Competing on Innovation:
Implications for Building the Middle-Skill Talent Pipeline

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Introduction and Overview

The United States will increasingly compete globally on innovation. American businesses will compete on how well they develop and engage workers to drive and support innovation resulting in new and improved products, services, processes, and business models as well as scientific and technological advances. They also will compete in how well they develop and engage workers through more open innovation partnerships with other businesses and colleges and universities.[1] At the same time, American workers, including middle-skill workers, will be in a race to gain the education and experience necessary to do the most critical innovation work in the most competitive American workplaces in the face of growing threats to their jobs from globalization and automation.

Competing on innovation will likely require new thinking in how we organize and manage employer-education partnerships to produce this "innovation talent" at all levels, from upper management and professionals to the middle-skill workforce. To date, most secondary and postsecondary education reforms related to innovation have focused on what we teach and how we teach. They have focused on building stronger STEM curriculum. They have also focused on strengthening secondary and postsecondary career-related programs to reflect higher competency and credentialing requirements for in-demand occupations (e.g., industry-recognized credentials) and cross-cutting workplace skills such as critical thinking and teamwork. In addition, they have promoted new approaches to learning that emphasize the application of skills and work-based learning. However, educational reforms have not focused

[1] This paper focuses on innovation within businesses that may or may not involve partnerships with colleges and universities. This paper does not address the important role of colleges and universities in carrying out innovation work including scientific and technological advances that are transferred to businesses. Many colleges and universities are also pioneering scientific and technological advances through interdisciplinary teams.

sufficient attention on how to partner with employers to create new learning opportunities that fully reflect how innovation talent is actually developed and engaged in modern workplaces.

Many leading businesses are now recognizing that some forms of innovation occur at the interfaces of disciplines and functions that cut across organizational boundaries and reach all levels of workers, including middle-skill workers. These businesses are using open and cross-functional teams—what some have called the "horizontal dimension" of work—to break down organizational silos and boundaries and carry out critical business functions and processes. They also are using these teams to build stronger innovation capacity.

This type of innovation work requires team members to have both skill depth and breadth—to have deep expertise in their primary jobs and related disciplinary backgrounds but also have the breadth to leverage the expertise of other team members from different professional/occupational and disciplinary backgrounds. Depth requires more extensive knowledge and practice to attain expert levels of performance within a function or discipline.[2] Breadth requires not just broader education and training (e.g., cross-cutting technical and workplace knowledge and skills such as teamwork skills) but also extensive experience in working as members of cross-functional, interdisciplinary teams and using innovation methods and tools that span professional and disciplinary boundaries.

High schools, colleges, and universities are pioneering some promising approaches for providing their students with education opportunities in doing cross-functional and interdisciplinary innovation work in cooperation with employers and other outside partners. In

[2] This paper is intended to raise awareness and promote further research and experimentation on the cross-functional and interdisciplinary dimension of innovation work and implications for building talent pipelines. The need for greater functional and disciplinary depth is also very important but is beyond the scope of the paper.

addition, many states are promoting career pathways and sector partnerships that have the potential to provide more depth and breadth in career preparation and support these types of educational opportunities. These promising practices provide examples of what could be done in developing new approaches to employer-education partnerships.

This paper proposes that in order to compete on innovation we must not only rethink what we teach and how we teach, but also how high schools, community colleges and universities could potentially partner with employers to provide more cross-functional and interdisciplinary experiences. In starting this process, we should explore how innovation talent is developed and used in modern workplaces with special attention to the role of open and cross-functional teams and what is the right balance of depth and breadth in career preparation. We also should explore how employers and their education partners can organize and manage secondary and postsecondary talent pipelines in ways that provide more students with the opportunities to carry out authentic innovation work tasks in cross-functional and interdisciplinary teams that cut across existing disciplinary and program silos in schools, colleges, and universities. Finally, we should promote more research into the effectiveness of cross-functional and interdisciplinary innovation work in workplaces and educational institutions for building talent pipelines including those for middle-skill workers.

We begin by addressing the growing importance of innovation in global competitiveness as well as the challenges faced by American workers in competing on innovation and winning the race against routine work. Next, the paper defines innovation and explores its major types with an emphasis on execution and implementation at all levels of the workplace. The paper then provides an overview of research on the changing organization of work and the role of open cross-functional teams. From there, the paper explores some promising practices and concludes with a call for more research to further explore this approach in both the workplace and in education and implications for building innovation talent pipelines including pipelines for middle-skill workers.

Competing on Innovation and the Race against Routine Work

There is growing recognition that the United States will increasingly compete on innovation in the global economy. Innovation that combines business entrepreneurship (Schram, 2006) and scientific and technological advances will be the major driver of productivity and economic growth as well as the major source of sustainable competitive advantage for the United States and its regional economies. It will also play a major role in addressing societal challenges in environmental management, energy, healthcare and international development that require new types of social entrepreneurship and new partnerships between the public and private sectors (Kao, 2007; Atkinson and Ezell, 2012; Council on Competitiveness, 2005; Atkinson and Wial, 2008).

More and more businesses are also recognizing the role of innovation in remaining competitive (American Management Association, 2006; Economist, 2009). Recent research and research-based publications on leading employer practices in innovation are full of examples of how businesses are exploring new ways to build stronger innovation capabilities both internally and through their more open innovation alliances (Christensen and Raynor, 2003; Chesbrough, 2006; Davila, Epstein, Shelton, 2006; Skarzynski and Gibson, 2008; George et al., 2005). This includes more open business model innovations that require the redesign of core business functions and processes within and across internal business units and across organizational boundaries. For example, some businesses are now moving to more open approaches to innovation by changing how they leverage both internal and external research and development expertise (Chesbrough, 2006) and how they co-create new products and services with customers and external design teams, suppliers and other partners (Prahalad and Krishnan, 2008). Recent research also highlights how businesses are integrating business model and technological innovations. For example, research has shown higher returns from information technology investment when they are used in conjunction with the implementation of business model and process innovations (Brynjolfsson and McAfee, 2014).

There also is growing recognition that the competitiveness of nations and businesses are increasingly dependent on a globally competitive workforce that can do the most creative and innovative work (National Research Council, 2007, 2010; National Center on Education and the Economy (NCEE), 2007). This can be seen in the growing research on how to identify and develop leading innovators (Dyer, Gregersen, and Christensen, 2011; Griffin, Price and Vojack, 2012). As a result, employers will increasingly be competing on how well they recruit, develop and engage what we call "innovation talent"—those people who have the skill-sets and experience in organizing and executing the most critical innovation work at all levels from upper management and professional positions to middle-skill front-line workers.[3]

[3] This paper refers to middle-skill workers as workers who play the most important front-line roles in carrying out core business functions and processes critical to the competitiveness of employers and the regions where they do business. They also play similar critical roles in the non-profit and public sectors. These middle-skill workers are in front-line skilled jobs that require more than a general high school diploma. However, they are not in upper management and professional positions and are not confined to scientific and technological research and development positions normally associated with innovation. Many of these workers have bachelor-level educational credentials such as nurses, engineering technicians, industrial maintenance technicians, software developers, network administrators, front-line production managers, and logistics technicians but still fall within the middle of current distribution of educational credential attainment between upper management and professional jobs and front-line, lower-skilled positions.

At the same time, more American workers are now in a race to gain these new innovation skill-sets and experiences to remain competitive and advance their careers. They are in a race against the twin forces of globalization and automation that are taking away jobs from workers who are doing routine work (Goldin and Katz, 2010; NCEE, 2007). The stakes are getting increasingly higher as workers from developing countries are gaining stronger academic and technical skills, and automation and robotics are expanding into new fields that involve higher-order cognitive reasoning, problem-solving, and communication (Brynjolfsson and McAfee, 2014).

What Do We Mean By Innovation?

Innovation is a widely used term in debates on global competitiveness, but there is not widespread agreement on its definition and how it relates to entrepreneurship and scientific and technology advancement. In this paper we use a broad definition: Innovation is the development and implementation of new ideas and new ways of doing things that create social value (Innovate Now, 2007; Tyszko and Sheets, 2012). When applied to the private, for-profit sector, innovation creates social value in the form of customer value that provides the foundation for business growth and competitiveness. Innovation may also create "shared value" for multiple stakeholders (Porter and Kramer, 2011). When applied to the public and non-profit sectors, innovation creates social value by providing a wider array of societal benefits including increased productivity and economic growth and solutions to major societal problems (e.g., environment, energy, healthcare).

Multiple Types of Innovation. Innovation can come in many types and forms beyond scientific and technological advances. Innovation can result in new markets and new and improved products and services. It can also drive new business strategies and business models as well as improved business processes and methods. It can also include new perspectives and methods from a variety of professional communities and disciplines including the fine arts and humanities, which has contributed "design thinking" (Brown, 2009) to the development of new products and services and new approaches to addressing social issues. Innovation captures both incremental improvements as well as breakthrough developments including what Clayton Christensen calls "disruptive innovation" that may change the basis of competition and configuration of entire industries (Christensen, 1997). In most cases, innovation work falls somewhere in-between, especially when it involves middle-skill workers.

This broad definition of innovation attempts to capture the complex interplay between business entrepreneurship and scientific and technological advances. Innovation is broader than widely used definitions of entrepreneurship which focus more on the business model side of innovation. As noted earlier, innovation is also broader than scientific and technological advances and the traditional boundaries of STEM disciplines. In addition, this broad definition attempts to convey the idea that innovation many times involves a combination of business model, product/service and process innovations that harness the power of scientific and technological advances.

The Discipline of Innovation Embedded in All Work. Our definition of innovation also emphasizes that it is not just about creativity and the generation of new ideas through an unstructured process and context. Instead, innovation refers to disciplined and deliberate actions that result in the fast and continuous generation of new ideas and new ways of doing things through approaches and methods that cannot be done by individual inventors and creative people working alone. It also involves rapid and effective execution and implementation to create and capture social value.

Just as scientists utilize the scientific method and engineers use a technology design process, the field of innovation leverages these methods and tools as well as an even broader array of methods and tools that define the discipline of innovation. As an example, leading employers utilize Lean Six Sigma methods and tools to achieve breakthrough process innovations in manufacturing, transportation and logistics, healthcare, and other industries (e.g., George, 2002). They also have utilized new perspectives and tools from the world of design (e.g., Brown, 2009) and ethnographic tools from the social sciences (George et al., 2007).

This definition also emphasizes that innovation is not solely pursued by upper-level management and professionals or workers in secluded innovation labs. It is embedded into the basic fabric of the modern workplace and is an important feature of day to day work at all levels of the organization. And, it is critical in winning the race against routine work, especially for middle-skill workers. As a result, innovation requires the building of innovation capacity in organizations including the education and training of workers at all levels to perform the work of innovation better, faster, and cheaper than anywhere else in the world.

How does innovation work get carried out in organizations and what is the role of middle-skill workers? We now turn to research on the organization of work and the role of innovation talent, including middle-skill workers.

The Changing Organization of Work and the Role of Open Cross-Functional Teams

Over the last few decades, researchers have attempted to capture the major changes in the organization of work in a rapidly changing global economy and their implications for changing skill requirements at all levels, from managers and professionals to front-line workers. Many researchers—including those addressing high performance work systems—have suggested an overall trend toward flatter organizational hierarchies, decentralized authority and responsibility, more worker involvement and flexibility in how work is organized and carried out, and an increase in contingent employment relationships (Cappelli et al, 1997; Karoly and Panis, 2004). This research also has highlighted the changing role and employment relationships of technicians (Barley, 2006). And, it has documented the shift toward the use of teams in organizing work (Batt and Doellgast, 2005) and the need to work across traditional functional silos (e.g., engineering, logistics, production, and marketing and sales) (Berryman and Bailey, 1992).

Open Cross-Functional Teams: The Horizontal Dimension of Work. These broad trends in work organization have prompted researchers to focus more attention on how to improve the performance of cross-functional teams in driving and supporting innovation. For example, management research has attempted to better understand the factors that contribute to better cross-functional team performance in product development, concurrent engineering, interdisciplinary healthcare delivery, and industrial maintenance as well as project management in many different industry and organizational contexts (Kozlowski and Ilgen, 2006; Denison, Hart and Kahn, 1996; Ford and Randolph, 1992; Hauptman and Hirji, 1999; Lichtenstein, Alexander, McCarthy and Wells, 2004; Brettel, et al. 2006; Sethi, Smith, and Park, 2001).

This more open and horizontal dimension to work has been further emphasized and highlighted by research based business publications that include case studies and promising practices from leading employers (Chesbrough, 2006; Davila, Epstein, Shelton, 2006; Skarzynski and Gibson, 2008; Rummler and Brache, 1995; Ostroff, 1999). Many of these books and articles argue that the fundamental building block in organizing and performing the most critical work in the modern workplace is the horizontal cross-functional "business process," (e.g., Rummler and Brache, 1995). They also point out the growing "democratization of innovation" with expanded roles for workers at all levels as well as customers and outside partners (Skarzynski and Gibson, 2008; Von Hipple, 2005).

These case studies and examples of business practices in innovation suggest that employers vary in how they organize and utilize open cross-functional teams to drive and support innovation based on their different innovation strategies (e.g., Davila, Epstein, Shelton, 2006; Skarzynski and Gibson, 2008; Rummler and Brache, 1995; Ostroff, 1999). As an example, some businesses could choose to compete on product and service leadership and innovation whereas others could choose to compete on price in providing more commodity-type products and services through lean production systems. They could identify the product/process development process as the most critical cross-functional business process involving the coordination of marketing and sales, design and engineering, production, and logistics as well as external customers and suppliers.

As another example, a healthcare employer could focus on providing high-quality community-based care through coordinated care models that involve coordinated cross-functional business processes in therapeutic and diagnostic services. Businesses could empower core process managers to lead cross-functional teams in driving and supporting continuous improvement in products, services and processes. Teams could include major customers as well as external partners, service providers, and suppliers who play a major role in different aspects of the end-to-end process. They also may organize “off-line” project teams to explore other innovation opportunities that may involve more disruptive innovations. In some industries, such as information technology, this horizontal dimension can also be seen in the project team that works together across the entire project life cycle from original design to development and user support and utilize methods and tools that integrate business model, business process and product/service innovation (e.g., Maurya, 2012).

Building Innovation Capacity and Talent in Organizations. Although there has been limited research on building organizational capacity, recent research and research-based publications on business innovation practices do provide some potential insights into what should be further explored in research. One theme is the need to develop a new type of organizational leadership and culture as well as new management systems for supporting these cross-functional teams (e.g., Hill et al., 2015; Davila, Epstein, Shelton, 2006; Skarzynski and Gibson, 2008). Another theme is that organizations must provide teams with the training and tools necessary to do the most critical innovation work (e.g., George, 2002). This research and related employer case studies provide a starting point in promoting further research into building innovation capacity through cross-functional and interdisciplinary teams and their implications for building talent pipelines.

Promising Practices for Building Talent Pipelines

This research and related business case studies also raise some important questions and issues to explore in rethinking how employers can begin to work with educational partners to develop this innovation talent in high schools, colleges and universities, especially for middle-skill workers.

- How can students gain education and experience in doing innovation work in open cross-functional teams at the secondary and postsecondary levels?
- What is the role of employers in providing these types of experiences through educational partnerships and work-based learning?
- How can educational institutions provide these types of experiences for more students?

Some leading secondary and postsecondary initiatives can provide important insights into how to explore these questions.

Illinois Innovation Talent. In 2008, the Illinois Department of Commerce and Economic Opportunity (DCEO) and the Illinois State Board of Education (ISBE) developed and launched a program known as Illinois Innovation Talent. The program matched teams of high school students with industry, community, and government partners to solve real-world, authentic challenges. Through these challenges students would be exposed to industry mentors, career information, and opportunities to apply their academic and career and technical skills to challenges sponsored by external stakeholders with a vested interest in reviewing and providing feedback on the arrived at solution.

The Illinois Mathematics and Science Academy (IMSA) was recruited to assist with the design of the challenges and to provide teachers with professional development. Each program year teachers were convened to receive a day of training on how to properly administer a project-based learning challenge where instructors play an advisory or coaching role instead of directing the learning experience. The first teacher convening was done in partnership with the employer, community, and government partners that were recruited to sponsor the challenges. With the help of an IMSA coach—and with support from DCEO and ISBE staff—each school and challenge sponsor co-created the challenge based on actual problems the challenge sponsor was confronting in their industry (Tyszko and Sheets, 2012).

The program began with pairing one school team with one external partner, but in subsequent years the program experimented with pairing multiple student teams from different schools with a single challenge sponsor. The objective was to design the experience and challenges such that one employer or sponsor could work with larger numbers of students, thereby achieving a scalable platform for offering authentic work-based learning experiences at the high school level. These challenges were designed to promote cross-disciplinary applications as well as more general workplace skills such as critical thinking, teamwork, and communication. Over three program years, Illinois Innovation Talent partnered with 92 schools, 274 teachers, and 4,300 students across 42 sponsored challenges (IMSA, 2009; IMSA, 2011; IMSA, 2012). Examples of the types of challenges include the following:

1) *Baxter International*: In 2009 Lindblom Math and Science Academy in Chicago organized a team of students to redesign Baxter International's HomeChoice Adult Renal Dialysis Machine in order to increase the compliance rate of children using home dialysis therapy. This challenge required the integration of cross-disciplinary skills and knowledge from engineering and product design, behavioral science, and health information (IMSA, 2009).
2) *ComEd*: In 2011 ComEd partnered with Mother McAuley High School, Neuqua Valley High School, and North Shore Academy to reduce energy consumption and costs in community infrastructure—including their school campuses. This challenge required

used to apply cross-disciplinary knowledge and skills from energy efficiency, engineering, architecture, and finance in order to develop solutions (IMSA, 2011).

3) *Excel Foundry & Machine*: In 2009 Limestone Community High School partnered with Excel Foundry & Machine to redesign the head ball and socket liner found in its rock crusher to reduce persistent failure rates. Students were required to combine skills sets across business, engineering and materials science in order to assess the problem and propose a solution (IMSA, 2009).

4) *Bison Gear & Engineering Corporation*: In 2012 Bison Gear partnered with Glenbrook South High School, Infinity Math, Science and Technology High School, and The Islamic Foundation to design and construct a mechanism that will interface with the ServoNow driver product and control system and demonstrate its practical applications. This challenges required skill applications in engineering design and manufacturing production to design model scenarios and products that integrate the ServoNow tool (IMSA, 2012).

5) Illinois Department of Transportation (IDOT): In 2009 Rolling Meadows High School partnered a team of students with IDOT staff to develop a robotic solution for performing safe and cost-effective inspections of the 8,000 plus bridges in Illinois. This challenge required the application of engineering and transportation management skills (IMSA, 2009).[4]

[4] Additional research is required to validate the skill acquisition and assessment of students that participate in industry sponsored challenges, such as those pursued as part of the Illinois Innovation Talent program. This is addressed in the final section of the paper.

This demonstration program enjoyed widespread support from industry partners, which led to several spinoff projects. One such example is the iBIO Institute's Stellar Girls program. The iBIO Institute is the education arm of iBIO—the state's largest biotechnology industry association—and was a program participant in all three years of Illinois Innovation Talent. Building off of their experience, they launched a teacher professional development program oriented around a signature challenge sponsored by multiple industry partners. Teachers were expected to implement the challenge during the following school year (iBIO Institute, 2015).

In 2013 participating teachers in Stellar Girls recorded gains in STEM content knowledge as assessed by a testing instrument that combined national and state assessment questions.[5] Their students demonstrated similar gains—particularly those at the 5th and 6th grade levels who registered a 16 point gain between their pre- and post-test. In 2014 the results were even more impressive with 5th and 6th graders demonstrating a gain of 19 points between their pre- and post-test (Feldmann, 2013; Feldmann, 2014).

In addition to the work of the iBIO Institute, the State of Illinois leveraged the Illinois Innovation Talent program as part of its Race to the Top grant award from the U.S. Department of Education. Using resources provided through Race to the Top, the State of Illinois launched seven STEM Learning Exchanges. As part of the Illinois Pathways initiative, these Learning Exchanges were envisioned as a new organizational model for aggregating business partners, nonprofit organizations, and other stakeholders around an industry sector for the purpose of organizing collective action and targeting investments to support P-20 education and workforce

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[5] The STEM questions were pulled from test item banks from the National Assessment of Educational Progress (NAEP) and the American Association for the Advancement of Science (AAAS) as well as state level assessments.

programs. One of the functions of the Learning Exchanges is to organize and coordinate industry-sponsored challenges for diverse student teams (State of Illinois, 2015).

The R&D STEM Learning Exchange, led by the Illinois Science and Technology Institute (ISTI), prioritized the sponsored challenge function and developed a new platform to continue the work originally pioneered under Illinois Innovation Talent. ISTI saw these sponsored challenges as a way to support the implementation of the practice dimension of the Next Generation Science Standards (NGSS) with its focus on scientific discovery and technological design. To assist them in the design and delivery of challenges, the R&D STEM Learning Exchange developed on online learning management system to serve as a matchmaking and project-management platform between challenges sponsors, teachers, and students. In 2015 the R&D STEM Learning Exchange launched 9 industry challenges with 17 participating high schools. Examples of participating companies included Motorola Solutions, Northrup Grumman Corporation, Microsoft, and Takeda Pharmaceuticals (ISTI, 2015).

Career Pathway Frameworks and Sector Initiatives. Illinois Pathways and the seven STEM Learning Exchanges were organized by seven major career clusters and sectors based on the National Career Cluster Framework that was originally designed for career and technical education.[6] This framework defines career pathways for each major economic sector (e.g., manufacturing and information technology) that, in most cases, reflect the most critical business functions and processes and the major occupations that carry out those functions, including both upper-level management, professional, and middle-skill occupations. For

[6] For more information, see http://www.careertech.org/career-clusters.

example, the Health Sciences cluster has pathways in diagnostic and therapeutic services. The Manufacturing cluster has pathways in product/process development and production.

This national framework is consistent with state and regional sector initiatives in workforce development that have attempted to promote career pathways in critical sectors. It also is consistent with business-led talent pipeline initiatives such as the U.S. Chamber Foundation's Talent Pipeline Management initiative, which focuses attention on the most critical business functions that are critical to the competitiveness of employers and the states and regions where they do business.

This framework has been useful in defining cross-cutting competencies within and across pathways and in promoting career pathways. The successful use of the framework in Illinois suggests that it also could provide a promising foundation for organizing and managing learning opportunities that build both depth and breadth in career preparation. In particular, this framework has the potential to support student experience in working in cross-functional and interdisciplinary teams, especially for those students pursuing middle-skill careers.

Postsecondary Frameworks and Initiatives Promoting Cross-Functional and Interdisciplinary Student Experiences. Leading employers, business, industry and professional associations and federal and state governments have increasingly sponsored challenges for postsecondary students to promote career opportunities and attention to major societal problems. One example is the National Science Foundation's (NSF) Community College Innovation Challenge.[7] Student teams supported by faculty mentors and community or business partners proposed innovative STEM-based solutions for real-world problems they

[7] See http://www.nsf.gov/news/special_reports/communitycollege/about.html.

identified within one of the following themes: Big Data, Infrastructure Security, Sustainability (including water, food, energy, and environment), Broadening Participation in STEM, and Improving STEM Education. They were asked to identify the problem to be addressed; why it was important; the potential impact of a solution; and, then propose a solution including the underlying science and technology of the solution and what challenges or barriers must be overcome to make the solution a reality.

In addition, many colleges and universities currently have engaged their students in interdisciplinary projects which are often times sponsored by outside partners, including employers. Some colleges and universities make it a requirement for students to participate in these projects as capstone experiences, especially in business and engineering programs. One leading example is how the Illinois Institute of Technology engages undergraduates in Interprofessional Projects (IPROs) that bring ten to fifteen students from across colleges and disciplines together to work on real world projects, often with industry sponsorship.

Recent national initiatives have developed curriculum and credentialing frameworks that have the potential to move these promising practices to scale and across the entire postsecondary curriculum so that students have more experiences in working in cross-functional interdisciplinary teams. One example is the Degree Qualifications Profile (DQP) that describes what students should know and be able to do at all postsecondary degree levels ranging from associate to bachelor's to master's degrees.[8] This framework emphasizes both breadth and depth by promoting specialized, broad, and integrative knowledge as well as applied and collaborative learning. Most importantly, it promotes student assignments in

[8] For more information, see http://degreeprofile.org/.

which students are asked to demonstrate the application and integration of broad and deep knowledge and skills. Another example is the Liberal Education and America's Promise (LEAP) initiative launched by the American Association of Colleges and Universities.[9] This initiative defines essential learning outcomes for college-educated students that emphasize broad knowledge (e.g., of science, culture, and society) and in-depth knowledge in a specific area of expertise. And, the LEAP Challenge encourages colleges and universities to engage students in "signature work" addressing unstructured problems in ways that will demonstrate their educational breadth and depth including their critical thinking, communication, and problem-solving skills. Many of these signature projects at colleges and universities involve external partners, including employers and business associations

Exploring New Strategies for Building the Talent Pipeline

The innovation research and the promising business and educational practices described above suggest the potential value of providing students with the opportunity to perform innovation work in cross-functional and interdisciplinary teams. However, more research and development work needs to be done in order to make specific recommendations. Here are some suggestions on future research that could provide a stronger foundation for recommending new strategies for building the secondary and postsecondary talent pipeline, especially for middle-skill workers.

Research on the Horizontal Dimension of Innovation Work. There still are major gaps in research on how open, cross-functional teams are organized and carry out their work across different sectors and the role middle-skill workers play in them. The research summarized in

[9] For more information, see https://www.aacu.org/leap/challenge

this paper focused largely on higher level management and engineering work. Although existing research and research-based books on leading employer practices identify promising business practices, there is not sufficient research on the extent and variation of cross-functional team use and effectiveness and how to improve their effectiveness through new management systems and training. This research could provide evidence on the right mixture between depth and breadth in career preparation for different industry sectors and provide representative examples and case studies of innovation work done by these teams across all major industry sectors (e.g., manufacturing, healthcare, information technology, and transportation and logistics).

This research also could identify the major factors and potential interventions that contribute to more effective teams including whether and to what extent businesses are establishing new organizational cultures, leadership and reward systems and providing the leadership and training to support these teams. Given the growing movement toward open innovation (e.g., Chesbrough, 2006) and new partnerships between businesses and universities, this research could draw on related research on team science as practiced in colleges and universities (National Research Council, 2015a). This research could be used to raise awareness and spark debate on implications for how high schools, community colleges and universities could provide the most authentic and effective cross-functional and interdisciplinary team experiences for their students in building innovation talent pipelines.

Employer Validation of Cross-Functional Innovation Work. This research also would provide a starting point in exploring how to engage employers in identifying and validating the most critical cross-functional innovation work that can be used to develop authentic employer sponsored projects and challenges. Although many schools and colleges have engaged employers in providing students with challenging cross-functional team projects, we do not have sufficient evidence to determine whether these projects represent authentic work activities that closely mirror the most important innovation work done in modern workplaces.

The education and industry credentialing communities have developed widely recognized methods (e.g., job analysis and DACUM) for identifying and validating competency requirements for specific jobs and programs as well as validating the more generalized workplace skills such as collaborative and teamwork. These methods are used for engaging industry advisory groups in defining the knowledge and skill requirements of more occupationally focused programs such nursing and machining. These methods also are used to meet program approval and accreditation guidelines. However, these methods are not designed to identify the larger end-to-end cross-functional business processes involved in innovation work; how different professional roles interface in carrying out this work; and the interprofessional knowledge and skills needed to play these roles including interprofessional communication skills.

For example, these methods may not directly address the entire end-to-end product design and development process and the interfaces between marketing, engineering, production and procurement and logistics and how different roles fit together for a business to be effective in product innovation. Rather, they would emphasize the work tasks and knowledge and skills of each professional role in isolation. As a result, they may not devote sufficient attention to how students must perform these roles in cross-functional teams to carry out the larger end-to-end business process—the product design and development process.

There are many promising starting points in developing a new approach for identifying and validating cross-functional business processes involved in innovation work. One potential starting point is exploring the methods now used to design and improve business processes in modern workplaces ranging from manufacturing to healthcare (e.g., Rummler and Brache, 1995). Another promising starting point is exploring the implications from research on team science (National Research Council, 2015a). A third starting point would be the approach taken by colleges and universities in developing interprofessional healthcare programs (Bridges et al., 2011). This research could provide stronger foundations for developing cross-functional and interdisciplinary programs and could provide templates and examples that employers and education partners could use in developing authentic student challenges and projects that may be appropriate for secondary and postsecondary education.

Employer Leadership in Organizing and Managing Talent Pipelines. Employers are now playing major roles in sponsoring student projects and challenges including those involving cross-functional interdisciplinary teams. As discussed earlier, there are many promising national, state and local initiatives that highlight the potential role that employers could play in promoting authentic cross-functional innovation work involving students from different disciplines and programs. However, more research is now needed on how employers can most effectively engage students in these projects and challenges as part of larger talent pipeline management strategies especially for middle-skill workers.

Employers many times have different objectives when sponsoring projects and challenges for students at different points in the talent pipeline. For example, employers working with middle-school and high school students may have the objective of expanding career awareness and engaging more students in STEM-related programs. At this stage, employer practices may be evaluated based on improvements in career attitudes and interests, academic achievement, and enrollment and performance in rigorous STEM programs.

In contrast, employers may sponsor projects and challenges for community college and university students to build cross-functional and interdisciplinary team skills and identify those students who are most qualified for more challenging projects and/or individual internships. For this stage, employer practices may be evaluated based on student on-boarding and advancement in the workplace including their performance in innovation teams. As a result, this research should identify and evaluate leading employers practices based these different strategies and objectives at different stages of the talent pipeline.

More research is also needed in how employers can most effectively balance depth and breadth in talent pipeline management. Typically employers are asked to participate on advisory groups and provide work-based learning opportunities (e.g., internships) for specific disciplines and programs at a high school, college or university. In addition to offering those types of experiences, employers and their industry and professional associations may sponsor challenges that are focused on specific programs such as business or engineering. And, they may also sponsor functional and interdisciplinary projects. More research is now needed on the how employers can most effectively manage their education partnerships to build better innovation talent pipelines. This research could inform national initiatives that are engaging employers in exploring more comprehensive talent pipeline management strategies such as the Talent Pipeline Management (TPM) initiative now being pilot-tested by the U.S. Chamber of Commerce Foundation (USCCF, 2014).

Leveraging Career Pathway and Credentialing Frameworks. As described earlier, national career cluster and pathway models and related sector models are organized around economic sectors and core businesses functions or processes and identify the most critical jobs involved in carrying them out. Some states, such as Illinois, have used these frameworks to plan and manage employer-sponsored innovation projects. As a result, they have the potential to be leveraged in developing a new approach for organizing and managing talent pipelines.

In addition, leading postsecondary credentialing frameworks and initiatives such as DQP and LEAP have emphasized the need for postsecondary students to perform signature projects and assignments that demonstrate the integration of knowledge and skills from multiple programs and disciplines. More research should be done to explore the outcomes of these promising frameworks and initiatives and, pending the results, how they can be scaled to address employer demand for well-prepared middle skill workers.

Managing Depth and Breadth in Secondary and Postsecondary Education. As discussed earlier, more research is needed on how secondary and postsecondary educational institutions can work with employers to provide students with the education and experience in cross-functional and interdisciplinary innovation work that benefit both employers and students. This will require more research at each stage of the talent pipeline and address both employer and student outcomes.

At the early stages of the talent pipeline, one potential starting point would be to extend current research into integrated STEM education (National Research Council, 2014). This research provides a useful framework for exploring the goals and outcomes of interdisciplinary learning experiences across STEM disciplines. These outcomes include career and education interest and engagement, academic attainment, college and career readiness, 21st century competencies (e.g., critical thinking, collaboration and teamwork), and high school persistence, graduation and transition. This research also provides a useful framework in exploring the nature and scope of integration and the implementation of these interdisciplinary learning experiences through different instructional approaches (e.g., project-based learning). It also provides a framework for addressing in-school and out-of-school contexts with different educator supports that may have an impact on these goals and outcomes (National Research Council, 2014).

For example, two major objectives of employers in the early stages of talent pipeline management is to spark interest in STEM careers and improve academic achievement, but there is currently not sufficient high-quality research to address how employers and educators can work together to achieve these outcomes. This research could be extended further from a broader innovation perspective as proposed in this paper by expanding the scope of integration beyond STEM disciplines to include the social sciences (e.g., behavioral economics) and final arts and humanities (e.g., design thinking) which are many times involved in cross-functional innovation work and have been addressed in leading examples of employer-sponsored innovation projects and challenges (e.g., Illinois Innovation Talent).

This research also could be extended to more closely focus on 21st century competencies (National Research Council 2012), integrated learning in both in-school and out-of-school environments (National Research Council 2015c), and the role of employers as mentors in interdisciplinary learning through employer-sponsored projects and challenges. Going further, this research could be extended to address the integration of academic and career and technical education and how to better leverage the career pathway frameworks now being used to promote school-wide integration in high schools and organize employer-sponsored projects and challenges as illustrated by Illinois Pathways. Finally, this research could be used to evaluate different approaches to the implementation of the Next Generation Science Standards (National Research Council, 2015b) and related math standards. This also could address the broader approach to innovation proposed in this paper that could integrate a wider spectrum of the high school curriculum (e.g., social sciences, fine arts, career and technical education).

There is also limited research at later stages of the talent pipeline where the focus is more on employer and student outcomes related to student transitions to work and how well students actually drive and support innovation work in the workplace. Although employers have worked with high schools, community colleges, and universities in sponsoring student projects and challenges, there has been limited research on whether these efforts have been effective in building innovation talent that is effective in driving and supporting innovation in the workplace. This research can build on current research into student project teams in engineering education (Burrego et al. 2013), interprofessional healthcare education (Bridges et al., 2011) and similar initiatives in other disciplines and programs including business education. This research also should begin to address cross-functional and interdisciplinary approaches that cross a wider array of business functions and disciplines (e.g., IIT Interprofessional Projects). In addition, it could focus more attention on the role of employers as mentors as well as the success of students in driving and supporting innovation in the workplace including the role of middle-skill workers.

Summary and Next Steps

This paper has explored the growing importance of innovation to global competitiveness and the race against routine work for American workers, including those in middle-skill jobs. It has highlighted the role of open, cross-functional teams in carrying out innovation work. This paper has also argued that innovation work in these open, cross-functional teams requires both depth and breadth in educational preparation. This challenges us to rethink not only what and how we teach, but how we organize and manage employer-education partnerships to provide more students with opportunities to participate in cross-functional and interdisciplinary team projects and challenges in ways that produce better outcomes for both employers and students. Lastly, this paper has highlighted some promising practices and the need for further research in exploring this new approach to talent pipeline management especially for middle-skill workers.

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