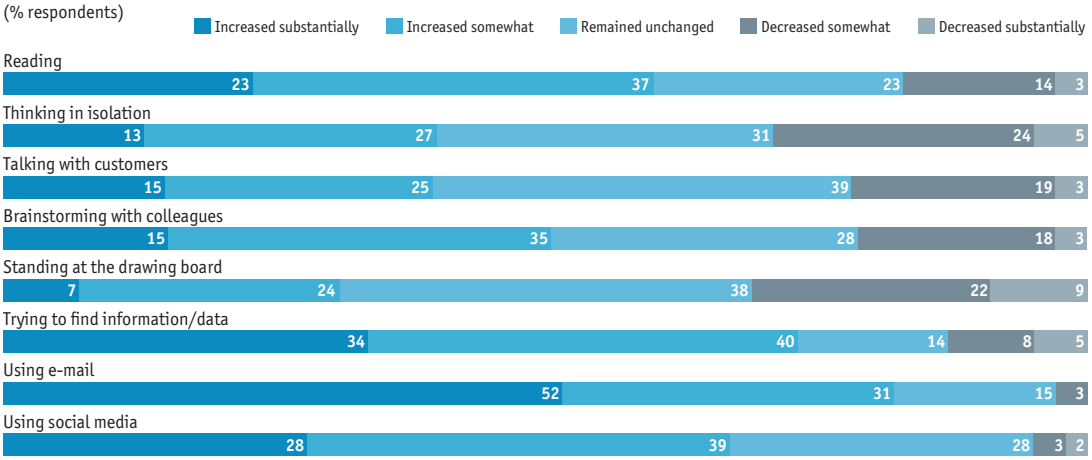
Which statements best characterise the challenges you face in dealing with technology? Please select up to two.
(% respondents)



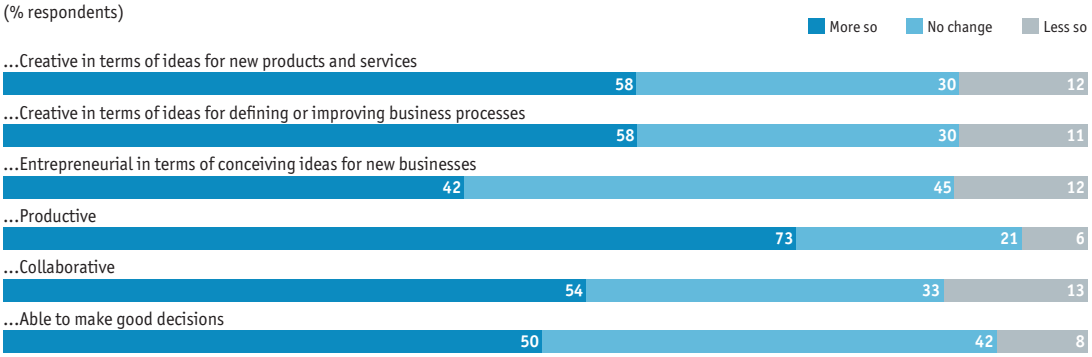
Are you personally more or less creative at work than you were ten years ago?
(% respondents)

Has technology helped you personally to become more or less creative in the last ten years?
(% respondents)

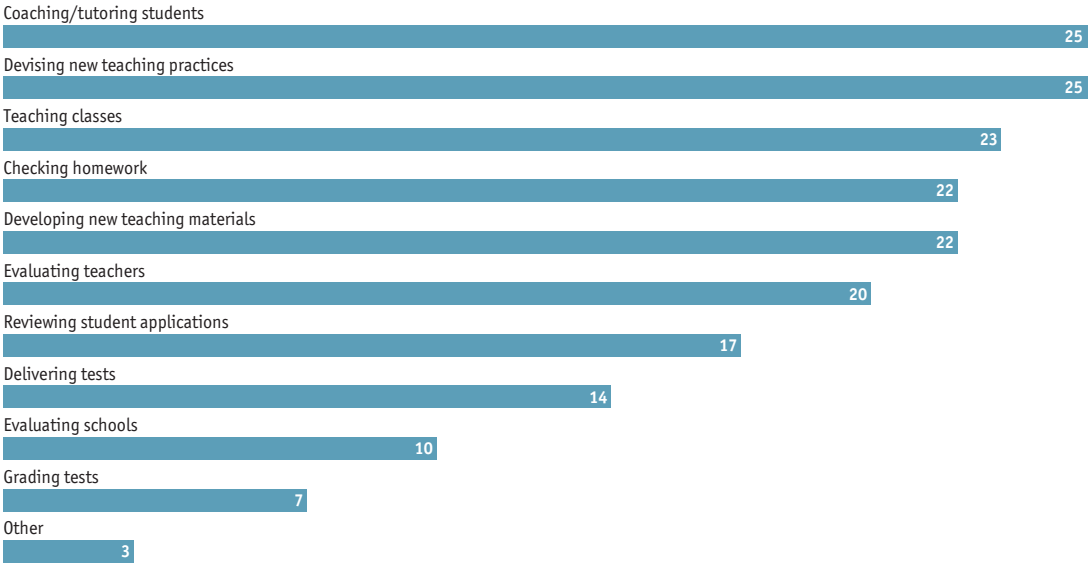
How has your time spent on these work activities changed in the past three years?
(% respondents)



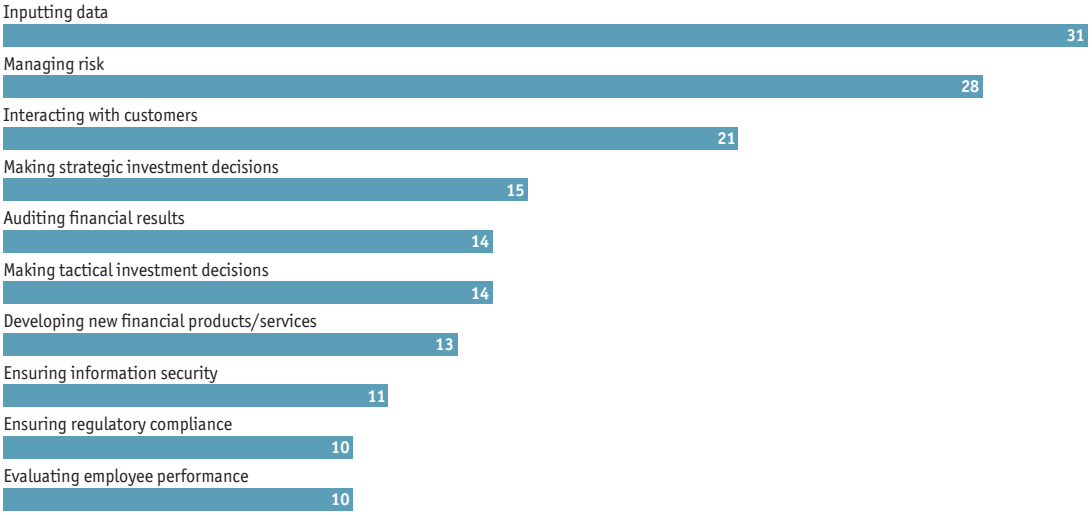
Would you say that increasing technology intensity has made employees more or less...
(% respondents)



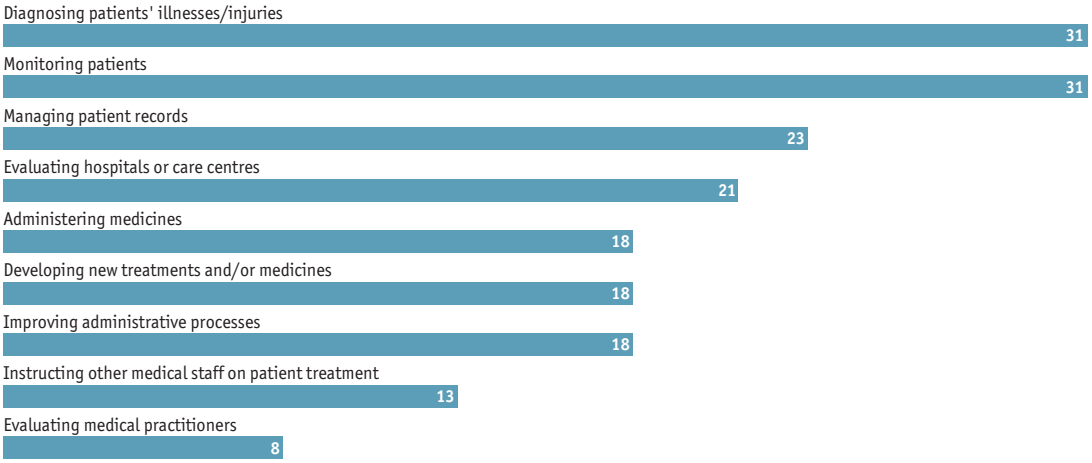
In your view, in which of the following activities has the role of human imagination or intuition declined most rapidly in the past five years? Please select up to two. **Education**
(% respondents)



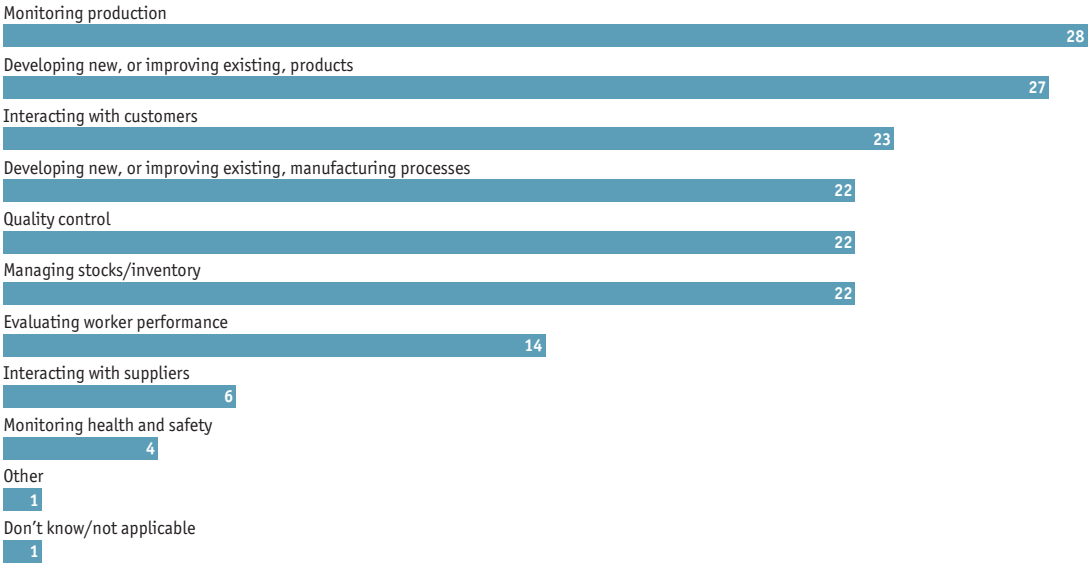
In your view, in which of the following activities has the role of human imagination or intuition declined most rapidly in the past five years? Please select up to two. **Financial services**
(% respondents)



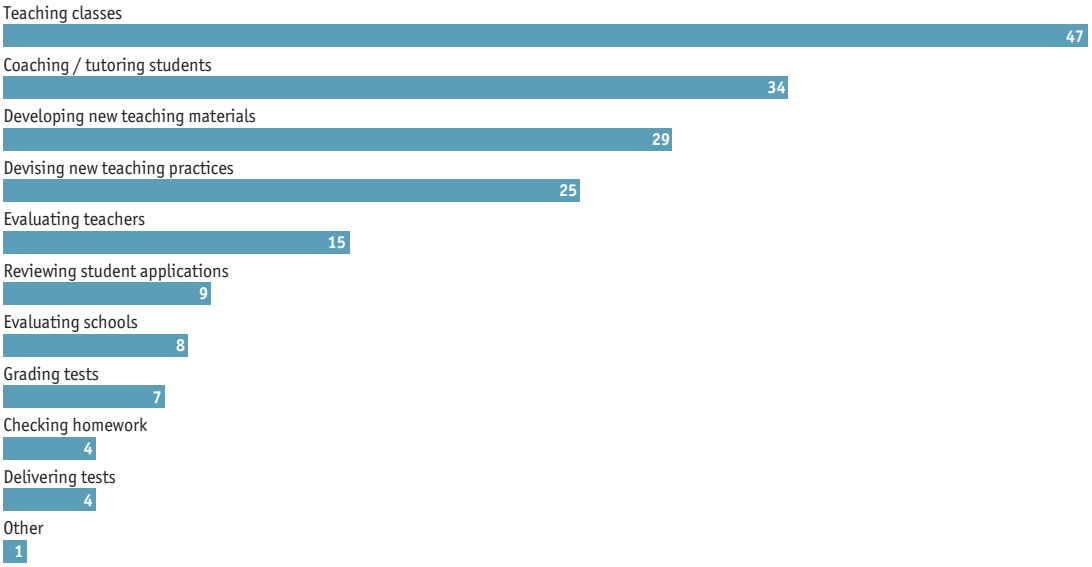
In your view, in which of the following activities has the role of human imagination or intuition declined most rapidly in the past five years? Please select up to two. **Healthcare**
(% respondents)



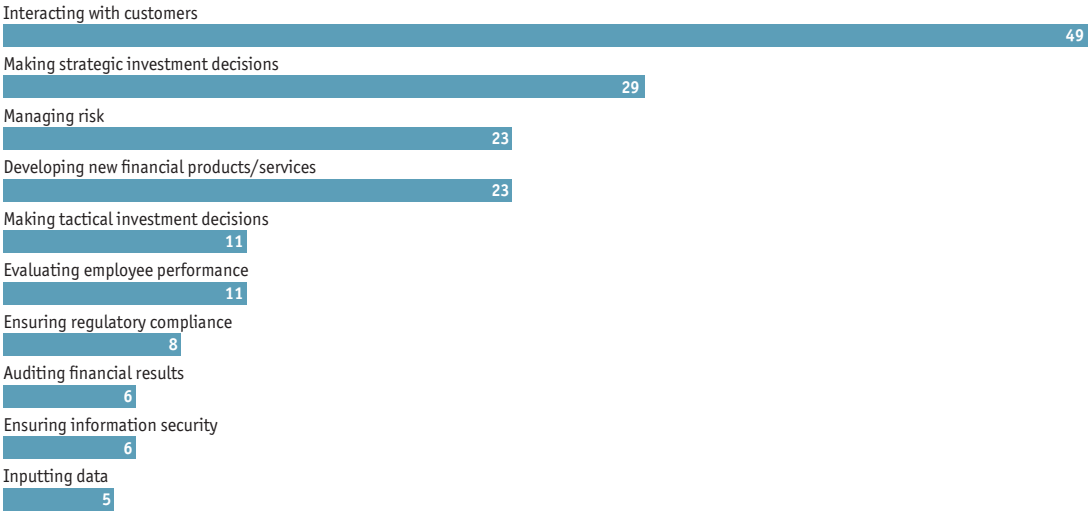
In your view, in which of the following activities has the role of human imagination or intuition declined most rapidly in the past five years? Please select up to two. **Manufacturing**
(% respondents)



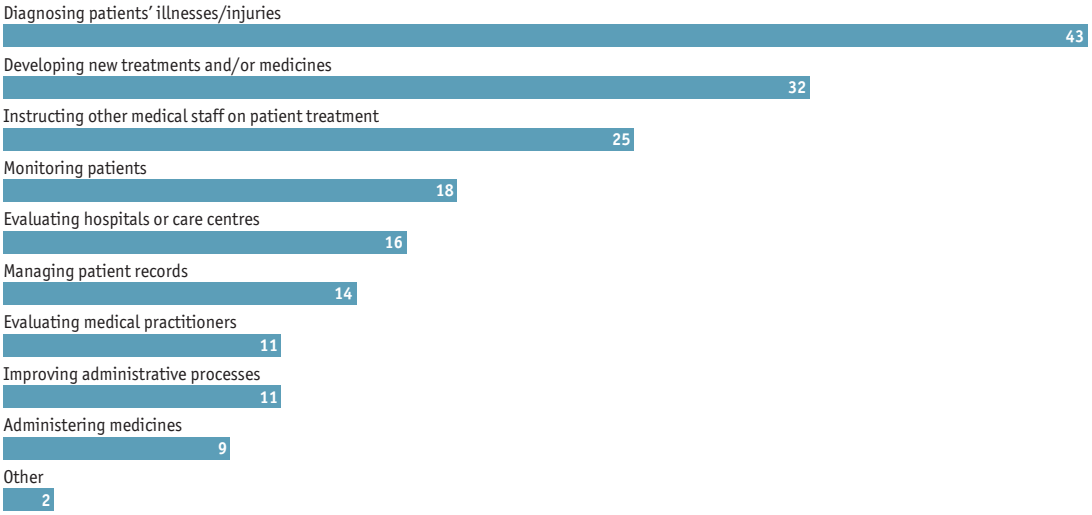
In your view, in which of the following activities is the need for retaining a role for human imagination or intuition most critical? Please select up to two. **Education**
(% respondents)



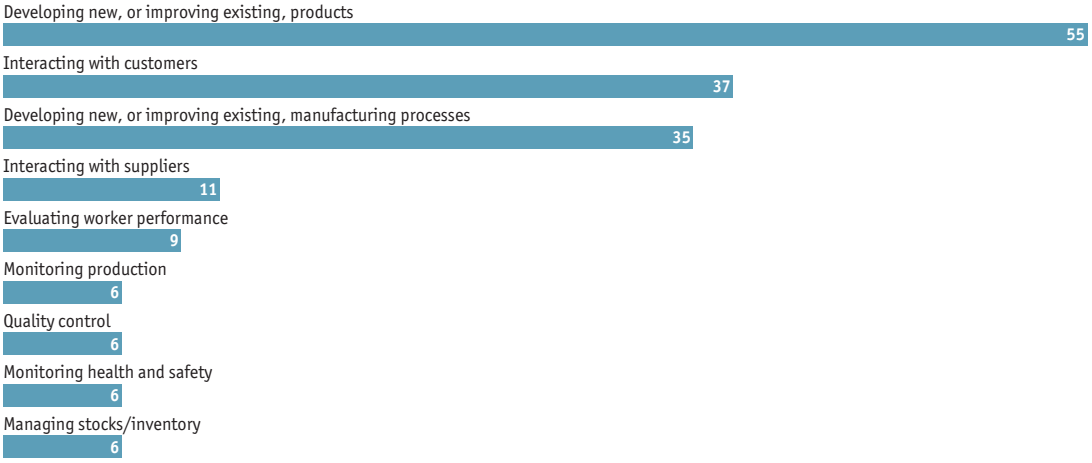
In your view, in which of the following activities is the need for retaining a role for human imagination or intuition most critical? Please select up to two. **Financial services**
(% respondents)



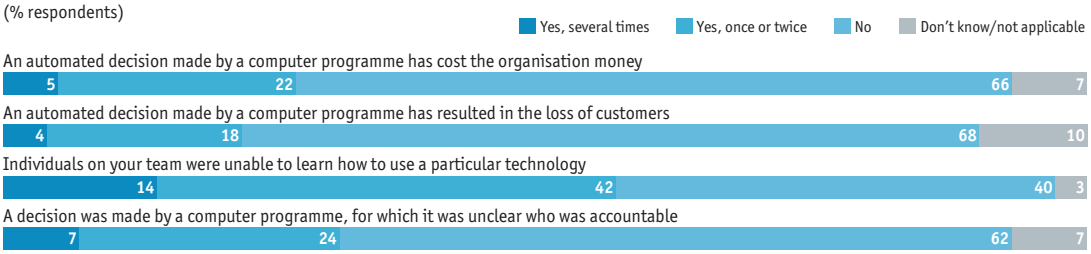
In your view, in which of the following activities is the need for retaining a role for human imagination or intuition most critical? Please select up to two. **Healthcare**
(% respondents)



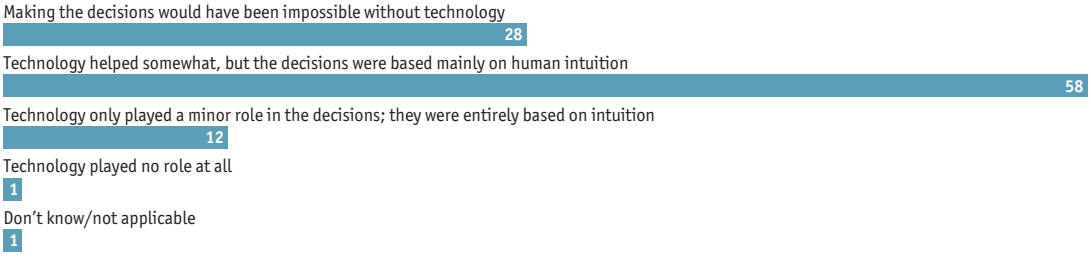
In your view, in which of the following activities is the need for retaining a role for human imagination or intuition most critical? Please select up to two. **Manufacturing**
(% respondents)



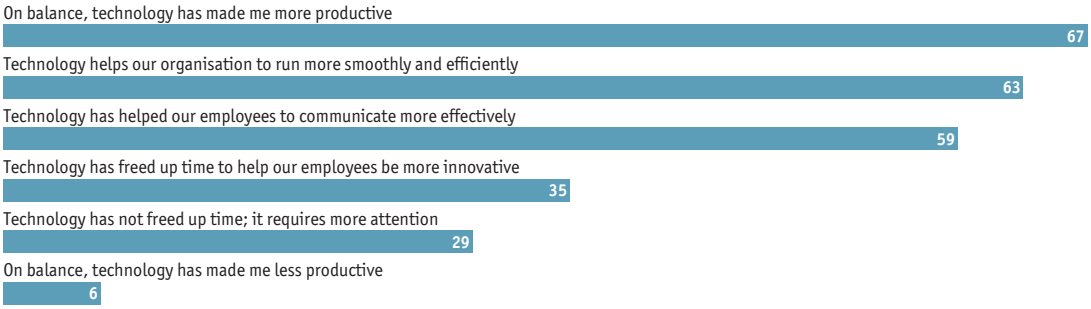
Have you encountered any of these situations in the past 6 months?
(% respondents)



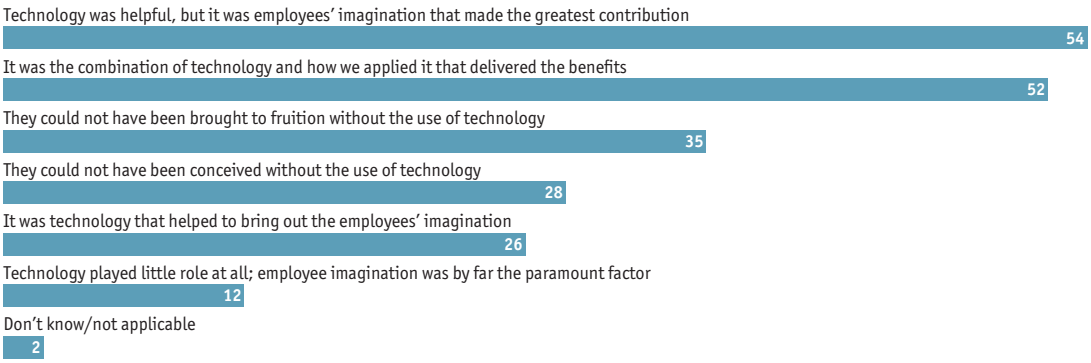
Which one of the following statements best characterises the role that technology (eg, data, networks, devices, applications) has played in your most important work decisions over the past year?
(% respondents)



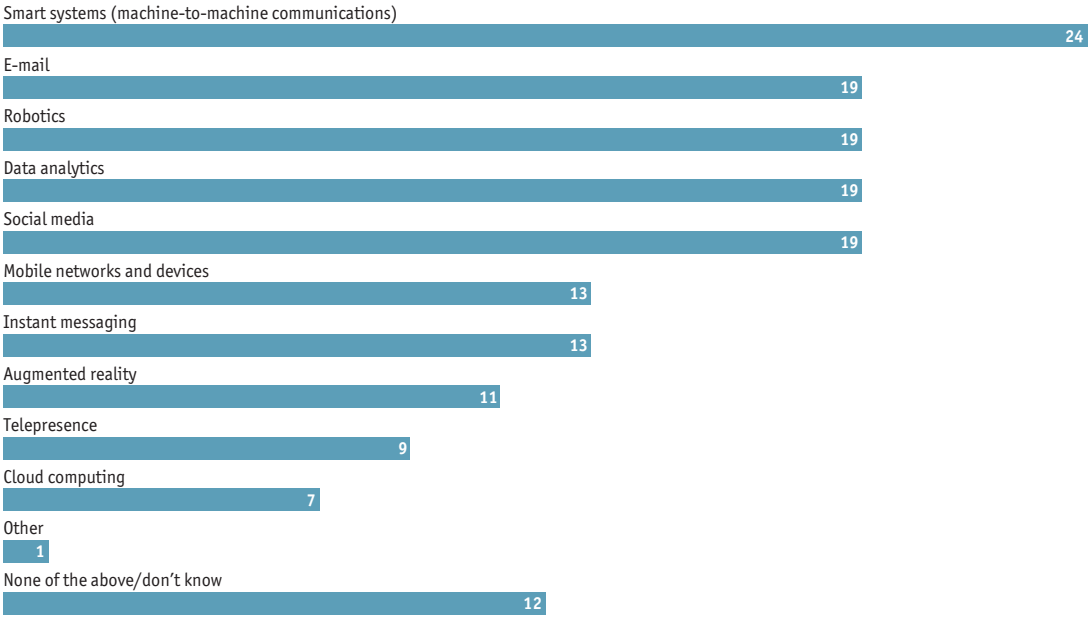
Do you agree with the following statements? Please select all that apply.
(% respondents)



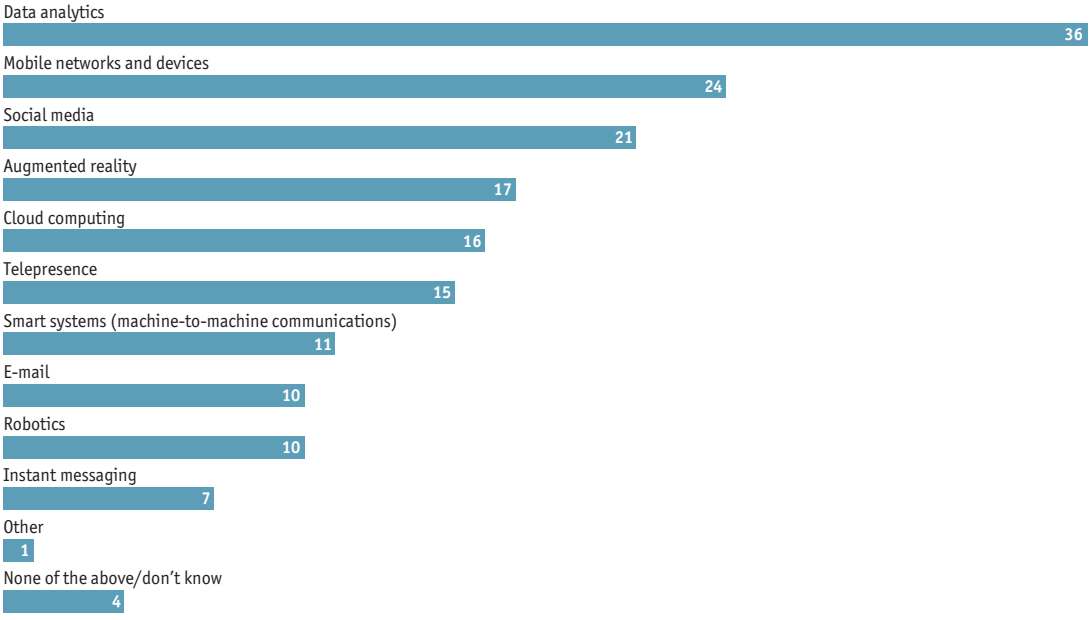
Which of these statements characterises your team's best innovations of the past three years? Please select all that apply.
(% respondents)



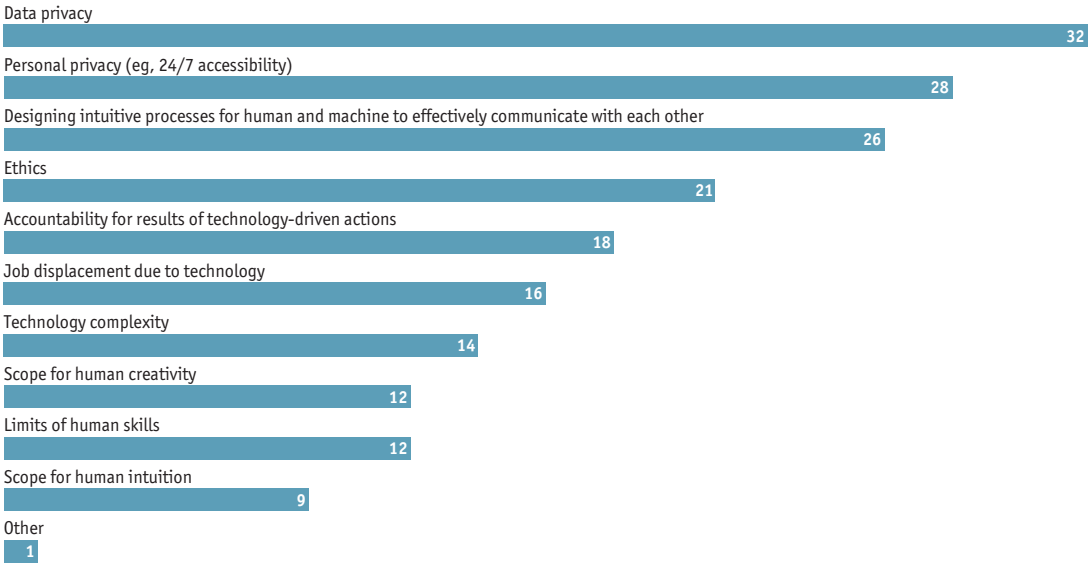
In your view, which of these technologies are most likely to narrow the scope of human imagination and intuition in the work environment? Please select up to two.
(% respondents)



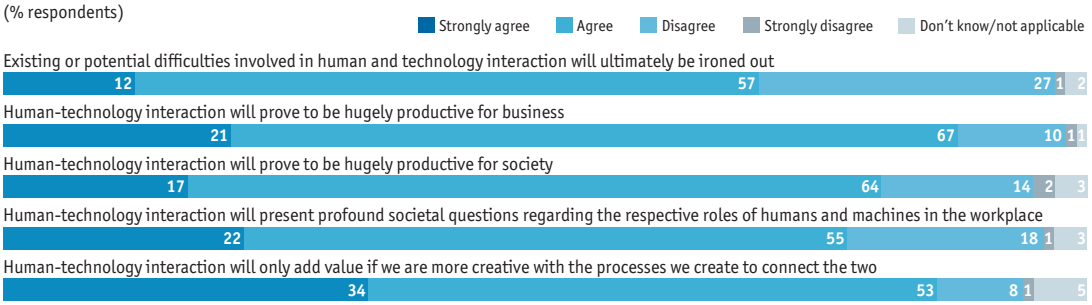
In your view, which of these technologies are most likely to widen the scope of human imagination and intuition in the work environment? Please select up to two.
(% respondents)



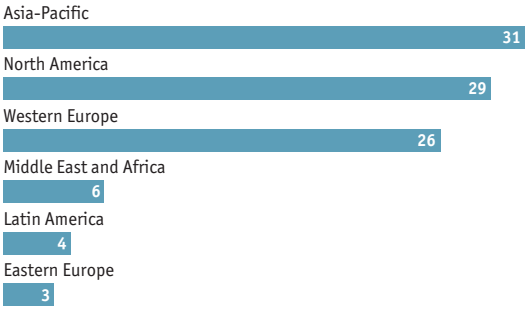
Thinking of the future of human-technology interaction, in what areas do you think the most difficult issues will lie?
Please select up to two.
(% respondents)



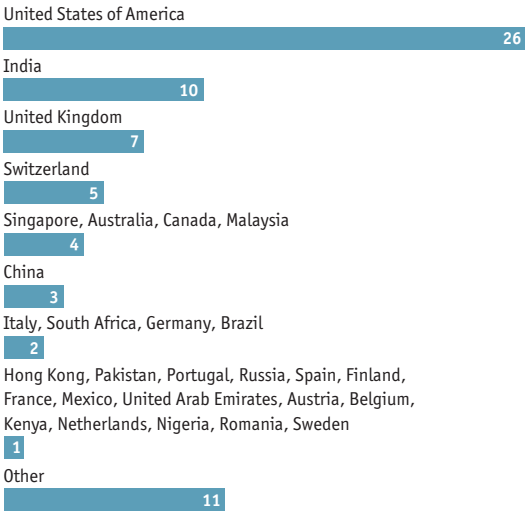
Please state the extent to which you agree with the following statements:
(% respondents)



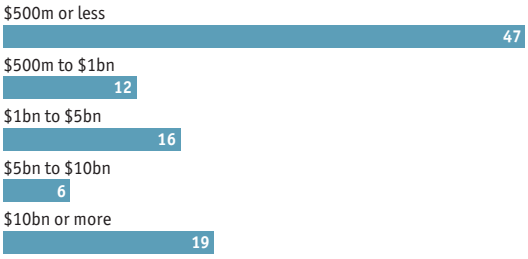
In which region are you personally located?
(% respondents)



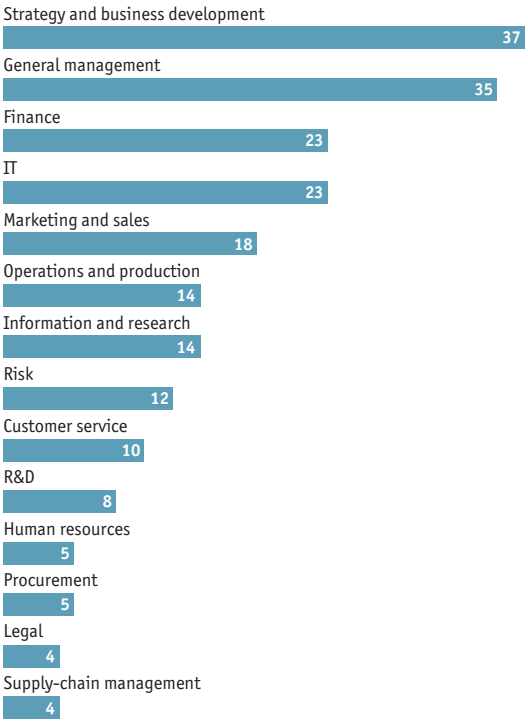
In which country are you personally located?
(% respondents)



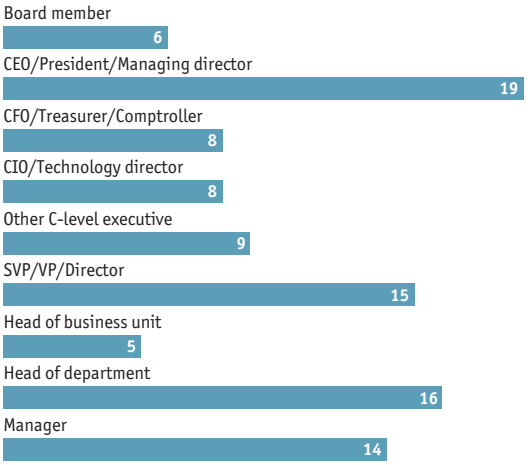
What are your organisation's global annual revenues in US dollars?
(% respondents)



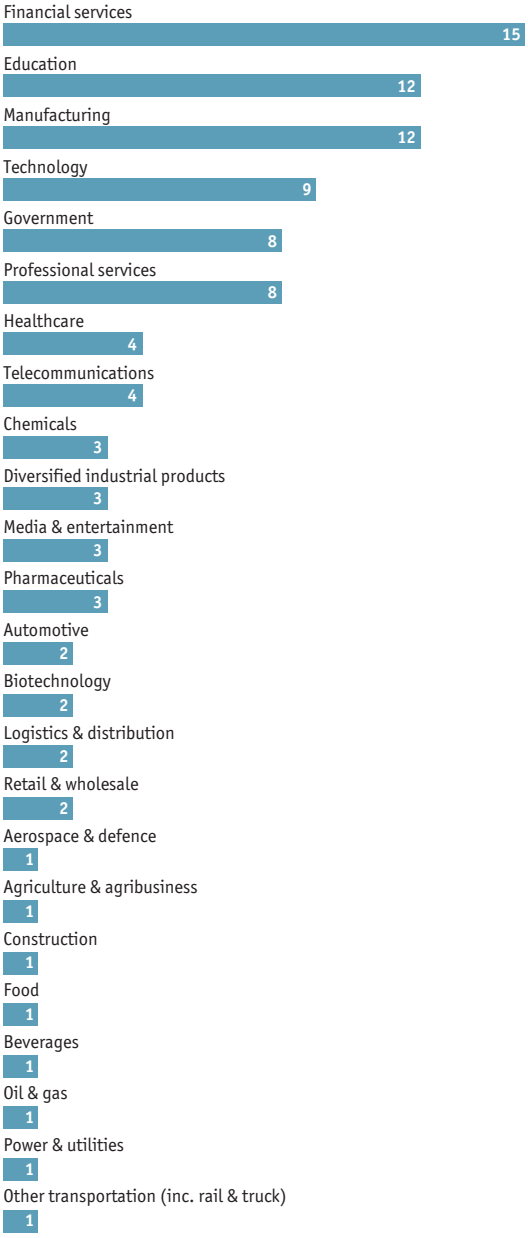
What are your main functional roles?
Please select all that apply.
(% respondents)



Which of the following best describes your title?
(% respondents)



What is your primary industry?
(% respondents)



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