Smart Machines and Human Expertise: Challenges for Higher Education

Our machines and systems are increasingly smart and capable. They can work alongside humans as professional partners, augmenting human expertise and helping us find and develop talent. How will higher education respond as our professions change?

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Alexa talks to you. Google finds answers to your queries. Amazon knows your preferences. Facebook not only knows your friends but also can help you find the perfect partner. These platforms seem to know what we are thinking almost before we do. Our world has taken on a digital smartness thanks to artificial intelligence (AI), data, natural language processing, automation, and robots that, although nearly invisible, impact much of what we do. This digital smartness is projected to have a massive influence on the world economy, adding $15.7 trillion to global GDP by 2030. It will increase productivity and wages, allowing individuals to purchase more and/or better products. Automation, driven by AI and robotics, is estimated to require the reskilling of one-third of the 2030 US workforce, with nearly 10 percent of positions being in fields unknown today.[1]

If "smart machines" are having such impact on the economy and our professions, what will they mean to higher education? For example, could a chatbot be your next TA? "Jill Watson," the first chatbot teaching assistant for an AI course at Georgia Tech, responded to students' questions so well that some students wanted to nominate "Jill" as the best TA in the course. At Beckett University in the United Kingdom, chatbots help prospective students find available courses of study. Georgia State University (GSU) uses an AI chatbot to respond to questions about enrollment and financial aid, handling peak volumes of as many as 2,000 calls per day, with 200,000 questions answered in the first summer of use. (When the system is less than 95 percent confident of an answer, the query is passed on to a staff member.) But the impact goes beyond handling call volume. GSU estimates that the timely responses to questions helped reduce "summer melt" (i.e., the loss of students who are admitted but not yet registered) by 20 percent. Deakin University in Australia has created a platform, Genie, that combines chatbots, AI, voice recognition, and a predictive analytics engine to create an intelligent virtual assistant that provides students with advice. Chatbots are being tested as English tutors as well.[2]

In spite of their growing use, digital assistants only scratch the surface of the coming changes. Colleges and universities are challenged to move beyond the use of technology to *deliver* education. Higher education leaders must consider how AI, big data, analytics, robotics, and wide-scale collaboration might change the *substance* of education. The world around us is getting smarter. What does it mean to be a professional in a world of smart machines?

The Smart Machines Around Us

These increasingly capable systems not only retrieve and present information more quickly and accurately but also solve problems and offer advice. Machine learning allows computers to "consume" information such as medical records, financial data, purchases, and social media and then develop predictions or recommendations. Today's AI uses "brute force" computing, enabled by massive amounts of data, memory, and processing power. Beyond processing instructions at incredible speed, these machines can create their own guidelines and discover patterns invisible to humans. AI allows IBM's Watson, for example, to aggregate clinical guidelines, medical literature, and patient data to help physicians diagnose and treat cancer. AI and imaging software can speed up the diagnosis and treatment of strokes.[3]

Digital smartness comes in other forms too. In health care, robots allow surgeons to perform precision surgery. Collaborative robots in e-commerce fulfillment facilities help workers "pick" (i.e., select) items two to three times faster and with close to 100 percent accuracy. ROVs (remotely operated vehicles) allow humans to explore other planets, collect data in active volcanos, and search for victims in a burning building—among other tasks. Robotic prosthetics and exoskeletons help amputees and those with impaired mobility. Self-driving cars and trucks promise to make transportation more efficient. Drones, essentially flying robots, have an increasing number of uses, from firefighting to farming, with an estimated value of $127 billion. In-space manufacturing and assembly is being explored using autonomous robots and additive manufacturing techniques (i.e., 3-D printing).[4]

Today's robots interact with the physical world. Robotic sensing gives machines the ability to "hear" through signal processing, "see" through image processing, and "touch" through pressure and pattern processing. In addition, this generation of robots can detect and express emotions. Social companion technology, in which a machine displays empathy, is being explored for the elderly to help combat loneliness as well as monitor wellness. These part-robot, part-AI systems use animatronic gestures and "speak," providing information, reminders, and support as they adapt to and learn from their human companions.[5]

If smart machines can take on all these human tasks, what does that mean for people? Will we need to know or do less—or more? And with these smart machines having such a large impact on the economy and the workforce, what will they mean for higher education? Rather than replacing people, smart machines augment human capabilities, meaning that we need to learn to work with machines as partners. Changes in our professions are becoming more rapid, suggesting that the way we develop and find expertise will change as well.

Augmenting Human Expertise

AI and robotics have catalyzed a wave of automation—based on artificial cognition, cheap sensors, machine learning, and distributed smarts—that will touch virtually all jobs, from manual labor to knowledge work. However, *automation* may be a less apt term than *augmentation*. As Garry Kasparov, former world chess champion, has observed: "Humans are not being replaced by AI, we are being promoted. Machine-generated insights add to ours, extending our intelligence in the way a telescope extends our vision. Think of AI as 'augmented intelligence.' Our increasingly intelligent machines are making us smarter."[6]

As machines can do more, professional roles shift. New tasks take the place of the ones that were automated. Historically, new technologies have spurred the creation of more jobs than they have destroyed. For example, in the United Kingdom, automation is estimated to have eliminated 800,000 lower-skilled jobs (e.g., call centers) while simultaneously creating 3.5 million higher-skilled ones. The higher-skilled positions often require retraining, however. At German auto-parts maker Bosch, welders, joiners, and mechanics were trained in basic coding skills to enable them to use robots as tools.[7]

Thus, whether it is AI, robotics, or another technology, today's machines can work alongside professionals as partners, amplifying human performance and augmenting human intelligence.

Data-Driven Insights

"Knowledge processing"—something much more sophisticated than information retrieval—is an example of a new approach to professional work. Today's systems can capture and reuse massive amounts of information, allowing a computer to compare a patient's symptoms against a database of millions of past patients. In law, intelligent search systems can outperform junior lawyers and paralegals in reviewing large sets of documents. Court decisions can be predicted by tapping databases of hundreds of thousands of past cases. Machines can consume vast quantities of information, discern patterns, and make predictions that allow professionals to work in different ways.[8]

Scientific research is an example of how the work of a higher education professional can change. Data-intensive science and computational science have augmented the traditions of theoretical or experimental research. Today, AI and automated hypothesis generation platforms are used to mine scientific literature and formulate hypotheses to help researchers focus their laboratory resources in areas that are most promising. For example, Baylor College of Medicine used IBM's Watson to design a Knowledge Integration Toolkit (KnIT). One test of KnIT focused on the functional properties of p53, a protein that is important in tumor suppression. At the time of the test, there were over 70,000 scientific articles involving p53. Humans can "consume" 1 to 5 scientific articles a day, so it would have taken a researcher approximately 38 years at best (assuming 5 articles consumed every single day) to assimilate the existing research. In one month, KnIT successfully helped researchers identify 6 protein kinases that phosphorylate (or turn on) p53; 28 had been found in the prior 30 years. At many steps in the R&D process—observation, hypothesis generation, experiment design, and results analysis—AI can provide insights that augment human capability, increase efficiency, and improve outcomes.[9]

More Accessible Expertise

Smart machines can perform faster and more accurately than humans, but they don't necessarily use the same processes. Consider an example from the legal field. When there is an unresolvable dispute between two parties, the dispute can go to court. Resolving legal claims is time-consuming and expensive—too much so to be viable for low-level claims such as are common in online commerce. Rather than sending the dispute through the courts, eBay resolves an estimated 60 million disputes per year using online dispute resolution (ODR). One approach to ODR involves a three-round blind bidding system that matches plaintiffs' demands with offers from defendants. If the offers are close, the system splits the difference between the bids and declares a settlement. Many disputes are resolved in the first round.[10]

ODR is used for more than e-commerce. It has also been used for no-fault insurance disputes and property tax appeal resolutions. In New York City, for example, ODR has been used for personal injury claims, with 66 percent of the claims settled within thirty days, saving $11.6 million in litigation costs on 1,200 claims. The United Kingdom has explored ODR and an internet-based court service as future options because the current judicial system for low-level civil claims is too slow, costly, and complicated, making it inaccessible and unaffordable for many people.[11]

The importance is not that machines can do things differently—it is that people can benefit from the outcomes. Society profits from the sharing of expertise, not just in the legal field but also in areas such as health care, education, business, architecture, agriculture, and engineering. Globally, there is huge unmet demand for this expertise. While non-thinking, high-performing machines do not necessarily operate the same way humans do, they may offer guidance or arrive at solutions that allow professionals to make expertise more accessible and affordable than ever before.[12]

Collective Expertise

We tend to think of professional work as being conducted by experts—people who hold degrees certifying their expertise and whose practices are defined by their profession. However, large numbers of people making small contributions have the power to impact scientific advances, social movements, product innovation, fund-raising, and more.

Online innovation platforms have emerged in the last decade to capitalize on "collective intelligence," encouraging more people—enthusiastic volunteers—to become involved in solving problems. The platforms expand the scale of collaboration possible and the range of expertise tapped. The ideas and insights gained through increased cognitive diversity can spark new ideas.[13] In addition, time to innovation (or discovery) can be reduced. InnoCentive, for example, is a clearinghouse for scientific problems. The "challenges" come from corporations, non-governmental organizations (NGOs), and other nonprofits. Small rewards are offered for the best solution. For example, a reward of $15,000 was offered for finding a way to provide a safe, affordable method to collect rainwater in developing countries for under $20 per 125 gallons. Teams self-organize and submit solutions. Over half of the challenges are solved, often by people outside the expected field of knowledge or expertise because they bring a unique perspective to the problem.[14]

"Communities of experience," which tap the experiences of laypeople to advance a profession, are another form of collective intelligence. An example is PatientsLikeMe, a social networking site for patients who suffer from rare and chronic diseases. The platform does much more than provide moral support for patients and their families. Over 600,000 people report on their experiences with 2,800 conditions. The platform aggregates and organizes more than 43 million member data points and shares the data with clinicians, pharmaceutical companies, federal agencies, and other institutions, enabling research and innovation. Using a give-data-get-data philosophy, patients are helped to find new treatments and connect with others.

Implications for Higher Education

Smart machines are reconfiguring professional work. Although the thought of tasks being performed by a machine can be disquieting, who performs the task is less important than the outcome. Is the task done better by "man" or "machine"? Robots can be more precise and reliable in advanced manufacturing or medicine, for example. However, just because a *task* can be performed better by a machine does not mean a *job* goes away. A robot that sutures a patient does not replace the surgeon.

Low-level tasks performed by humans can be replaced with higher-level ones.

What does this mean for higher education? One answer is that AI, robotics, and analytics become disciplines in themselves. They are emerging as majors, minors, areas of emphasis, certificate programs, and courses in many colleges and universities. But smart machines will catalyze even bigger changes in higher education. Consider the implications in three areas: data; the new division of labor; and ethics.

Data. Today's machines and systems develop new knowledge by feeding on data. Compiling large datasets is a prerequisite to the use of AI. Poor data or insufficient data will result in faulty conclusions or decisions. Considering how prevalent AI and analytics have already become, future professionals will very likely need to know how to gather and analyze large datasets as well as how to interpret the results. Data cannot depend on data scientists alone. Data is a critical element of virtually all professions. Higher education leaders should ask questions such as the following:

- What place does data have in our courses?
- Do students have the appropriate mix of mathematics, statistics, and coding to understand how data is manipulated and how algorithms work?
- Should students be required to become "data literate" (i.e., able to effectively use and critically evaluate data and its sources)?

The New Division of Labor. The impact of AI and robotics comes from connecting the physical and the virtual, the human and the digital, which can result in combinatorial and exponential change. Our disciplines and professions are no longer confined by physical or virtual boundaries—they can be both, simultaneously. This represents a new division of labor between "man and machine." Core competencies such as problem-solving, cross-functional collaboration, and teamwork will be more important tomorrow than they are today. However, the best way to integrate human expertise with machines and collective intelligence is largely uncharted. Higher education leaders should ask questions such as the following:

- How might problem-solving and discovery change with AI?
- How do we optimize the division of labor and best allocate tasks between humans and machines?
- What role do collaborative platforms and collective intelligence have in how we develop and deploy expertise?

Ethics. Professionals will need many capabilities in the era of smart machines. One is cognitive capability—the ability to think, reason, solve problems, and reflect. Another is affective capability—the ability to feel and relate to others. Motor skills and manual capacity constitute a third capability. A more nebulous, yet critical, capability is moral—the ability to distinguish right from wrong, just from unjust, or to take responsibility for one's choices. While our machines and systems are increasingly capable, they lack this last capability.[15] In a world where new technologies present complicated choices, ethics may become more important than ever. Higher education leaders should ask questions such as the following:

- Even though something is possible, does that mean it is morally responsible?
- How do we achieve a balance between technological possibilities and policies that enable—or stifle—their use?
- An algorithm may represent a "trade secret," but it might also reinforce dangerous assumptions or result in unconscious bias. What kind of transparency should we strive for in the use of algorithms?

Finding and Developing Human Expertise

As our professions are changing due to smart machines, big data, and robots, the capabilities we look for in professionals—and how those professionals are selected and advanced—are changing as well. AI is playing a critical role in this shift.

Virtually all position descriptions are advertised online. Credentials (e.g., resumes, transcripts, and test results) are available in digital format, making it possible for natural language processing and big data to power talent analytics platforms. Massive amounts of data can be aggregated and analyzed to gain new insights. For example, employers are using talent analytics to answer questions such as "What are the characteristics of employees who are being promoted?" Quality-of-hire analysis helps answer "What skills do they have?" and "Where and how did they learn this skill?"[16] Detailed analyses of the competencies associated with professional success are informing position descriptions and enabling competency-based hiring.

Machine learning and AI are being used in nearly all phases of talent recruitment:

- AI-powered chatbots are being used to recruit possible employees and to ensure that candidates have a positive experience. These digital assistants can converse with potential candidates and answer questions as well as make sure they receive regular updates about their application status.[17]
- The process of screening and judging candidates based on resumes often fails to recognize core capabilities. AI and machine learning are tapping publicly available data to provide insight beyond what is available in a transcript or resume in areas such as leadership and technical skills.
- New interview protocols and pre-hire assessments are being used to focus hiring more closely on ability.[18] One of the reasons is diversity. Unconscious biases can be triggered by aspects such as a person's name, gender, age, institution attended, or appearance. For example, women are 11 percent less likely to make it through application reviews, 19 percent less likely to get through recruiter screens, 12 percent less likely to proceed through assessments, and 30 percent less likely to move on from onsite interviews.[19]

New ways to assess and credential professionals' qualifications, communicate those qualifications to the market, and match talent with positions are emerging. Badging is just one example.

Performance-Based Assessment

Historically, the best indicator of intellectual and interpersonal skills was a degree. However, supplementing the degree by measuring ability through performance simulations may result in better matches between candidates and positions. EquitySim , for example, is a simulation platform that helps employers identify top talent for entry-level financial trading positions. Because it is performance-based, it helps reduce biases, such as those associated with age or gender. The platform can also identify talent at institutions where employers don't usually recruit. The simulation involves having the user trade stocks, bonds, currencies, and securities, yet the data collected is much richer. The platform captures more than 100,000 behavioral data points per user (e.g., order of steps followed, duration of time spent). These data points are associated with important characteristics, such as risk management capability, in order to target candidates based on competencies that are predictive of success and retention. Although the simulation measures performance, success in the simulation can result only from critical thinking, problem solving, and other core cognitive skills. When companies use EquitySim, 48 percent of candidates hired are female, compared with 25 percent when using traditional approaches.[20]

Transferable Skills

A fusion of education, training, and experience will be required for the long-term career growth of tomorrow's professionals. A 2016 survey found that 54 percent of Americans believe it will be essential and 33 percent believe it will be important for them to develop new skills throughout their career to keep pace with changes.[21] Competencies will be key for the future of professionally oriented education because many of them (e.g., problem-solving, collaboration) are common across industries. Sustainable career paths depend on transferable skills and competencies. Although the term "soft skills" is often used to describe problem-solving, communication, collaboration, critical thinking, and teamwork, a better term may be "mobility skills" because they enable individuals to move from one position to another.

The options for developing these skills are all around us: competency-based education, apprenticeships, internships, certificates, boot camps, and badges. Do-it-yourself learning opportunities are available online, all the time. Stackable credentials offer learners pathways from today's jobs to tomorrow's. Whether skills and competencies are developed at a college, university, or corporation or were self-taught matters less than the ability to transfer that expertise to new problems. Employers are interested in "agility"—the ability to adapt rapidly and on an ongoing basis.[22] As a result, the adoption of approaches such as badging is growing among both professionals and employers.

Co-Created Degree Alternatives

If training and education must become more frequent across a career, blocks of courses in two- or four-year degrees will be too inflexible for a continuous work-learn model that may span forty to fifty years. Alternative models are emerging.

One example of a blended work-and-learn model is Northeastern University's professional master's degree programs that provide pathways from IBM badges to academic degrees. Under IBM's "New Collar" program, 15 percent of its skilled jobs are now held by workers without college degrees. Badges are being used as a way to develop skill and verify talent with "competency stacks." IBM has issued more than 850,000 badges. When Northeastern administrators reviewed the badges, they found many that could be applied toward academic degrees. To date, 3 professional master's programs build on IBM badges, with another 51 degrees and 17 certificate programs under consideration. Other large employers that have recently announced badging programs for talent development or competency-based hiring include Microsoft and Ernst and Young.[23]

Integrating Credentials Online

Learning and credentialing take place on the job as well as at colleges and universities. Hundreds of organizations offer an estimated 250,000 credentials such as badges, micro-master's, certificates, and degrees.[24] Now that credentials are digital, online platforms can integrate education and experience into a single online identity. Degreed, for example, will aggregate an individual's learning experiences in something akin to a "credit score." Degreed Skill Certification goes a step farther, allowing individuals to demonstrate and certify what they know, regardless of where the skill was gained. The program scores skills in areas such as writing, sales, programming, and leadership through a process that involves peer and expert review. It uses machine learning and inter-rater reliability to improve consistency and confidence in the reviews. As a result, companies can codify the skills of employees, and employees can have their skills professionally certified, adding a degree of certainty and potentially helping to reduce forms of bias.[25]

Online talent platforms such as LinkedIn help make the connections between education, experience, and the labor market more transparent. LinkedIn has become a credential and competency clearinghouse for consumers, employers, and educators with approximately 560 million registered users as of June 2018. Employers and job-seekers are matched on a massive scale. Beyond helping users find jobs, LinkedIn can assist individuals in identifying skill gaps, developing new capabilities (e.g., through courses offered by LinkedIn Learning or Lynda.com), and charting new career paths.[26] By supplying market information and training, LinkedIn does not just find and connect talent—it grows talent.

Implications for Higher Education

How will higher education (either through degree programs, certificates, or continuing education) help ensure that millions of new and existing professionals have the skills to transition to new positions? Clearly education is a critical component of how society manages the massive disruption smart machines represent. But to what extent does that future education look like today's?

In the near term, changes may be felt by college/university career planning and placement offices as students prepare to enter the job market. But it is not only new college graduates at the start of their career who need assistance in developing their talent; this shift includes adults at varying stages of professional and lifelong learning.[27] Longer-term impacts revolve around the transparency of what a degree signifies. Students invest in credentials to advance their careers. Though the significance of a degree and the power behind a college or university brand are likely to remain, data-driven and competency-based approaches will challenge higher education institutions to provide greater transparency into what graduates can *do,* both on graduation and throughout their career. Ultimately, talent platforms will enable employers and educators to better align professional demands with educational options.[28] Higher education leaders should ask questions such as the following:

- Are we making students aware of possible career pathways and how they can develop and demonstrate the intentional, continuous learning and agility they will need to be future-ready? Are we helping students learn how to develop and share digital credentials that will serve them throughout their careers?
- To what extent are programs aligned with the labor market? How "industry-informed" is the curriculum? How well-informed should it be?
- How will colleges and universities work with business and government to grow talent on a lifelong and global scale?

Challenges for Higher Education

AI and other technologies will find their place in higher education. Today chatbots are responding to questions about registration, course availability, and homework assignments. AI is already conserving resources and saving money for colleges and universities, such as by reducing the amount of water used by sprinkler systems.[29] But higher education's greater challenge is to anticipate what it means to be a knowledge worker in a world of smart machines. Changes brought about by AI and robots are taking place in the professions faster than they are in higher education. Without a close connection to business and industry, higher education will be challenged to anticipate the changes in our disciplines and professions. Even if higher education is a keen observer of changes, can programs adjust quickly enough? Are hybrid business/academic options more likely to be successful?

A focus on competencies, credentials and certifications—and what they mean to the labor market—will become increasingly important. With greater transparency between educational experiences and expertise being created by talent platforms, colleges and universities may need to refine how they certify what graduates know and can do. Enhanced transcripts, badges, and competencies are existing options. More options are likely to emerge. No matter what the mechanisms, the speed of innovation and implementation will matter. Without rapid change in higher education, large-scale solutions in the market may circumvent traditional approaches.

Finally, with career mobility hinging on education, training, and experience, is higher education sufficiently focused on the skills and competencies that are transferable to fields that have yet to be created? With the need for lifelong education becoming more critical than ever, can higher education develop shorter, more flexible, and more closely connected paths to needed education and training?

There will be no "one-size-fits-all" future. Some higher education institutions may change the structure and flexibility of their programs. Others may focus on competencies and how they are certified. Still others may choose to not change at all.

Our machines and systems are increasingly smart and capable. They can work alongside humans as professional partners, augmenting human expertise and growing talent. Together, humans and machines can create great value for society. What role will higher education choose to play in this new world? Will we take on the challenge?

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