

The 4th Industrial Revolution and the Coming Talent War

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David Pistrui, Ph.D., is an executive, educator, and entrepreneur, with over 35 years of experience serving the corporate, nonprofit, and education sectors. Dr. Pistrui has held corporate leadership positions with both Fortune 500, and mid-sized companies including VideoCart, MediaOne, Parade Publications, Time Incorporated, and Purex Industries.

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Currently Dr. Pistrui is leading a consortium of ten Michigan universities and colleges (and their industry partners) in a multi-year applied research project focusing on Industry 4.0 (the fourth industrial revolution).

Dr. Pistrui has served as an economic advisor to the states of Michigan, North Carolina and Illinois, Austrian Federal Economic Chamber, AutoCluster Styria (Austria), Bahrain Institute of Banking and Finance, Middle East Economic Digest, and the Family Firm Institute.

As an educator, he has held faculty appointments at the University of Detroit Mercy, Fayetteville State University (North Carolina), Illinois Institute of Technology, DePaul University, and Alfred University. He has held endowed chairs in entrepreneurship and family business. Dr. Pistrui has co-authored over 60 publications in the areas of talent development, artificial intelligence, robotics, technology entrepreneurship, strategy, family business, and engineering education.

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In addition to academic work, Dr Kleinke continues his involvement in industry as he conducts seminars on innovation which are tailored to the needs of industrial product companies. Dr Kleinke's work with the Detroit-based technology hub, Automation Alley, is engaging academia in the dissemination of Industry 4.0 knowledge to support the regional industrial ecosystem.

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Introduction and Overview

Imagine a world in which engineers can interact with 3D models in an immersive environment, where doctors use artificial intelligence to create individually customized treatment plans, and where products wend their way independently through the production process. This is Industry 4.0, the Fourth Industrial Revolution, defined as the convergence of digital, biological and physical technologies disrupting manufacturing, agriculture, healthcare and all industries across the globe. Automation Alley, Michigan's Industry 4.0 Knowledge Center, identifies Industry 4.0 as a collection of eight emerging technology sectors, all of which require new ways of thinking and working [1]:

Table 1 - Eight Industry 4.0 Disruptive Technologies

 The Industrial Internet of Things	 Artificial Intelligence and Big Data
 Robotics	 Cybersecurity
 Advanced Materials	 Cloud Computing
 Additive Manufacturing	 Modeling, Simulation and Visualization

Source: Automation <https://www.automationalley.com/techreport>, 2018

Technology demand is out-pacing training capacity, causing an all-out war for talent. The National Association of Manufacturers [2] reports that over the next decade 3.5 million manufacturing jobs are going to need to be filled, yet two million of these jobs will remain unfilled. Furthermore, the World Economic Forum [3] estimates that 65% of children entering primary school today will ultimately end up working in completely new job types that currently do not exist.

This research seeks to identify emerging trends, pinpoint challenges and opportunities and gain insights into the technical, cultural and socio-economic forces shaping the talent pipeline, and what the implications are for industry and educators in the years ahead.

This research will produce new insights into how Industry 4.0 is shaping the talent needs in the U.S. and around the world.

The research objectives are to:

1. Gain insights into the emerging trends and forces shaping the talent today and the emerging talent needs of tomorrow.
2. Explore the intersections and relationships between the eight segments of Industry 4.0, including the identification of specific needs related to talent development.
3. Identify the talent centric challenges and opportunities facing industry as they relate to Industry 4.0 and the eight technological sectors.
4. Gain insights into the cultural and generational forces shaping the talent pipeline, and how they relate to current and future employment and job creation.

5. Assess the implications of Industry 4.0 for industry, educators and policy makers.

This research will include valuable new insights into the future talent needs related to the eight segments of Industry 4.0. Armed with these data-driven insights and new knowledge, industry and educators will be better prepared to collaborate and lead their company or institution's talent development strategies.

The research outcomes include:

1. A data-driven and rigorous overview of the current state of the talent pipeline and what the future needs will be to guide industry and educators to work together to strengthen the human component of Industry 4.0.
2. A comprehensive overview of the talent landscape including key trends and implications related to demographics, generational shifts and human interface associated with the eight technology sectors driving Industry 4.0.
3. A detailed list of the challenges and opportunities related to developing the necessary talent pipeline that will be required for U.S. industry to maintain a global leadership position.
4. An informed recommendation of what industry, education and government can do to collectively develop, grow and maintain appropriate talent pools to leverage Industry 4.0 and the eight technology sectors associated with it.

Dramatic Cultural and Technical Transformation

The cultural and technical forces associated with Industry 4.0, are unprecedented. This profound and dramatic transformation of industry is rooted in a unique combination of forces, including the velocity, breadth and depth of change [4], and is shaping our talent pipeline.

What is Industry 4.0's implications for industry and educators in the years ahead? These disruptive market forces are driving the development of new business models that have great impact on the employment landscape. Many of the major drivers of transformation currently affecting global industries are expected to have a significant impact on both job creation and job displacement.

Industry 4.0 is also producing profound ramifications for businesses' cost structure, work process design and the involvement of human labor to drive innovation and growth [5]. While some jobs will be eliminated, more importantly, new and different types of work will emerge. For companies, reskilling and upskilling strategies will be critical if they are to find the talent they need and to deliver the work of the future.

In addition to the rapid advances in technology, there are also cultural forces shaping the employment landscape, principally generational transition as Baby Boomers retire and GenXers, Millennials and GenZers become the primary workforce. These succeeding generations have a distinctly different set of perspectives and values as it relates to work, education and life balance.

Educators will also be required to radically rethink their models, methods and offerings to meet the needs of industry and a rapidly changing society. Regions that thrive and prosper will be the

ones that bring industry, education and policy makers together around common objectives combined with the ability to be agile and reactive to continued disruption and change in the marketplace.

Prevailing Trends and Emerging Forces

Physical, cyber and human worlds are merging into a series of new and uncharted systems and subsystems that are reshaping the socioeconomic, technical and economic landscapes (see Table 2). Generational succession is changing how people view the nature of work. This combined with other trends such as urbanization, changing family composition and a shifting middle class are all impacting where, when and how we work.

Table 2 - Trends and Emerging Forces

Demographic & Socioeconomic	Technical Advancement	Economic Models
<ul style="list-style-type: none"> • Changing nature of work • Generational succession • Role of middleclass • Aspirations of women • Urban migration 	<ul style="list-style-type: none"> • Mobility and the cloud • Data analytics • Internet of things • Alternative energy sources • Artificial intelligence 	<ul style="list-style-type: none"> • Sharing economy • Responsive business models • Enterprising mindset • Continuous generative ideation • Customer experience

Sources: World Economic Forum (2016), Pistrucci and Kleinke, 2017

Industry leaders, educators and policy makers must accept that radically new ways of working are opportunities to embrace, not simply problems to try and solve (see Table 3). The driving forces changing how we work and the jobs that we do will impact organizations of all sizes across all sectors.

Table 3 - Work Environment Paradigm Shift Trends

Yesterday	Tomorrow
<ul style="list-style-type: none"> • Centralized 	<ul style="list-style-type: none"> • Decentralized
<ul style="list-style-type: none"> • Task Driven 	<ul style="list-style-type: none"> • Value Driven
<ul style="list-style-type: none"> • Command & Control 	<ul style="list-style-type: none"> • Empowered & Autonomous
<ul style="list-style-type: none"> • Closed System 	<ul style="list-style-type: none"> • Emerging Integrated Systems

• Problem Solving Mentality	• Opportunity Seeking Mindset
• Classroom Education & Training	• Continuous Personal Learning
• Traditional Work Ethic	• Balance Based Work Ethic

Source: Pistrui and Kleinke, 2018

Organizations that understand the implications of the disruption of traditional views of today and embrace the opportunities to reshape their culture will enhance their abilities to attract and retain the human talent that will be essential to survival, continuity and growth.

New and Dynamic Talent Horizon

Those individuals and organizations that prosper will be required to develop a new set of 21st Century skills. Calls for stepping up workforce reskilling as a critical component of preparing labor markets for the Industry 4.0 have become ever more urgent [4]. The factories of the future will be very different from the workplaces of today – in 2015 alone nearly 100,000 robots were deployed in automotive factories and a further 65,000 were installed in factories making

electrical and electronic goods, so automation will continue to reshape the labor pool [6]. In a recent study conducted by the Ralph C. Wilson, Jr. Foundation reports that 30% of the middle skilled labor pool will be displaced by automation by 2030 [6].

There will also continue to be a shortage of workers with the skills industry is seeking. Many people will need to transition from “traditional careers” where they have trained to do specific tasks (mechanical engineer) to “multitrack careers” where they will have multiple jobs (engineer, data analyst, network administrator).

21st Century Skill Sets

In their 2016 report “The Future of Jobs,” the World Economic Forum identified 10 key skills critical for success in the workforce [8] As Table 4 illustrates we have grouped these skills into three categories. The first category People Centered includes managing relationships, coordinating and providing service.

Table 4 - Ten 21st Century Skill Sets

People Centered	Skill Centered	Thinking Centered
People Management	Complex Problem Solving	Critical Thinking
Coordinating with others	Creativity	Emotional Intelligence
Service Orientation	Negotiation	Judgement and Decision Making

Source: World Economic Forum, 2016

The second category Skill Centered includes problem solving, creativity and negotiation. The third category is comprised of critical thinking, emotional intelligence, decision making and cognitive flexibility. It will be important for educators, industry leaders and policy makers to work together to coordinate and integrate programs and offering to build these skill sets.

Addressing the Skills Gap

Research conducted by University of Detroit Mercy in partnership with TTI Success Insights, a leading global supplier of data-driven behavioral assessments, provides insights relating to categories and specific types of skills that Original Equipment Manufacturers (OEMs) and Tier 1 and 2 suppliers, as well as STEM educators across Southeast Michigan, view as critical areas to focus professional development (see Table 5).

The need for developing discerning skills is a result of the disruption, change and uncertainties associated with Industry 4.0. This applies to both companies and educators. People need to be able to identify patterns and make new connections in ways never imagined before. Moving forward, they must envision and create new products, services and user experiences consistently and in new ways.

Table 5 - 21st Century Skill Development Areas of Focus

Discerning Skills - Perceptive, astute and discriminating aptitudes

Creativity and Innovation - Creating new approaches, designs, processes, technologies and/or systems to achieve the desired result.

Conceptual Thinking - Analyzing hypothetical situations, patterns and/or abstract concepts to formulate connections and new insights.

Futuristic Thinking - Imagining, envisioning, projecting and/or creating what has not yet been actualized.

People Skills - Individual, team and group effectiveness

Interpersonal Skills - Effectively communicating, building rapport and relating well to all kinds of people.

Understanding Others - Understanding the uniqueness and contributions of others.

Teamwork - Cooperating with others to meet objectives.

Purposeful Skills - Determination, aim and need for achievement

Self-Starting - Demonstrating initiative and willingness to begin working.

Continuous Learning - Taking initiative to regularly learn new concepts, technologies and/or methods.

Negotiation - Listening to many points of view and facilitating agreements between two or more parties.

Sources: Pistrui, Kleinke and Bonnstetter, 2015-18; TTI Success Insights, <https://www.ttisuccessinsights.com>

Good people skills impact organizations at all levels from the executive suite to the shop floor. People are the key to success, and today there is a shortage of individuals to fill the jobs available in the market- place. People skills can mean the difference between survival, growth and failure. Communicating, listening, understanding and embracing diversity along with building trust are critical to both the success of companies and educators.

Strong purposeful skills that include the need for achievement and self-initiative are essential to navigate the integration of learning new concepts, methods and technologies. Listening, openness to new ideas and respecting different points of view are vital to working effectively across generations (consider Baby Boomers, GenXers and Millennials). Facilitating agreement and building effective teams are central to the success of all organizations.

Creating a Culture of Collaboration

The World Economic Forum report “Collaborative Innovation: Transforming Business, Driving Growth” chronicled that when firms share resources and engage in collaborative innovation practices significant value can be created for stakeholders [10]. This is not to say that collaborative innovation is easy to undertake. The report argues that there are steps, processes and activities associated with success (see Table 6).

Table 6 – Opportunities and Challenges Associated with Collaborative Innovation

Response Strategies:

- Prepare – Well-defined objectives and a carefully-designed business case
- Partner – A supportive culture with links to relevant networks and markets
- Pioneer – Willingness to work with competitors and firms of all sizes

Support Strategies:

- Empower – Create champions and develop public-private partnerships
- Educate – Introduce and operationalize new tools, techniques and knowhow
- Enable – Offer policy-based incentives and reduce perceptions and barriers

Source: World Economic Forum, 2015; Pistrui and Kleinke, 2018;

The disruptions associated with Industry 4.0 are forcing both industry and educators to in essence reset, recalibrate and create new types of collaborative partnerships. The enterprises' ability to manage the re-skilling and retraining of their workforce in the digital age will be a critical determinant of how swiftly they adopt these technologies [5]. This requires that industry, educators and policy makers collectively collaborate to re-skill, up-skill and develop completely new combinations of skills to meet the demands of the rapidly changing socioeconomic environment.

21st Century Workforce Development Opportunities

So what should these new combinations of skills look like in order to prosper in an Industry 4.0 environment? Table 6 provides a series of workforce development snapshots relating to four different areas. These were created by reviewing a series of reports from the Workforce Intelligence Network, World Economic Forum in combination with empirical research and structured interviews conducted by the authors [3], [9], [11], [12], [13].

We are at a new frontier when it comes to connected and autonomous vehicle development (CAV). Since this is a newly emerging field and marketplace, we are only beginning to get some clarity as to what the skill sets that are required to develop this emerging sector. What is clear is that the development of CAVs will require the development of a new combination of technical skills that are not currently being offered by our education institutions. Our universities are only now beginning to offer curriculum to address these needs, usually through certificate (up-skilling) and concentrations such as mechatronics (new combinations).

For the most part, the employability skills components are most often not a part of a formal high school or college education today and represent an enormous opportunity for reformers. The lack of well-developed employability skills can stymie innovation, collaboration, teamwork and job performance.

Table 7 – Industry 4.0 Focused Workforce Development Snapshots

<u>Connected & Autonomous Vehicles</u>	<u>Cybersecurity</u>
<u>Technical Skills</u> <ul style="list-style-type: none"> • Software & Applications Development • Information Security Analysis • Computer Systems Engineering • Electrical Engineering • Computer Systems Analysis 	<u>Technical Skills</u> <ul style="list-style-type: none"> • Advanced Software Skills • Information Systems • Information & Network Security • Technical Support • Cryptography
<u>Employability Skills</u> <ul style="list-style-type: none"> • Creativity & Innovation • Futuristic Thinking 	<u>Employability Skills</u> <ul style="list-style-type: none"> • Communication Skills • Problem Solving • Teamwork

<ul style="list-style-type: none"> • Problem Solving • Teamwork • Communication Skills 	<ul style="list-style-type: none"> • Collaboration • Planning & Organizing
<p style="text-align: center;"><u>Advanced Materials</u></p> <p><u>Technical Skills</u></p> <ul style="list-style-type: none"> • Chemical & Material Science • Composites Knowledge • Manufacturing Skills • Engineering & Computer Skills • Skilled Trades Knowhow <p><u>Employability Skills</u></p> <ul style="list-style-type: none"> • Multidisciplinary Skills • Communication Skills • Conceptual Thinking • Teamwork • Continuous Learning 	<p style="text-align: center;"><u>Mobility Product Development</u></p> <p><u>Technical Skills</u></p> <ul style="list-style-type: none"> • Systems Engineering • Systems Architecture • Engineering & Computer Systems • Information Technology Networks • Materials Science & Manufacturing <p><u>Employability Skills</u></p> <ul style="list-style-type: none"> • Creativity & Innovation • Futuristic Thinking • Interpersonal Skills • Business Acumen • Communication Skills

Sources: WIN Reports, 2016-17; World Economic Forum, 2015-18, Pistrui and Kleinke, 2015-18.

Cybersecurity is also a new and rapidly emerging field requiring a new combination of technical and employability skills. On the technical side there are three clusters related to software, systems and security that need to be blended in complementary ways. On the employability side the clusters include people skills, problem solving, and planning skills.

Mobility Product Development is at a cross roads in the Industry 4.0 environment. With the movement towards electrification and autonomous vehicle development, in combination with the move to mobility versus manufacturing mindsets mobility product development requires some radical transformation. On the technical side there is a need to move away from the traditional silo system, towards a multi-disciplinary approach blending systems engineering and architecture, together with IT network optimization, materials science and advanced manufacturing.

Concerning employability skills and mobility product development, there are three primary clusters in need of development to meet the demands of Industry 4.0. First, is the development of innovative and futuristic thinking skills. Second, are the role of communication and people skills to complement technical knowhow. Strengthening people and communication skills (including listening) are important as companies navigate through generational leadership succession (Baby Boomers, GenXers to Millennials), and attempt to better understand their customers. Business acumen is the third employability skillset vital to mobility product development and the creation of new business models.

The Innovation Intersections of Industry 4.0 Technologies, Systems and People

Twenty-first century industry requires a complex mix of Industry 4.0 technologies, systems and people. As the fourth industrial revolution routinely disrupts people and technologies, business systems must be nimble and dynamic and ready to assess the value (or threat) of relevant Industry 4.0 technologies. This is a particularly difficult task when simultaneous developments are occurring in independent domains, yet the combination of two or more developments could have exponential effects on a businesses' ability to collaborate, innovate and grow.

Rechtin states that "value can be generated as new and unique system functions are created by organizing otherwise separate elements [14, p. 24]. New and far reaching innovation can occur by leveraging the interrelationships and elements by combining and aligning systems in new ways [15].

The companies that can leverage the interrelationships and organization of Industry 4.0 technologies, systems and people can gain considerable competitive advantage (see Table 8). But this requires the corporate leaders to invest in (or develop) the right talent within their organization.

But which Industry 4.0 elements should be combined? What type of company would benefit from the emergent system behavior? What core competencies does the business need? To begin to answer such questions, the authors propose the following typologies, to match Industry 4.0 intersections with technologies, systems and teams.

The hypothesis is that the three Industry 4.0 technology segments (rectangles) shown are the most likely candidates to intersect, leading to exponential collaborative innovation and growth opportunities. Simultaneous breakthroughs in multiple segments could exponentially impact the collaborative innovation (diamonds).

Table 8 - Industry 4.0 Intersection Typologies



Sources: Pistrui and Kleinke, 2018, [15], Keeley et. el. 2013, [16].

Implications for Education - The Industry 4.0 Academic Gap

The hypotheses of the typologies in Table 8 is a key issue associated with talent development. If the hypotheses are correct, it points to a gap in academic curricula. In general, academia views the Industry 4.0 technologies as segregated, individual technologies. Few programs, if any, align the interacting segments. Academia is still aligned with the traditional engineering disciplines (Mechanical, Electrical, Chemical, etc.) associated with Industry 2.0. This should serve as a wakeup call for academic institutions to address the urgent need to collaborate with industry and policy makers to realign and reform education around the needs of the marketplace.

One example to draw from is the Innovate Now: Report on Innovation Initiative developed for the state of Illinois. In the Innovate Now: Report on Innovation, Pistrui provided a series of

recommendations for educators to employ to build the Metro Chicago and state of Illinois talent pool [18]. Table 9 provides an overview of the recommendations from the report.

Table 9 - What Universities and Community Colleges Can Do Better

The following seven-point action plan to support the development of entrepreneurship and the innovation talent pool:

1. Make entrepreneurship and innovation education a priority on every campus.
2. Develop and support a group of “innovation champions.”
3. Demand cross curriculum and interdisciplinary collaboration between students, faculty, universities and industry.
4. Invest in educating and building the knowledge and skills of educators and community leaders.
5. Connect the regional university communities with entrepreneurs, industry, and government to enhance strategic competitiveness.
6. Build a regional coalition of universities, community colleges, and high schools around entrepreneurship and innovation.
7. Raise the funding necessary to support such initiatives and develop a leadership council to direct and lead such efforts.

Source: D. Pistrucci, 2007, Innovate Now: Report on Innovation

Implications for Industry

Today, there is a significant shift from selling what exists to imagining what's next. Fifty years ago, the life expectancy of a Fortune 500 firm was around 75 years. Currently, it is less than 15 years and declining rapidly. Dynamic change and a disruptive consumer-oriented market economy are fueling these changes. Today, even the largest companies risk being marginalized, commoditized or disrupted in other ways. As well-funded startups and risk-embracing players seek to challenge prevailing paradigms and alter long-standing models, innovation has become critical, not merely to growth but for survival.

As volatility, uncertainty, complexity and ambiguity rise, disruptive and disintermediating transformation in products, services and offerings will continue to increase. Imagination and the creation of compelling experiences, radical brand evolutions and new business models will drive this revolution. Airbnb, Amazon and Uber are examples of disruptive new innovative business models. Innovation created around human-centric dynamic thinking will continue to emerge as critical survival skills and growth strategies. Generative research focused on gaining entirely new insights and inspirations that drive new offerings will become the strategic tool of choice for agile companies in a rapidly evolving marketplace.

In order to navigate the chaos, and identify and capitalize on the disruptive opportunities associated with Industry 4.0, we must create a culture of dynamic thinkers across all levels of

society. This is paramount to sustain our leadership position locally, regionally, nationally and on a global level.

Concluding Thoughts and Call to Action

Today we are at the crossroads of the fourth industrial revolution combined with generational succession. Both forces are disrupting and driving dramatic and systematic changes. We offer the following thoughts to guide the ongoing discourse relating to challenges and opportunities at hand.

Table 10 - Implications for the Future

1. The development of a new and more diverse talent pipeline is vital for nations (and regions) to maintain global leadership positions and socioeconomic wellbeing.
2. The three primary forces of disruption industry and education faces in navigating Industry 4.0 include: 1 – Demographic/Socioeconomic Shifts, 2 – Technical Integration and Innovation and 3 – Creating New Economic Business Models.
3. Industry 4.0 will continue to radically transform the workplace, displacing workers while creating demand for different combinations of skills to fill new jobs and types of work.
4. There are four primary areas of growth and development opportunities that industry can pursue around the intersections of Industry 4.0: 1 – Network Innovation, 2 – Process Innovation, 3 – System Innovation and 4 – Structural Innovation.

Source: Pistrui and Kleinke, 2018

In addition to technical knowhow, 21st Century skills need to be innovative and leverage Industry 4.0's disruption through: 1 – Discerning Skills (Conceptual and Futuristic Thinking), 2 – People Skills (Teamwork and Understanding Others), and 3 – Purposeful Skills (Self Starting and Continuous Learning). Industry and educators must focus collaboration on the intersections of the eight technological segments associated with Industry 4.0 to guide the development of a talent pipeline and ensure industry receives graduates with employable skills. Creating a culture of dynamic thinking (people-centric and opportunity seeking approaches) across organizations is essential to both navigate and capitalize on the opportunities associated with Industry 4.0.

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