Ask About AI:

The Future of Work and Learning

Tom Vander Ark | November 2017

GETTING SMART
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About Tom Vander Ark

Tom Vander Ark is a recognized advocate for powerful learning experiences. As CEO of Getting Smart, he advises school districts and networks, education foundations and funders, and impact organizations on the path forward. A prolific writer and speaker, Tom is author of Getting Smart: How Digital Learning is Changing the World; Smart Cities That Work for Everyone: 7 Keys to Education & Employment; and Smart Parents: Parenting for Powerful Learning. He has published thousands of articles, co-authored and contributed to more than 50 books and white papers. He writes regularly on his Education Week blog, Vander Ark on Innovation, and contributes to GettingSmart.com, Medium, HuffPost and LinkedIn.

Previously, Tom served as the first Executive Director of Education for the Bill & Melinda Gates Foundation. He also served as a public school superintendent in Washington state and has extensive private sector experience. Tom co-founded the first education venture fund, Learn Capital. Tom is Board Chair of Charter Board Partners, Director for 4.0 Schools, Digital Learning Institute, eduInnovation and Imagination Foundation and Advisor for One Stone and Teton Science Schools.

About Getting Smart

As a mission-driven organization, Getting Smart® is passionate about accelerating and amplifying innovations in teaching and learning. Getting Smart Solutions designs customized partnerships to amplify and extend the work of those dedicated to impacting the way the world learns. Through our advocacy, advisory and coaching services, we work with impact-oriented partners to invent the future of learning.Our innovations in learning blog, GettingSmart.com, is a community of learners and contributors that cover important events, trends, products and publications across K-12, early, post-secondary education and lifelong learning opportunities.

About eduInnovation

eduInnovation is a global nonprofit committed to advancing the future of work and learning. We are a diverse group of educators, researchers and investors who have a shared mission to create positive social impact through our work. Our campaigns can be found on our media partner site GettingSmart.com.

SUMMARY

"We stand on the brink of a technological revolution that will fundamentally alter the way we live, work and relate to one another. In its scale, scope and complexity, the transformation will be unlike anything humankind has experienced before."

—Klaus Schwab, World Economic Forum

Code that learns will prove to be humankind's greatest invention—and, some worry, its demise. Artificial Intelligence (AI) will have more influence on the lives and livelihoods of young people over the next several decades than any other factor.

Fed by big data and equipped by robots and other enabling tools, AI will help address our most pressing problems: it will help us cure disease, unlock clean energy, and create valuable and affordable services. Simultaneously, it will cause massive dislocation, widen income gaps, weaponize robots and pose other existential threats.

A year ago there was almost no discussion of AI in K–12 education. Given its likely benefits and potential problems, however, we think it is a good time to Ask About AI (#AskAboutAI). Sponsored by eduInnovation and powered by Getting Smart, this campaign was organized to investigate the implications that AI will have for employment, education and ethics—to start a conversation about how we can shape a future that works for everyone.

Objectives of the #AskAboutAI Campaign

EMPLOYMENT

Describe future labor-market impacts and required competencies

ETHICS

Identify the social and civic implications of exponential technology, particularly the emerging issues that educators, parents and policymakers should begin addressing now

EDUCATION

Advise educators, parents and policymakers on knowledge, skills and dispositions likely to be important in the automation economy. Illustrate new pathways to contribution.

An early advocate of system thinking, Fritjof Capra plowed the ground for Peter Senge[1] and Meg Wheatley.[2] His seminal 1982 piece The Turning Point described a specific turning point—the emergence of the information age in science and technology—but he admitted that man always assumes that he is at a turning point. The remarkable rise of machine intelligence in 2017 marks a shift from the information economy to the automation economy—a shift that appears to be another pivotal turning point in human history.

This report attempts to summarize the implications of machine intelligence for education: both the ways it will improve learning, and its implications for what should be learned. We will do this by asking, addressing and answering three questions: What's happening? What does it mean? And how to prepare?

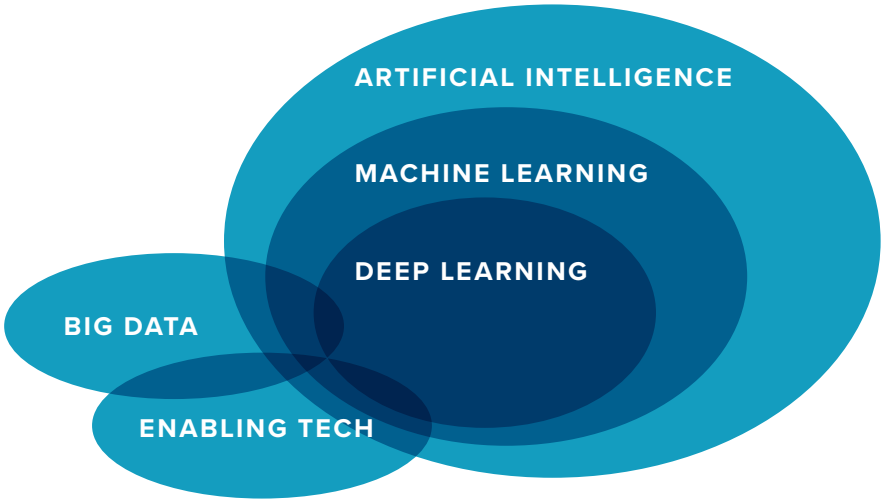
WHAT'S HAPPENING?

"AI is already changing our daily lives, almost entirely in ways that improve human health, safety, and productivity."

—Artificial Intelligence and Life in 2030: One Hundred Year Study on Artificial Intelligence (AI100)

You've seen the warning on your rear-view mirror, "Objects in the mirror are closer than they appear." Only now it's true for stuff in the windshield, too—exponential technology means the future is approaching more rapidly than it used to.

Artificial Intelligence (AI)—the notion that machines could exhibit human intelligence—was first conceived in the 1950s, but it became a really big deal with the recent explosion of big data powered by cheap computing and storage and lots of devices, sensors, cameras and RFID tags (collectively termed the Internet of Things).



Many of the smart machine advances in 2017 were the result of deep learning, a subset of machine learning that uses layers of neural networks—computer models roughly based on the structure of the human brain. When combined with big data, machine learning informs enabling technologies and creates new capabilities. For example, to AI and big data, add:

- Robotics, and you have custom manufacturing (often called industry 4.0[3])
- Cameras and a sensor package, and you have self-driving cars[4]
- Sensors and bioinformatic maps, and you have precision medicine[5]
- CRISPR, and you have genomic editing[6]
- Chatbots,[7] and you have personalized health monitoring, retail and music

The profound change is that, rather than hard-coding a solution, you can feed large datasets into a machine-learning application and it will learn how to perform a given task better and more quickly than expert humans. The combination of machine learning and big data has resulted in impressive accomplishments over the last 18 months, including beating the world-champion Go player (after analyzing millions of professional games and playing itself millions of times[8]), playing dozens of Atari video games[9] better than humans, and reading and comprehending[10] news articles.

Definitions

ARTIFICIAL INTELLIGENCE

Computer code that displays some form of intelligence, learning and problem solving—currently in narrow slivers, but eventually more broadly (often called artificial general intelligence, or full AI, and beyond that, superintelligence).

MACHINE LEARNING

A subset of artificial intelligence that uses algorithms to learn from data and then make a determination or prediction.

NEURAL NETWORKS

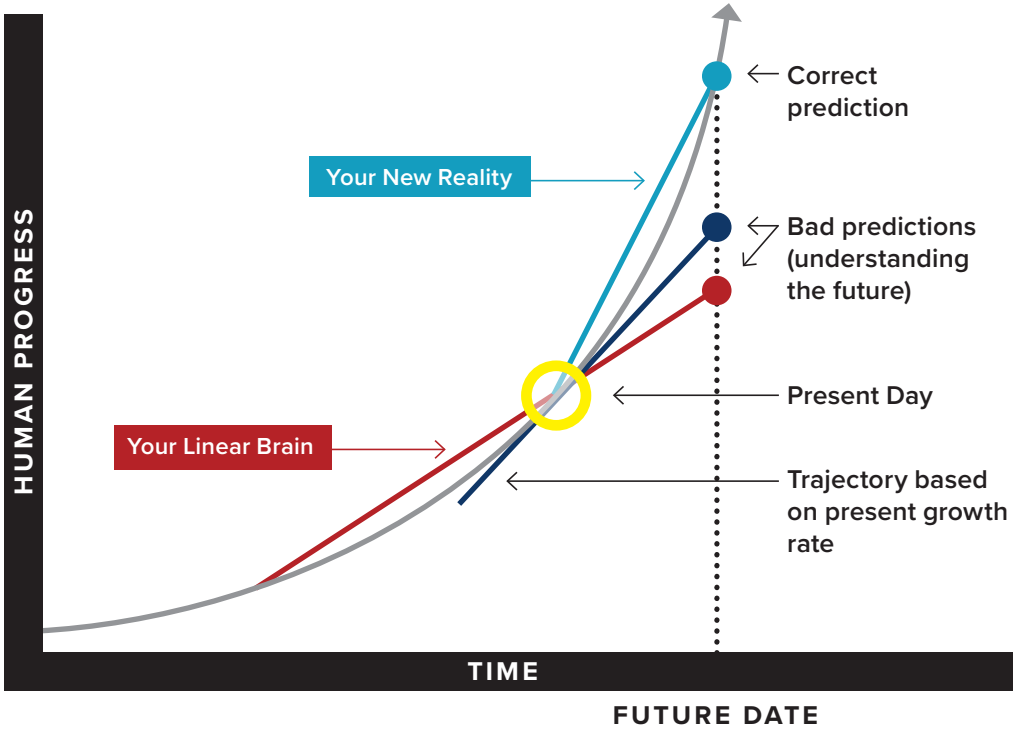
A subset of machine learning that were inspired by the connections of the human brain. But unlike the brain, neural nets have discrete layers that direct the data flows. They've been around since the early days of AI, but were computationally intense until the development of graphics-processing units popularized by Nvidia.

DEEP LEARNING

While at Google in 2012, Andrew Ng put the "deep" in deep learning[11] by adding layers of neural networks and then running massive amounts of data through the system to train it. (For more, watch this Frank Chen video.[12])

Exponential technologies are rapidly becoming more powerful with time. Moore's Law,[13] a term that originated in the 1970s, states that "processor speeds, or overall processing power for computers, will double every two years." We may be nearing the physical end of the limits of silicon-based chips, but a constellation of technologies, including quantum computing, will continue to drive rapid technology growth. (Watch this video on Moore's Law.[14])

EXPONENTIAL TECH: OUR BRAINS THINK IN LINES, NOT CURVES



Source: Adapted from Tim Urban, Wait But Why

Tim Urban of Wait But Why explains[15] that "in order to think about the future correctly, you need to imagine things moving at a much faster rate than they're moving now."

AI is a growing web of related technologies that, with increasingly ubiquitous use, broke through to the popular press in 2016. When Google's DeepMind beat the world-champion Go player in March[16] and self-driving cars showed up in Pittsburgh in September[17], it became obvious that this new cluster of technologies was moving fast and had broad implications.

In the early 2000s, Bill Gates aimed Microsoft researchers at developing speech-recognition software. By the end of the decade, they were making progress with deep stacks of neural networks. In the last few years, the use of deep learning algorithms has produced accurate speech and image recognition—in some cases better than human experts are capable of. AI routinely beats experienced radiologists at tumor detection.[18]

AI Is Here!

The #AskAboutAI investigation began in December 2015 by cataloging applications of artificial intelligence. In less than a week of news, over 100 applications were identified in every aspect of life, suggesting much more widespread use than is recognized by the public. Examples of applications current at the time of this publication include:

MEDIA	Article writing, making movie trailers, curating Facebook feeds, mapping, speech recognition, translation and image recognition
RECREATION	Dating assistance, relationship coaching, game playing and making art
TRANSPORT	Autonomous cars/trucks/buses, route optimization and vehicle tracking
AVIATION	Airplane simulators, aircraft sensors and autopilot intelligence
SECURITY	Fraud detection, crime prediction, aerial and undersea warfare, smart home control, data mining, and voice and face recognition
WORK	Virtual assistance, coding, customer service, improved service delivery, legal services, inventory and underwriting
MARKETING	Demand predictions and market and trend analysis
FINANCE	Tax prep, algorithmic trading, optimized spending and portfolio management
INDUSTRY	Robotics, failure prediction and improved design
ENERGY	Exploration improvement, pollution prediction and grid efficiency
AGRICULTURE	Crop-yield optimization and reduction of chemical use
EDUCATION	Adaptive skill building, recommendations, scheduling, feedback writing, career education and pupil transportation
HEALTHCARE	Diagnosis, precision medicine, X-ray interpretation, error reduction and genome editing
HR	Recruiting, identity verification, match improvement, application/ interview management and employee relations
MUSIC	Human-like composition and recommendation engines
GAMES	AI-enabled toys, video game bots and robot pets

In 2012, essay-scoring systems[19] equaled teachers in measuring quality. In 2017, leading outlets regularly post machine-written articles on routine events, from sports to financial reporting.

AI can help solve some of the most pressing social and health problems by mining social media to infer possible health risks, predicting patients at risk, accelerating and targeting drug development, and supporting robotic surgery.

Platforms Rule

Push a button and a car shows up. Search, click, shazam: dinner arrives. Want to make a quick trip to New York? A flight and a room in a stranger's apartment are a few clicks away. Digital platforms have transformed the way we live, work, travel and learn (or at least they are starting to). The six largest business firms[20] (by market capitalization)—Apple, Alphabet, Alibaba, Amazon, Facebook and Microsoft—all run AI-powered platform businesses.

"A platform is a business based on enabling value-creating interactions between external producers and consumers," said Sangeet Choudary, co-author of Platform Revolution.[21] Platforms provide an open, participative infrastructure for interactions. The platform's overarching purpose, according to Choudary, is to consummate matches among users and facilitate the exchange of goods, services or social currency, thereby enabling value creation for all participants. With AI-powered platforms, the more you (and people like you) use them, the more they learn, and the better they get at matching and recommending.

Platforms driven by AI offer big advantages:

- They scale more efficiently by eliminating gatekeepers
- They unlock new sources of value creation and supply
- They use data-based tools to create community feedback loops
- They bring the outside in

The sectors that usually join the platform revolution, according to the authors, are information-intensive, fragmented and controlled by non-scalable gatekeepers that maintain information asymmetries. They conclude, "Education is perhaps the prime example of a major industry that is ripe for platform disruption."

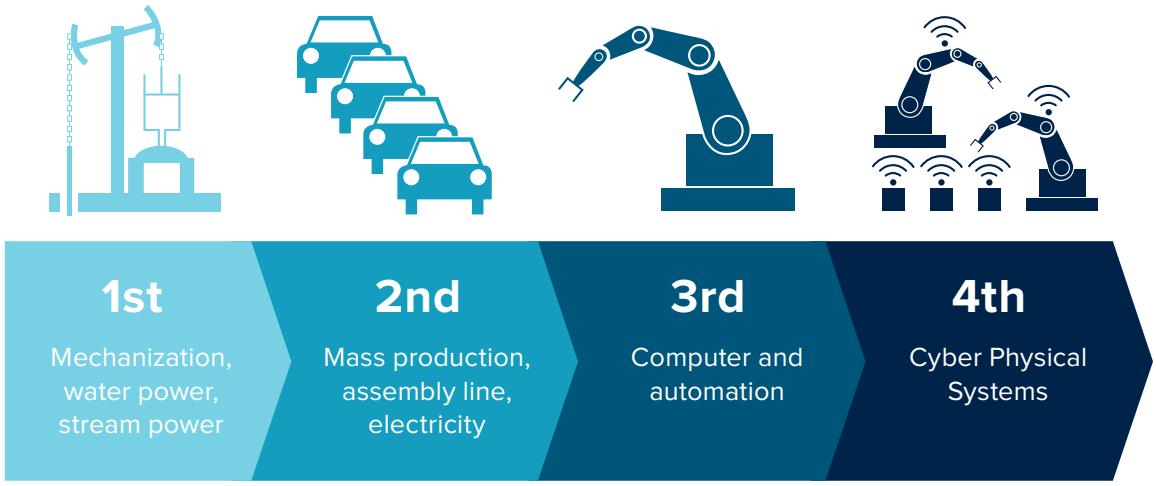
Platforms including Coursera, edX, Skillshare and Udemy have transformed informal learning and career education. Wikipedia and YouTube have made it possible for anyone to learn almost anything. Choudary notes that more people are using Duolingo to learn a language than all the high-school students in the U.S. combined. All of these are prime examples of AI-driven platforms providing real-time responses and results for continuous learning.

Most higher-education institutions have adopted a learning management systems (LMS). Blackboard, Canvas (Instructure), Brightspace (D2L) and Moodle account for more than 80% of the market.[22] Adoptions may have boosted efficacy and perhaps efficiency, but most have been well short of transformational.

The Fourth Industrial Revolution

The first industrial revolution included industrial and urban labor. The second expanded to include steel, oil and electricity. The third is referred to as the digital revolution and expansion of technology. We are now entering a fourth industrial revolution that World Economic Forum founder Klaus Schwab describes[23] as "the fusion of technologies that is blurring the lines between the physical, digital and biological spheres."

The AI-powered Fourth Industrial Revolution (or 4IR, as it's abbreviated) is a productivity revolution paving the way for cleaner, safer distributed manufacturing. Imagine custom shirts and shoes at mass-production prices, with same-day delivery; turbine parts produced at the airport where and when they are needed; a new tooth made for you while you're in the dentist's chair.



Source: Adapted from The Fourth Industrial Revolution by Klaus Schwab

Schwab continues, saying, "the possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited." He predicts that transportation and communication costs will drop, logistics and global supply chains will become more effective, and the cost of trade will diminish, all of which will open new markets and drive economic growth.

On the other hand, according to America Succeeds,[24] "Millions of jobs are at short- or medium-term risk of disappearing. Many that don't disappear will be so radically restructured as to be unrecognizable, with enormous implications for today's workers."

WHAT DOES IT MEAN FOR US AND OUR KIDS?

"What we're just beginning to experience will rival any technological upheaval in history in both scope and impact."

—America Succeeds, Age of Agility

So what does this mean for us? The big question is, Can we adapt fast enough to keep up with computer technology? Harvard's Erik Brynjolfsson[25] thinks that computers "already are much smarter than us at many things."

Change will accelerate over the next two decades. Powered by exponential technology, the costs of storage and computing are already near zero, making it possible to crunch gigantic data sets and enabling a new generation of AI. Application-development tools and enabling technologies (e.g., sensors, cameras, robots) have improved dramatically. The combination makes it possible to automate even super-complex tasks like driving.

To comprehend the growth that is occurring, we organized convenings in cities across the country to #AskAboutAI and investigate the civic, social and educational implications of exponential technology. Invitees included technologists, entrepreneurs, social scientists, impact investors and educators. A sampling of their contributions is show below:

MARKETS BACK AI

How do we understand the rapid speed at which we are able to develop new microchips, and why does it matter to us? Timothy Melano, a research staff member at IBM, explained, "AI will make a big impact behind the scenes, with transportation systems and healthcare systems being largely impacted. We see investors, entrepreneurs and scientists optimizing the markets to adjust to these technologies."

ETHICS AND AI

Babson professor Ruben Mancha[26] suggests that organizations should set the following ethical guidelines for algorithms:

1. Consider ethical outcomes first, speed and efficiency second
2. Make ethical guiding principles salient to your organization
3. Employ programmers well versed in ethics
4. Interrogate your algorithms against your organization's ethical standards
5. Transparently share results with stakeholders

AI AS SOCIAL MIRROR

"Technologies such as artificial intelligence and machine learning can serve as important mirrors for our society. When we have algorithms learning how to interact with humans based on text that they read from the data provided to them, they show us what they learned quickly. When parents see their children picking up ways of talking and being that are likely to have come from something they modeled, they sometimes begin to reflect on their actions more. With more artifacts of AI such as chatbots or image-processing assistants innocently offending people as they learn, we get more opportunities to reflect on how we can be better models for machines and our children, and have more opportunities to talk about tough issues.

"I enjoy teaching more than just the requisite set of algorithms to introductory software-design students. I include examples from sources such as the new book Technically Wrong by Sara Wachter-Boettcher. I welcome lunchtime discussions from my students about the interactions of AI and activism. I look forward to speaking about these topics at Data for Black Lives."

—Amon Millner, Olin College

ENTERTAINMENT AND AI

"Immersive technologies touting augmented, virtual and mixed reality are poised to become readily available en masse. The deeply crafted experiences built on these platforms will naturally find a fuller stride through advanced AI. We simply must ask, how will interacting with 'smart' agents affect our interactions with other humans? With this level of immersion, it will be increasingly important to educate the future developers in the humanities. We must strive to create experiences that have purpose—reinforcing what makes us human."

—John Balash, Entertainment Technology Center at CMU

AI POWERS GENOME EDITING

Barry Schuler, DJF Growth Fund and Chairman, New Tech Network, believes that AI and gene editing[27] will change the course of evolution, one way or another. With nearly three billion base pairs or snippets of code, locating the ones you want to edit can be very difficult. On the upside, we could be editing to eliminate birth defects and diseases like cancer; on the downside, many scientists are wary of efforts to create an "off-switch" for editing genes. Schuler recommends that we need an ethics committee to weigh in on controversial genomic issues.

AI IS TRANSFORMING CLASSROOMS

"Artificial intelligence is beginning to transform classrooms through customizable content and tracking and monitoring diagnostics. AI can automate basic routine work, such as grading simple tests. It can apply greater levels of individualization through adaptive learning programs, games and software, and AI tutors can support students through basic mathematics. … Adaptive testing will provide questions that suit the current ability of individual students."

—Cameron Paterson, Shore School in Australia

You Have Been Augmented

We live and work with machines that are getting smarter every month. Most machine functions will soon be augmented, requiring higher operational skill while extending individual contributions. However, these promising developments come with new ethics and privacy issues:

- Who will gain access to machine intelligence?
- How will we safeguard privacy when everything is connected to the Internet?
- How do we provide lifelong learning opportunities, so that everyone can benefit from machine intelligence?

Many experts tout the benefits of augmented intelligence,[28] suggesting that AI isn't going to replace the amazing, intuitive, creative human brain. In his new book, The Economist columnist Ryan Avent[29] predicts that in the next few years, machine learning will complement many workers in the office, augmenting rather than replacing their labor.

For the next few decades, at least, it will be combinations of human and machine intelligence that make a difference. "Using our natural intelligence and the external extensions of intelligence we've progressively built over the last millennium, we have now developed tools of creation such as genomics, synthetic biology and robotics that literally allow us to program our existence in any way

we can imagine," said Bryan Johnson,[30] founder of Kernel. "We have progressed from players to makers of the game."

About four in ten recent graduates work in the freelance economy.[31] An equal number work for others. Together they make up the vast majority of the workforce—and they manage their work in projects. Most of these projects involve teams, and the functions of the people on those teams are increasingly augmented by smart machines that aggregate and analyze data, conduct experiments, carry out operations, monitor progress, provide feedback and recommend next steps.

People anticipate that AI[32] will challenge them to improve and do more (23%), provide complementary skills (19%) and inspire them to generate new ideas (17%). AI could be the empowerment to better communication and adaptability among teams, work faster and solve bigger problems.

In the first three quarters of 2017, more than 400 AI-powered startups were funded in the human-resources space alone. Entrepreneurs in AI technology are changing the way companies find, recruit, hire, onboard and develop talent.

Big companies are also using technology to understand the power of their workforce. In The Power of Many,[33] EY concludes, "The rise of HR analytics gives companies a much better opportunity to map their talent assets globally and understand where pools of expertise lie."

WHAT IS DATA SCIENCE?

Data science is a set of methods and tools used to extract knowledge and insights from data sets, which may be highly structured or very unstructured. It draws heavily on statistics and data analysis.

WHY HAVE I NEVER HEARD OF THIS FIELD?

It's new. You would not have seen many job postings for it in the last decade. But five years ago, Tom Davenport in HRB called it "The Sexiest Job of the 21st Century."[34]

HOW IS DATA SCIENCE DIFFERENT FROM CODING?

Computer programming is usually a very directed task, with some specific functionality in mind. Data science is usually more discovery-oriented. As Davenport explained, "data scientists make discoveries while swimming in data."

WHAT IS DATA WRANGLING?

It's the messy process of sourcing, mapping and transforming raw data into a clean data set worth analyzing, visualizing and extracting new knowledge from.

WHAT ABOUT DATA ANALYTICS?

It's the discovery, interpretation and communication of meaningful patterns in data.

After Augmentation Comes Automation

A Bay Area computer scientist launched a marketing company in 2017. In a short demonstration of his software, he analyzed the purchase patterns of a market, selected target customers and built a targeted marketing campaign. “I just eliminated three jobs: a data analyst, a marketing manager and an advertising coordinator,” he said. He generalized, “There are another thousand startups in the valley automating away jobs in every sector.” He talks “augmentation” in public, but he’s building the guts of the automation economy—and he’s confident that it will eat millions of jobs.

Smart machines will eat jobs,[35] except where smart people create them. “No office job is safe,” said Sebastian Thrun,[36] Stanford CS professor and MOOC pioneer. “Lots of lawyers, accountants, even surgeons will be automated away. Having spent my career watching the long, slow carnage of my own industry, I have some insight into how that will feel, and how to cope.”

In the most dire near-term prediction yet, a new Forrester report predicts that 9 percent of U.S. jobs will be lost to automation in 2018, a number only partly offset by a 2 percent growth in jobs supporting the automation economy.[37] “Specifically impacted will be back-office and administrative, sales and call-center employees. A wide range of technologies, from robotic process automation and AI to customer self-service and physical robots, will impact hiring and staffing strategies, as well as create a need for new skills,” said Forrester.

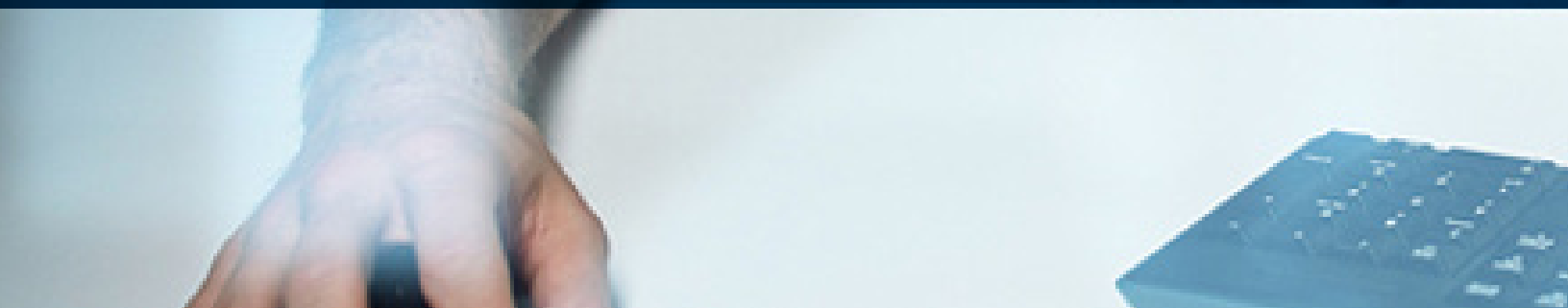
A recent Bureau of Labor Statistics report predicted a bifurcated economy, with growth in low-wage jobs (think food preparation and the work of home health aides) and growth in technical roles (like that of software developers) that require advanced degrees.[38]

The flipside of the “an algorithm ate my marketing job” situation is that with smart chatbots, U.S. companies will be able to re-shore call centers—so five skilled technicians in Boston will be able to take the jobs of 500 call-center workers in Bangalore. A few centers of expertise will form around AI, marketing and customer service—and a few smart people will make a lot of money.

“While AI technologies are likely to have a profound future impact on employment and workplace trends in a typical North American city, it is difficult to accurately assess current impacts, positive or negative.” That was the conclusion of a Stanford study, Artificial Intelligence and Life in 2030.[39] The study projects that the greatest impacts will be in transportation,[40] healthcare,[41] education,[42] public safety and security,[43] home/service robots[44] and entertainment.

10 Big Challenges

While there is lots of good news here—diseases will be eradicated, clean energy will be produced and massive wealth will be created—we also have a problem: these issues are moving faster than civic infrastructure can handle. Innovation is outpacing public policy on all fronts. There are 10 public policy issues coming at us fast that we (in the U.S. in particular) are not yet ready to deal with.



1 UNEMPLOYMENT

We may be near full employment now, but it doesn't feel that way. "Workers who have steadily lost access to the economy as digital processes replace them have a sense of things falling apart, and a quiet anger about immigration, inequality and arrogant elites," said Brian Arthur[45] of the Santa Fe Institute.

Things get worse from here. A PwC report[46] predicts that more than a third of jobs could be at risk by 2030. New jobs will be created, but that is even harder to predict than displacement, which will vary by sector and geography.

Hundreds of millions of jobs based on repetitive rules application will be phased out in the coming years, creating an even larger divide. Smart machines will eat the middle of the job market—in some places as soon as 10 years from now, while in others it may take 20 years. Job loss will be compounded by even bigger income gaps as the developers, owners and financiers of AI robots win the top places in the automation economy.

AI will also spur contribution and job creation in new categories. Tens of millions of new high-wage jobs will be created in smart cities that skill up. The biggest contributions will be made by cities that make commitments to new markets and jobs.

Arthur notes that we're at the end of the old production economy, driven by free-market economics and old measures of growth, and entering a distribution economy, where it's all about who has access to what's produced—and that creates a new political problem.

2 INCOME INEQUALITY

If you think people were ticked off about income inequality last year, just wait. The folks that develop, finance and own the robots are winning in the automation economy. Arthur predicts that "Jobs will be fewer and work weeks shorter, and many jobs will be shared."

Income inequality will accelerate and, combined with massive job dislocation, will require some kind of income protection—a universal basic income[47] or tax credits and social services that serve the same function. Income protection could also cover social contributions such as elder care, youth mentoring and public arts.

With socialist roots, Europe and Scandinavia will adjust more easily and quickly than America to radical income stratification. Finland is already using design thinking[48] to inform basic income policy experiments. In the U.S., cities are likely to lead proactive social experiments.

3 PRIVACY

There will be 50 billion devices[49] connected by 2020, including a billion cameras[50]—all feeding data to artificial intelligence platforms. Perhaps you've noticed the marked improvement in the

facial-recognition software used by Facebook over the last few months. Chip maker NVIDIA wants cities to use its new Metropolis artificial intelligence platform[51] to tap into all of those cameras and sensors. Very soon, wherever you are, it will be best to assume that you're on Candid Camera.

We are approaching an era of radical transparency, where every search, every move, every test informs a merchant, authority or insurer of something. Want to preserve any shred of privacy? That will take some new policies.

4 ALGORITHMIC BIAS

AI gets smarter the more data you feed it. But it also quickly learns our biases and those prejudices that are embedded in our society. For example, cameras missed the mark[52] on racial sensitivity, and software used to predict future criminals[53] showed a bias against black people. Increasingly, AI determines who gets a loan, who is insured and who gets hired—and it's subject to many of the same biases we are.

What biases will AI surveillance learn? What kind of sanctioned profiling will this lead to? Could a court order tell a computer to unlearn a profile? How do we get algorithmic transparency?

The Berkman Klein Center at Harvard recommended[54] that AI systems can and should be held to a similar standard of explanation as humans. They acknowledge that this will not be easy, in part because bots construct complicated algorithms and are inventing new ways to communicate with each other.[55] They also worry that poor choices may result in regulation that not only fails to truly improve accountability, but also stifles the many beneficial applications of AI systems.

Bias prevention will require creativity and diligence—and some new policies. And these policies will need to be frequently updated as AI capabilities shift (something that Congress has a poor track record on).

5 ACCESS

The most powerful tools the world has ever known have been created, and they are getting smarter every day. But who will have access to AI tools?

Google open-sourced TensorFlow and Microsoft open-sourced[56] some of its tools (but both resulting technologies require technical sophistication to use). OpenAI is a nonprofit AI research company created by Elon Musk, Sam Altman and others to develop open-source AI that's beneficial to humanity. All this is good news, but access to tools and the chops to use them will continue to be a challenge.

With access to smart tools like speech recognition and real-time translation, it could help language minorities and people with learning differences access the innovation economy.

6 MACHINE ETHICS

John Giannandrea, AI chief at Google, is concerned[57] that bias is being built into many of the machine-learning algorithms by which the robots make decisions. “The real safety question, if you want to call it that, is that if we give these systems biased data, they will be biased,” he says.

In *Moral Machines: Teaching Robots Right from Wrong,*[58] Wendell Wallach and Colin Allen suggest that teaching robots to know right from wrong will advance human ethics by providing a platform for experimental investigation—a great thought, but one requiring sophisticated public and private partnerships to enact.

Take autonomous-vehicle policies as an example. AVs are on the road today, and municipalities are scrambling to figure out if and how to regulate them. As Wallach and Allen predicted, AVs surface moral dilemmas[59] (e.g., in situations that force the AV to kill a driver or nearby pedestrians) and provoke debate, but do we want 10,000 municipalities all trying to figure this out on their own, and building a patchwork of unique laws?

7 WEAPONIZATION

Former President Obama kicked drone strikes into high gear—an opening salvo in modern mechanized warfare. Autonomous killer robots aren’t far behind the drones.

In a letter to the Australian prime minister, Australian AI leaders[60] urged a ban on autonomous weapons, saying, “These will be weapons of mass destruction. One programmer will be able to control a whole army. Every other weapon of mass destruction has been banned: chemical weapons, biological weapons, even nuclear weapons. We must add autonomous weapons to the list of weapons that are morally unacceptable to use.”

Despite Australian and Canadian leadership in rejecting such weapons, a global AI-powered arms race is inevitable. With the U.S. now walking away from global trade and climate treaties, a new Geneva Convention for robo-war seems unlikely.

8 HUMANITY

How do machines affect our behavior and interaction? AI bots are becoming better and better at modeling human conversation and relationships. This and better calibration and gamification are making videogames and mobile games more addictive. Will tech addiction[61] be the next addiction wave, after opioids? And if it doesn’t lead to an addiction crisis, will AI simply build alienation and resentment, or will it threaten human dignity? The answers will involve a mixture of practice and policy.

Will robots gain consciousness as we know it? As they get smarter, are there moral obligations to smart machines? Do they deserve some form of human or animal rights?[62] Saudi Arabia recently granted citizenship rights to a robot in a PR stunt, but it’s easy to imagine how quickly issues might move from science fiction to reality.

9

GENOME EDITING

Machines are learning to recognize tumors and edit genomes. This is good news if you think cancer stinks, but it raises a bunch of tough questions about who is allowed to edit genes and for what purpose, and which of the soon-to-be eight billion people on Earth will have access to precision medicine and preventive prenatal care.

10

BAD AI

Elon Musk thinks AI is more worrisome[63] than North Korea. His startup Neuralink is building a brain interface to ensure that we're smart enough to keep up with super AI—what Nick Bostrom[64] thinks may be the last invention humans ever need to make.

This is a few years out, but tech progress will continue to accelerate, resulting in very powerful computers, advanced weaponry, space travel, increased human longevity (for some), realistic VR and fine-tuned emotional and motivational controls. There are many ways this could go badly—very badly. Musk wants us to start considering purposeful limitations. Mark Zuckerberg thinks he's alarmist.[65] Either way, it's worth having the conversation.

These questions are new and unfamiliar—and exist outside the moral, ethical, economic and political frameworks that have guided life on Earth for hundreds of years.

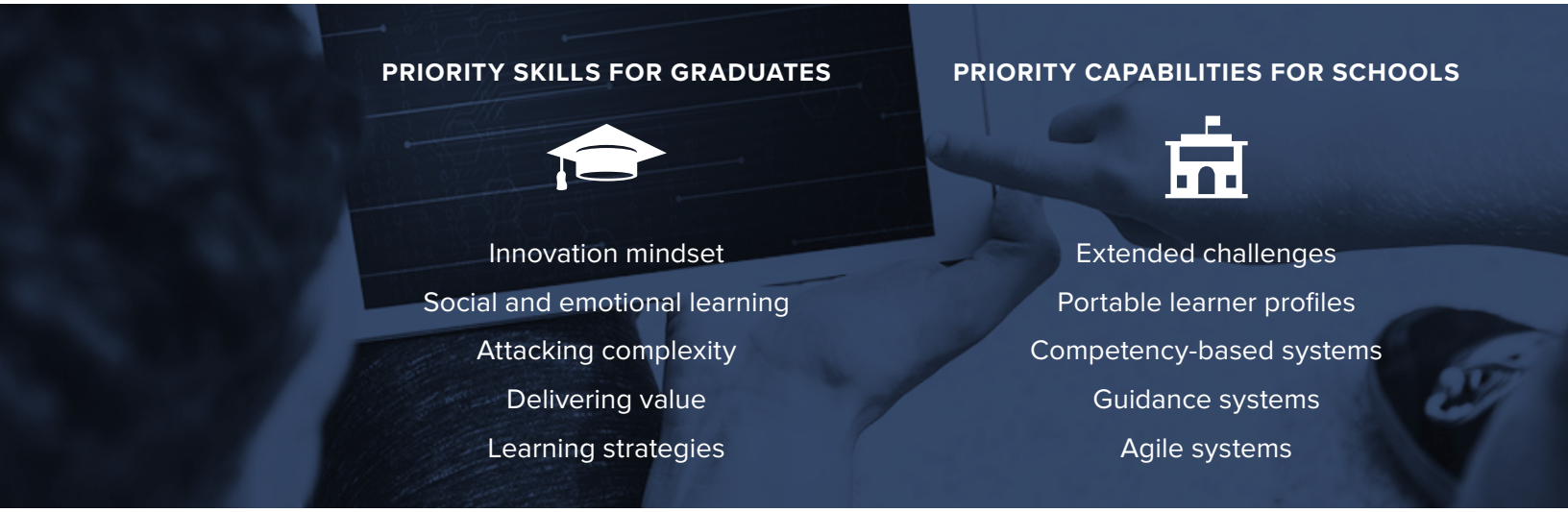
HOW TO PREPARE?

"Students today are coming of age in an era of rapid change and disruption."

—NGLC, MyWays

How do we prepare for what is coming? What should students know, and know how to do? What kinds of learning experiences will most benefit youth in an increasingly AI-integrated world?

Our two-year investigation yielded five priority skills that will help young people find and make their contribution in the innovation economy. For many school systems, these will be new additions to their graduate profile and new-learning priorities. The education system will require five improved capabilities to support these priority skills. Both sets are summarized and discussed below.



INNOVATION MINDSET

The first task for all us is to learn how to be in the automation economy. Cancer researcher Kevin Jones[66] describes his work as "taking a bath in uncertainty, unknowns, exceptions and outliers." Dr. Jones suggests that the two most important values, given the level of uncertainty in his line of work, are humility and curiosity.

Our friendly amendment would be confident curiosity—the creative know-how to apply attack skills like design thinking to problems we've never seen before.

Our study of learning ecosystems[67] identified an innovation mindset—a combination of growth mindset, maker mindset and team mindset—as key to this thinking, along with the central recognition of effort, initiative and collaboration.

SOCIAL AND EMOTIONAL LEARNING

Machine intelligence will make workplace predictions cheap, but human judgment even more valuable. The abilities to read social situations and develop productive relationships are, for the foreseeable future, uniquely human skills, and will become increasingly important and valuable in an automation economy.

Source: Adapted from Casel

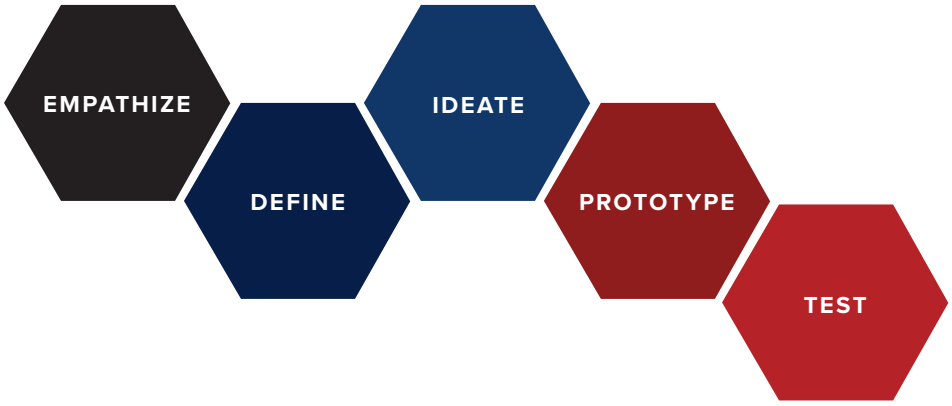
The nonprofit research and advocacy group CASEL defines social and emotional learning (SEL) as a combination of self-management, self- and social awareness, relationship skills and responsible decision-making. Research suggests[68] that SEL should be taught explicitly and integrated across the curriculum in active forms of learning.

Similarly, the KnowledgeWorks Foundation suggests redefining readiness to include self-knowledge, emotional regulation, empathy and perspective-taking.[69]

ATTACKING COMPLEXITY

Many of the problems and opportunities we face are new. They often sit at the boundary of traditional discipline, at the intersection of manmade and natural systems. These challenges require a new approach to problem identification and solution.

A five-stage model called design thinking has been advanced by the Hasso-Plattner Institute of Design at Stanford (d.school). The steps to this model are empathize, define, ideate, prototype and test.



Source: Adapted from Stanford d.School

Design thinking is central to the approach at a number of innovative new schools, including Design Tech High in San Mateo, High Tech High in San Diego, and One Stone in Boise. In higher education, the best example of design thinking is found at Olin College,[70] near Boston.

Most work is now conducted in projects. More than four in 10 high-school graduates work in the freelance economy (with that number likely to increase to a majority within 10 years[71]), and probably as many who go to work for others end up working on or leading project teams. The best preparation for a project-based world[72] is learning to manage extended challenges—some well defined and others open-ended design tasks.

Most professions exceed the capabilities of any individual, and require cross-functional teams to deliver properly. Dr. Atul Gawande, author of Being Mortal,[73] said that medicine had moved past the individual craftsman to delivering in teams. "It's no longer an individual craft of being the smartest, most experienced and most capable individual," he said. "It's a profession that has exceeded the capabilities of any individual to manage the volume of knowledge and skill required. So we are now delivering as groups of people." Gawande said[74] that what was most needed in professional preparation now was the study of the science of teams.

MIT's Eric Lander said that "in a few years, every biologist will be computational."[75] The same will be true for doctors, mechanics, economists, water managers and soldiers—nearly every field is being transformed by the combination of AI, big data and enabling technologies. As a

result, advances almost always involve assembling a big data set—a task that requires creativity, partnership, analysis, a lot of cleanup and a good truth detector. Value creation is being led by people passionate about a cause, who are adding data science to their quest.

For young people facing novelty and complexity, critical attack skills include design thinking, project management, data science and delivering in teams.

DELIVERING VALUE

"We are all entrepreneurs now," said microfinance pioneer Muhammad Yunus[76] (and many others). But most young people never receive formal education in how to build an impactful organization. High-school graduates should know how to start and capitalize a business and pick a tax status and business model.

As every field becomes computational, data science is becoming key to delivering value. Every big problem has a big data set associated with it that will be part of game-changing solutions (we call it cause + code).[77] Understanding how to wrangle and analyze data will equip young people for careers and civic contribution.[78] In five or 10 years, AI will take over much of the data wrangling, but data science will still be important for today's secondary students.

LEARNING STRATEGIES

To initiate lifelong learning, secondary schools should encourage students to be reflect on how they learn, and build habits of success. There are an increasing number of organizations interested in being lifelong learning partners for students—college alumni associations, professional schools and private marketplaces among them.

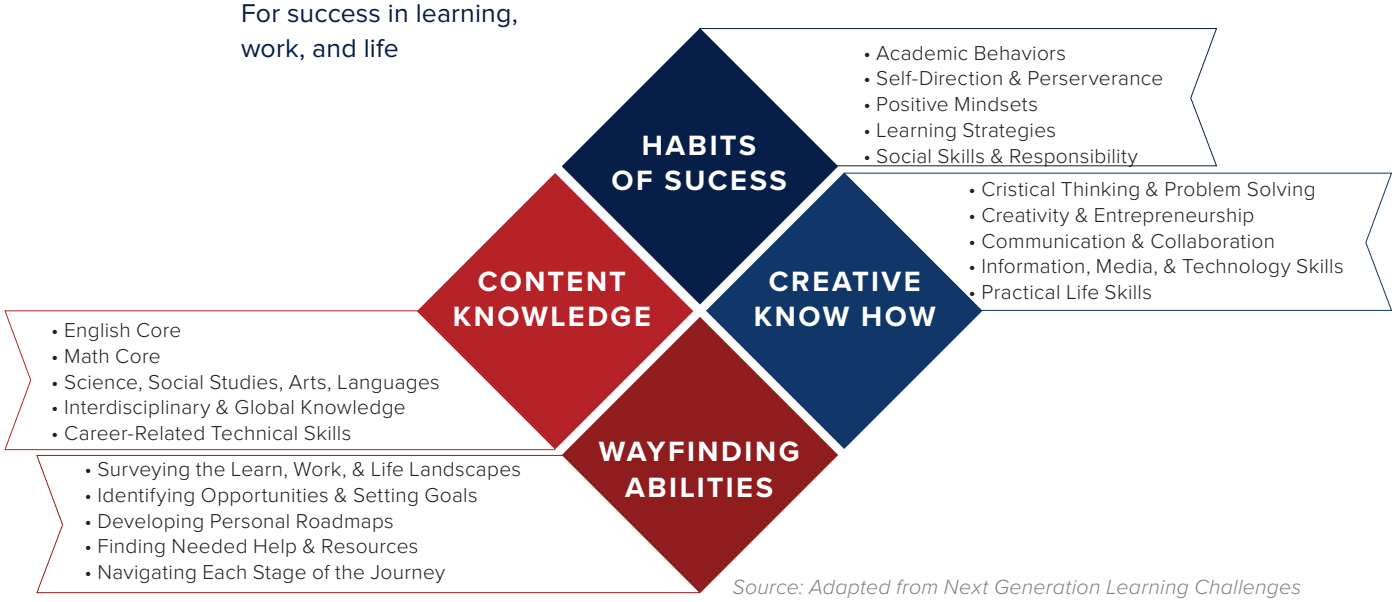
Self-directed learning is most powerfully driven by a sense of purpose. In our study of Millennial employment, Generation Do It Yourself, we learned that it is critical for young people to develop a sense of purpose before attending college to avoid the new worst-case scenario—racking up college debt and dropping out. A sense of purpose can be developed around a talent or issue, or their intersection; both can be cultivated by a robust guidance system (discussed below).

We've been teaching digital literacy for two decades, but what's new is that we all need to appreciate that algorithms curate every screen we see. As smart machines augment our capabilities, they will increasingly influence our perceptions, opportunities and decisions. That means that to self- and social awareness, we'll soon need to add AI awareness.

Taken together, these skills and dispositions create a sense of agency—the ability to take ownership of learning, grow through effort and work with other people in order to do the learning you need to do.

An example of a new-outcome framework that captures many of of these new competencies is MyWays from Next Generation Learning Challenges. Habits of Success includes mindset, learning and elements of social and emotional learning. Creative Know How includes problem solving and entrepreneurship. Most unusually, MyWays includes Wayfinding Abilities for each stage of the learning journey.

MYWAYS COMPETENCIES
For success in learning, work, and life



Source: Adapted from Next Generation Learning Challenges

Priority Capabilities for Learning Organizations

To cultivate priority learning capabilities, school districts and networks need to build five key capabilities.

EXTENDED CHALLENGES

To boost agency, attack skills, and social and emotional learning, young people need the opportunity to work on big integrated projects. New Tech Network facilitates these extended challenges with integrated team-taught blocks, personalized skill building, and project authoring and scoring tools.

AI PROVOKES PROBLEM SOLVING

The future is about solving problems, according to Jaime Casap, Chief Education Evangelist at Google. According to him, we shouldn't ask students what they want to be when they grow up—we should ask them what problems they want to solve.

Casap helped launch the Phoenix Coding Academy, a new high school that features a lot of coding—but rather than learning coding as an abstract career skill, students address big problems and learn how to use computation as part of their solution.

Extended and integrated challenges are the best way to promote deeper learning outcomes (discussed above) and develop readiness for the automation economy.[79] Impact-focused projects get students into the community and connected with local resources (we call it #PlaceBasedEd).

Big integrated challenges focused on interesting and timely causes motivate young people and boost engagement, attendance and learning. They shift the paradigm from "prepare for a career 10 years from now" to "make a difference right here, right now."

"We should be supporting and compelling students to do well-crafted work that makes them, their families and their communities proud," said Ron Berger of EL Education.

Taking on real challenges promotes creative and effective uses of technology, shifting from consumption to collaboration to production. Making a contribution toward a goal students care about may be the best way to develop student agency—and agency may be the most important ingredient in life.

PORTABLE LEARNER PROFILES

One key to powerful lifelong learning is portable learner profiles that show what students know. With better interoperability, profiles will integrate input from many sources, track progress, recommend next steps and accelerate development.

An easy addition for most systems is a digital portfolio that helps learners share their personal bests. One of the current challenges is measuring growth in social and emotional learning.

COMPETENCY-BASED SYSTEMS

Asking learners to periodically show what they know and allowing them to progress as they demonstrate mastery are two hallmarks of next-generation learning systems. It has been possible but challenging to operate low-tech schools with students moving at their own pace; new tools make it much easier.

Adaptive learning systems (in reading and math) and automated skill feedback (in writing) is making it easier for learners to receive frequent and detailed feedback. Assistive technologies support special-needs learners. Detailed mastery trackers are replacing simple gradebooks for progress monitoring.[80] AI-powered learning platforms recommend the best learning experiences for individual students. New transcripts signal competence rather than seat time.

GUIDANCE SYSTEMS

Now that most of us are connected, the new divide is guidance. Young people need sustained relationships at home and at school that support powerful learning experiences. Technology can be a powerful tool with good guidance, but it can be a waste of time (or worse) without it.

In the face of a changing employment landscape, the most important element of secondary education is an advisory system that provides career and college awareness, academic monitoring, and links to youth and family support systems.

A new guidance topic that every high-school student should study is the potential ways that machine intelligence influences and could influence their life and livelihood. Stanford's AI100 report provides an overview of the eight sectors likely to be most impacted.

AI behind everything in education

While AI is making leaps and bounds in other industries, we are witnessing a lag in impact in the education system. The challenge is that outcome frameworks are more dynamic and broader. Raise the bar, increase the dashboard, and it will change frequently. So how do we handle this shift, and what areas should we be focusing on?

It's clear that the traditional one-size-fits-all model will not sustain. So where can AI make the biggest advancements in education?

TUTORING	It's estimated that education tutoring could be wiped out by AI in the next five years. Intelligent Tutoring Systems (ITS) will simulate one-to-one human tutoring.
ASSESSMENT	AI will help build more efficient, personalized and contextualized support for students.
RECOMMENDATIONS	Smart recommendation systems or machine-assisted systems will show student mastery, repeat necessary lessons and suggest a personalized learning plan.
HIRING & DEVELPMENT	Upskilling and continuous development will be required for teachers and administrators to keep pace. We'll also see new models of boot camps and EdX-like offerings from universities to serve as gap-fillers for skills.
SCHEDULING	Algorithms will make it easier to maximize learning environments and schedules.
TRANSPORTATION	Some believe that by 2025, ride-sharing fleets and autonomous vehicles will be transporting students to school.

AGILE SYSTEMS

Many school districts will see more rapid changes in enrollment as a result of increasing competition and shifting demographics. They will need to become more agile in capacity shifting, incorporating new learning outcomes and updating student learning experiences.

School districts can take advantage of AI-powered systems in hiring and talent development, transportation scheduling (eventually including autonomous vehicles) and efficient operations.[81]

Learning tools are also becoming more sophisticated (as discussed in #2), but incorporating them into personalized and competency-based learning models is complicated. School networks that share a learning model, a platform and professional learning experiences can leverage expertise and investment. School districts can either operate like a network or leverage several networks to ensure quality and increase learning options.[82]

Matt Candler, founder of 4.0 Schools, a national community of people testing new designs in schools, sees new interest in microschools as communities try to become more responsive. "We're see growing interest in microschools from people you might expect—entrepreneurial educators eager to try a new approach to learning at a small, humanizing scale," he says. "But we're also seeing interest from unusual suspects, like superintendents curious about the power of microschooling within a district. That's really exciting. We're adapting our pop-up and field-trial investment programs so anyone can learn to create smaller, more modular learning spaces that work for all kids."

CONCLUSIONS

Code that learns is the most important invention in human history—and it's being supercharged by an explosion of sensors and supercomputing. It is changing the employment landscape and swamping our civic infrastructure with issues inconceivable just a few years ago. It may even prove to be the the most dire existential threat we have ever faced.

The flipside is that AI will help us cure disease, create clean energy, boost productivity, improve services and fight drudgery. There has never been a better time to make a difference. People young and old who discover a cause can learn at unprecedented rates, accumulate giant data sets, build powerful solutions and deliver unimagined value.

The November 2016 election may have marked the end of the information age and the beginning of the automation economy. Many of us came to realize that there was a new operating system at work, and that the change was driven, in part, by AI-powered curation that had created discrete information gullies—further dividing perceptions, rather than creating a shared perception as many of us platform optimists had hoped.

As the automation economy marches on and the benefits and concerns of AI become widely apparent, the employment landscape will be dynamic, with unprecedented displacement in waves that will differ by sector and geography. Policy priorities will shift from production to sharing. Lifelong learning will be a requirement. Ethical issues around the new technology will be vexing.

Our two-year #AskAboutAI investigation has yielded eight conclusions:

IT'S TIME TO #ASKABOUTAI

Every community should be discussing the enormous potential benefits and emerging challenges associated with AI, and more broadly the future of work (#FutureofWork). By discussing what's happening, people begin to better anticipate exponential change. Local conversations should focus on near-term threats to employment and unique assets that can be leveraged to support new businesses.

IT'S TIME TO UPDATE GRADUATE PROFILES

Community conversations about the implications of exponential change will help educators update student learning goals. Social and emotional learning and an innovation mindset should be central—it's now clear that they are even more important than traditional measures of academic success.

Practicing design thinking across the curriculum will prepare students for the new kinds of adaptive problems they are likely to face.

Young people also need to be AI-aware, with the near-term knowledge that algorithms curate every screen they see, and the long-term awareness that smart machines will shape their lives and livelihoods.

As every field become computational, it's time to teach data science. Every big problem has a big data set associated with it that will be part of game-changing solutions. Understanding how to build and analyze these data sets will equip young people for careers and civic contribution.

In the new freelance economy, everyone is an entrepreneurship. Most young people will manage their work life as a series of projects, being sometimes employed by others and sometimes self-employed. Giving them the skills to get work (marketing) and deliver value (project management) should be core to secondary and postsecondary education.

IT'S TIME TO UPDATE DISTRICT AND NETWORK CAPABILITIES

School districts and networks need to improve the quality of the guidance and career education they provide. Every high-school student should have the benefit of a sustained advisory relationship and the opportunity to study the ways AI could influence their life and livelihood.

School districts will need to become more agile in terms of space provisioning and updating school models and learner experiences.

IT'S TIME TO OPEN-SOURCE AI TOOLS

Google and Microsoft have set a good example with TensorFlow and Azure Machine Learning, but both of these tools take a good deal of judgement and technical expertise to use. In order to give every high-school and college student exposure to open AI tools and their use, we could really use some advice on using open-source tools.

IT'S TIME TO BUILD A STRONGER SOCIAL SAFETY NET

There are likely to be waves of dislocation and transition. Vulnerable populations will be at risk more frequently, putting new demands on social services including transitional housing, job training and mental-health supports.

IT'S TIME FOR A NEW CIVIC INFRASTRUCTURE

Finland may be iterating on basic income schemes that won't fly in the gridlocked U.S. Congress, despite advocacy from tech leaders including Elon Musk and Mark Zuckerberg.[83] As with Seattle's leadership on minimum wage, cities and states will be the laboratories of the new social compact in the U.S.

Taking a page from the Silicon Valley playbook, government entities will need to become more nimble by surveying and convening stakeholders to develop temporary agreements—a form of iterative social development. (The Finns changed their constitution to allow this form of active experimentation.)

IT'S TIME FOR A NEW ETHICAL INFRASTRUCTURE

Given the speed and technicality of the subject, our society needs a new ethical infrastructure to predict threats and opportunities and recommend policy, investment and learning responses.

The new infrastructure will include nonprofit groups like the Future of Life Institute, OpenAI, the Foresight Institute and the Ethics and Governance of Artificial Intelligence Fund; industry consortia like the Partnership on Artificial Intelligence; and university study groups like Stanford's One Hundred Year Study on Artificial Intelligence.

IT'S TIME TO BUILD SMART CITIES

Every region needs to develop learning ecosystems that help people skill up fast around distinctive capabilities. As we noted in Smart Cities That Work for Everyone, learning ecosystems include innovation leadership, public and private partnerships, aligned investment, talent pipelines and multiple affordable-learning entry points that recognize prior knowledge and certify new skills.

For youth, there's never been a better time to build an app, launch a campaign or start an organization. For educators, because income inequality will continue to grow, we need to continue to teach and advocate. Policymakers will need to anticipate issues, hold community conversations and facilitate temporary agreements.

The potential to make people's lives better is enormous, but the threats are equally daunting. We have work to do.

RESOURCES

ARTIFICIAL INTELLIGENCE ORGANIZATIONS

- OpenAI: OpenAI is San Francisco–based nonprofit artificial intelligence research company, whose mission is to build safe AI and ensure that AI's benefits are as widely and evenly distributed as possible.
- AI100: Stanford created a 100-year effort to study and anticipate how the effects of artificial intelligence will ripple through every aspect of how people work, live and play.
- Ethics and Governance of Artificial Intelligence Fund: Created by Reid Hoffman, Pierre Omidyar, Harvard, MIT and the Knight and Hewlett foundations, the AI Fund sponsors research and public events.
- Allen Institute for Artificial Intelligence: Focused on impact research and engineering.
- The Partnership on AI: This organization was established to study and formulate best practices on AI technologies, to advance the public's understanding of AI, and to serve as an open platform for discussion and engagement about AI and its influences on people and society.
- Future of Life Institute: The Institute's mission is to catalyze and support research and initiatives for safeguarding life and developing optimistic visions of the future, including positive ways for humanity to steer its own course in considering new technologies and challenges.

REPORTS, WHITE PAPERS AND ARTICLES

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- Life 3.0: Being Human in the Age of Artificial Intelligence, Max Tegmark.
- Moral Machines: Teaching Robots Right from Wrong, Wendell Wallach.
- Rise of the Robots: Technology and the Threat of a Jobless Future, Martin Ford.
- The Fifth Discipline: The Art and Practice of the Learning Organization, Peter M. Senge.
- The Fourth Industrial Revolution, Klaus Schwab.
- Whiplash: How to Survive the Faster Future, Joi Ito and Jeff Howe.

GETTING SMART ASKABOUTAI PODCASTS

- Barry Schuler on the Power of Networks, Getting Smart with Barry Schuler.
- Google's Jaime Casap on Inequity and Inquiry, Getting Smart with Jamie Casap.
- KnowledgeWorks on Redefining Readiness, Getting Smart with Katherine Prince.
- Michael Moe on AI in Human Resources in Education, Getting Smart with Michael Moe.
- Stanford CTO Provokes Good Questions Online (and Off), Getting Smart with Paul Kim of Stanford.
- The Future Is Here: Artificial Intelligence and What It Means for Our Kids, Getting Smart with Gerald Huff of Tesla.
- Zoran Popovic on Accelerated Learning with Smart Tools, Getting Smart with Zoran Popovic.

STUDENT LEARNING OUTCOMES

- MyWays, Next Generation Learning Challenges.
- Profile of a Graduate, Battelle for Kids.
- The Future of Learning: Redefining Readiness from the Inside Out, KnowledgeWorks.

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