FUTURE SKILLS

Update and Literature Review

PREPARED FOR ACT FOUNDATION AND THE JOYCE FOUNDATION BY:

Devin Fidler

Institute for the Future

Edited by Susanna Williams

ACT FOUNDATION™

The Joyce Foundation

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INTRODUCTION

This report, *Future Skills Update and Literature Review* by Institute for the Future (IFTF), undertaken in partnership with ACT Foundation and Joyce Foundation, is an update to IFTF's ongoing exploration of the kinds of skills that will allow people to thrive in the future.

In 2010, IFTF authored a well-received report, Future Work Skills 2020. This work drew on the Institute's ongoing research and expert workshops to chart the most powerful drivers of change in the ways that we work, and the skills likely to become relatively more important as these changes take shape.

Since then, the issues pointed to in that report, including increased automation, shifts in the culture of work, and new organizational models, are becoming more urgent. The timing is right to revisit the issue of future work skills. In particular, collaboration with ACT Foundation has allowed us to look much more deeply into each of the skills that industry leaders have highlighted as increasingly important for the world ahead.

In the process, it has become very clear that these topics extend beyond just work. Indeed, the blurring of the skills necessary for work and for all the other aspects of life has been a key theme of this research. In this paper, we have sought to make it clear that both work skills and professionally useful skills gained outside of traditional employment matter.

This white paper is designed to deeply explore both the universe of future skills themselves, as well as the ways that they are currently taught and measured, in the hope that they can be more fully integrated into workforce training and evaluation. In particular, we have followed ACT Foundation's lead in connecting these skills to the National Network's Common Employability Skills, developed by a consortium of industry employers to highlight "a core set of fundamental skills that potential employees need in the workplace."

We first revisited the skills themselves. Through a review of work skill lists compiled by other organizations and internal workshops, we sought to validate the skills we had highlighted as important and the addition of ideas like "resilience".

Next, we undertook a comprehensive literature review for each of the skills outlined, systematically tagging both relevant background material and specific information about ways the skill is currently defined, taught, and measured. A parallel scan revealed commercial training and measurement products in each space.

The concise summaries of all of this information were reviewed by a total of eighteen experts, recruited from both industry and academia, with specific expertise in at least one of the skill areas. Finally, the insights from each of these reviewers was evaluated and folded into the report where appropriate.

The ways that we work and live are poised for substantial changes in the years ahead. Our hope is that this report can serve as a tool to help meet these emerging challenges head on, and to contribute to a better future for all of us.

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PERSONAL SKILLS

The National Network's Common Employability Skills framework defines Personal Skills as those that “demonstrate that the engaged employee is a striver and a role model.” These transversal skills include treating others with respect, demonstrating a willingness to work and seek out new challenges, exhibiting responsibility and adaptability, and demonstrating professionalism. In other words, resilience.

RESILIENCE

Thomas Edison is as famous for developing the first commercial incandescent light bulb, but he failed ten thousand times first. He didn’t give up, however. He continued to learn from his mistakes and worked the problem until he gave the world light.

Accelerated technological developments will increasingly pull us toward what IFTF futurist Bob Johansen describes as a “VUCA world”—an environment that is characterized by Volatility, Uncertainty, Complexity, and Ambiguity. As Edison demonstrated, however, difficult circumstances can serve as valuable experiences in service of growth and achieving goals. The way individuals react to adverse situations will greatly affect both their future success as well as the success of their organization. The ability to competently overcome setbacks, challenges, and other obstacles is called “resilience” and it is important to cultivate at both the individual and organizational level.

Resilience is a foundational quality for future workers. As companies undergo increasingly rapid changes, resilience will become essential to employees and organizations. Currently, workers are expected to acquire new skills, assume extra responsibilities, and accomplish more with limited resources. Some may not cope well with the additional stress associated with new expectations, while others appear to not only adapt but thrive in these conditions. Being able to respond positively to constantly evolving challenges will help people succeed in any workplace environment.

PERSONAL SKILLS
RESILIENCE

BACKGROUND AND DEFINITIONS

Psychologists originally categorized resilience as a stable personality trait where those with higher reported rates typically possessed "a greater ability to dynamically and appropriately self-regulate themselves than individuals with low trait resilience.[1] " In the context of a stressful or traumatic situation, this means that highly resilient individuals maintain positive emotions and, in some cases, can actually thrive in the face of crises. Resilient people also tend to demonstrate more flexibility with change, more stability in demanding situations, and less aversion to risk than their non-resilient counterparts.[2]

More recently, researchers in organizational studies, human resources management, and engineering have adopted and expanded on this psychological construct in the workplace.[3] Studies looking at entrepreneurs suggest that resilience is more than a stable personality trait; it is also a dynamic process in which individuals capitalize on the resources around them in pursuit of a long-term goal or other positive outcome.[4] This ability to marshal and implement resources in adverse situations has important implications for both individual employees and the companies for which they work. For example, resilience-training research conducted with the United States Army taught soldiers to focus on positive outcomes and promote optimism during times of great difficulty, and resulted in better communication, more successful missions, and improved performance over time.[5] Seligman and his colleagues suggest that the results of this study can be successfully applied to organizations to improve individual and team propensities to actively thwart failure.

It is important to remember that resilience is composed of many different factors (grit, hardiness, self-efficacy, etc.) and operates along a sliding scale. Individual fluctuations in resilience often depend on available internal and external resources. Since internal resources are independent and not as easy to control, companies would benefit from both increasing access to external resources and making sure that these resources are equally distributed. In addition, resilience may not present itself in each individual uniformly. Some people may demonstrate a form of "hidden resilience" that does not conform to dominant cultural understanding. Regardless of the way they manifest, all forms of resilience are helpful.

ACQUISITION AND DEVELOPMENT

Observational learning emphasizes modeling the behavior of resilient individuals through mentorship programs, team exercises, and group assessment.[6] Resilience emerges from day-to-day interactions but it can also be taught over time through business development training programs, like Master Resilience Training.[7] Originally developed to help drill sergeants foster more productive military units, Master Resilience Training focuses on "enhancing mental toughness, highlighting and honing strengths, and fostering strong relationships—core competencies for any successful manager. "[8]

Resilience can also be acquired by enhancing specific psychological traits that are associated with developing and maintaining the skill. In particular, a new line of research has started to examine the connection between entrepreneurial resilience and "grit," or perseverance and passion for long-term goals.[9] While grit and resilience share some overlapping qualities, like the ability to persist in the face of adversity, the presence of grit in an individual does not necessitate a stressful situation. This makes it easier to develop more stable traits that influence resilience across different contexts. Therefore, training programs that also emphasize other traits like grit,[10] hardiness,[11] and entrepreneurial self-efficacy[12] can greatly contribute to increased resilience in the workplace.

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1. Loh & Dahesihsari, 2013, p.109
2. Fredrickson, Tugade, Waugh, & Larkin, 2003
3. Tierney, 2003; Weick, Sutcliffe & Obstfeld, 1999
4. Hedner, Abruzecden, & Klofsten, 2011
5. Seligman, 2011
6. Bandura, 1977; McMillen, 1999
7. Sutcliff & Vogus, 2003
8. Seligman, 2011, p. 105
9. Duckworth, Peterson, Matthews, & Kelly, 2007
10. Duckworth et al., 2007
11. Maddi, Matthews, Kelly, Villarreal, & White, 2012
12. Bullough, Renko, & Myatt, 2013

ASSESSMENT AND EVALUATION

Several reliable instruments have been designed to assess resilience, grit, and hardiness based on qualitative, quantitative, performance, and self-assessed measures. There is also a deep field of research on entrepreneurial self-efficacy, that being an individual's belief in his or her ability to take entrepreneurial actions based on his or her managerial, functional and technical skills; however, there are not standard evaluations of this suite of competencies. There are several widely employed measures of resilience including:

1. **The Connor-Davidson Resilience Scale** is a valid self-report measure that assesses resilience and hardiness. The tools have been administered globally and across a range of populations, including community samples, survivors of various traumas, members of different ethnic groups and cultures, and professional groups.[13]

2. **The Brief Resilience Scale** is a six-question self-reported questionnaire that measures an individual's ability to "bounce back" or recover from stress. It has been shown to predict coping, social relationships, health and well-being across samples.[14]

3. **The Resilience Scale** for Adults was designed to capture a set protective of factors that shape individual resilience in the face of stress and adversity. Intended for use among youths and adults across a variety of settings, its creators say it helps participants identify resilience as an individual capacity that makes it possible to respond in a positive way to whatever life brings.[15]

4. **The Grit Scale**, designed by MacArthur "Genius" Award winner and founder of the Character Lab Angela Duckworth, is a self-assessment designed to measure an individual's ability to pursue goals or stick with challenging tasks over time. It has been used in both student and adult populations.

13. Connors & Davidson, 2003
14. Smith, Dalen, Wiggins, Tooley, Christopher, & Bernard, 2008
15. Friborg, Barlaug, Martinussen, Rosenvinge, & Hjemdal, 2005

PEOPLE SKILLS

Within the National Network's Common Employability Skills framework, People Skills demonstrate that "the engaged employee is a team player." These skills center on a worker's ability to work effectively with others, to maintain open lines of communication, and to work effectively with other people who have diverse backgrounds.

CROSS-CULTURAL COMPETENCY

In a globally connected world, cultural agility is a prized attribute, allowing workers to operate effectively across a broad range of environments and to quickly switch between contexts. Workers may find themselves shifting between teams and projects or engaged in tasks across multiple countries. Cross-cultural competency requires not only specific content knowledge, such as language skills, but also adaptability to changing circumstances and an ability to sense and respond to new contexts.

On an institutional level, diversity is a driver of innovation. Research shows that one of the key characteristics of a truly creative and innovative team is variety—the combination of different ages, skills, disciplines, and working- and thinking-styles that members bring to the table. Scott E. Page, professor and director of the Center of the Study of Complex Systems at the University of Michigan, has demonstrated that groups displaying a range of perspectives and skill levels outperform like-minded experts. He concludes, "progress depends as much on our collective differences as it does on our individual IQ scores."

At the same time, collaborative and teleworking technologies are connecting diverse workers around the world, and multinational organizations often assemble teams of employees from different continents. Moving forward, this kind of global teamwork will become a larger part of everyday life, particularly as real-time translation software for both spoken and written communications reach maturity. In many cases, people will even build their own personal teams of assistants, coaches, tutors, and mentors from across different cultural and social settings.

Over time, global flows of information and people will fundamentally reshape the experience of work. These flows will result in new work teams and styles based on new interactions between people of different origin and heritage, as well as life stages, levels of engagement, and perspectives. Employers will need to reset their expectations for addressing differences among people and develop new skills for understanding and responding to these differences.

Managing culture and diversity will therefore become a core competency for organizations over the next decade. Successful employees within these diverse teams need to be able to identify and communicate points of connection (shared goals, priorities, values) that transcend their differences and allow them to build relationships and work effectively.

PEOPLE SKILLS
CROSS-CULTURAL COMPETENCY

BACKGROUND AND DEFINITIONS

In recent decades, the concept of intercultural or cross-cultural competency has received increased attention because of its significance in global workforce development. Very simply, intercultural competence is the ability to understand and then effectively perform, communicate, and engage with others in a different cultural context.[16]

A number of processes are at work in cross-cultural exchange, however research stresses four main components that can be used to evaluate an individual's intercultural competence:[17] a knowledge component (the level of cultural knowledge an individual has about another person); an affective component (emotional aspects of an individual in that particular cultural setting); a psychomotor component (an individual's physical ability to appropriately communicate verbally and nonverbally); and a situational component (the setting in which cross-cultural communication takes place). Importantly, findings from recent studies on intercultural competence acquisition demonstrate that mere exposure to other ways of life does not significantly predict the perceived level of intercultural competence. In other words, spending time in a foreign culture does not equate to intercultural sensitivity, Instead, researchers maintain that cross-cultural competency must be learned through practice and training.[18]

The term ***intercultural communication*** generally refers to communication between individuals of different national origins. Researchers generally define a culture as a learned system of values, norms, symbols (including language), and beliefs shared by members of that culture. Accordingly, group membership is marked by internalization of the group's generally accepted values, norms, symbols, and beliefs.

By contrast, the term ***diversity*** generally refers to differences in belief systems, thinking and information processing styles, physical characteristics, and personal preferences, as well as differences in national origin. Smaller groups of people who share values, norms, symbols, and beliefs can be said to construct diverse ***co-cultures,*** around such identifying features as gender, sexual orientation, religion, and political ideology.

Developing cross-cultural competency rests in part on achieving a balance in how individuals navigate diverse social and cultural contexts. We often run the risk of either presuming extreme difference or likeness. A central challenge is to preserve the fact that there are many ways of viewing the world without denying certain elements held in common. Therefore, we must first understand that differences exist and then work towards building a common foundation to adequately communicate cross-culturally. Finally, cross-cultural competency should strive to assess and represent both the universal and the culture-specific aspects of how individuals conceptualize the world. By striving to account for this array of perspectives, we will be better able to acknowledge cultural differences while also attending to shared experiences.

16. Abbe, Gulick, & Herman, 2008; McDonald, McGuire, Johnston, Semelski, & Abbe, 2008; Selmeski, 2009
17. Spitzberg & Cupach, 1984
18. Liu, 2014

PEOPLE SKILLS
CROSS-CULTURAL COMPETENCY

ACQUISITION AND DEVELOPMENT

Experiential learning activities and other training can help to develop critical intercultural competency skills.[19] Often, this involves encouraging certain traits such as respect, empathy, patience, openness, motivation, tolerance, and curiosity.[20] However, learning to successfully perceive and express oneself in a cross-culturally competent manner also requires being able to interpret a situation accurately and act accordingly.

Addressing this need, Dr. Tabitha Hart of San Jose State University maintains that the tools of ethnography are useful to building intercultural sensitivity. This training, though time-consuming, has broad applications that workers can apply across companies and cultures. According to Dr. Hart, this approach to building intercultural sensitivity, as opposed to learning about specific cultural norms, runs minimal risk of introducing misinformation or stereotypes.

Several different types of training materials currently exist that can help design intercultural programs and activities. These include but are not limited to: the Experiential Learning Cycle;[21] fifty cultural and intercultural activities;[22] activities for intercultural learning;[23] and cross-cultural training methods.[24] In addition, the recently published book ***Cross Cultural Competence: A Field Guide for Developing Global Leaders and Managers***[25] includes a section designed to help instructors assess, develop, and foster intercultural competence.

ASSESSMENT AND EVALUATION

Tools that assess cross-cultural competency look to how well an individual engages with people who are culturally different in terms of national affiliation, ethnic background, religious affiliation, generation, and gender identity, among other characteristics. Several instruments have been designed to assess these competencies based on qualitative, quantitative, performance, and self-assessed measures, including:

1. **The Intercultural Development Inventory** assesses the ability to shift cultural perspectives and adapt behavior according to cultural differences and commonalities. This validated measure can be customized for use in different demographics in both educational and other organizational settings. The results of individual evaluations can be applied toward creating tailored Intercultural Development Plans, which provide a blueprint for developing greater intercultural competence through learning opportunities, such as coaching, workplace activities, site visits, and interpersonal interactions.
2. **The Intercultural Effectiveness Scale**, developed by the Kozai Group at the Intercultural Communication Institute, evaluates competencies for effective interaction with people from different cultures across three dimensions: continuous learning, interpersonal engagement, and hardiness. The tool was designed for use by nonprofit organizations, government agencies and educational institutions to aid with human resources management, accreditation, diversity trainings, and global communication.
3. **The Global Competencies Inventory**, also developed by the Kozai Group, measures leadership competencies of corporate managers and global professionals across three categories of cross-cultural engagement: perception, management, relationship management, and self-management. This tool, which assesses discrete skills, such as tolerance of ambiguity, social flexibility, emotional sensitivity, and self-identity, has been used as part of hiring and promotion screenings, diversity courses, and executive coaching curricula.
4. **The Cross-Cultural Competence Inventory**, developed by the Cognitive Performance Group, assesses competencies of military personnel. Specifically, it was designed to assist commanders in evaluating the readiness of their troops to interact effectively with foreign nationals, multi-national forces, and other agencies. The self-report instrument measures six dimensions: willingness to engage, cognitive flexibility and openness, emotional regulation, tolerance for uncertainty, self-efficacy, and ethno-cultural empathy.

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19. Eisenberg et al., 2013
20. See e.g., Kealey 1990, p. 5; Kohls 1979
21. Kolb, 1984
22. Fantini, 1997
23. Seelye, 1996
24. Fowler & Mumford, 1999
25. Dolan and Kawamura, 2015

PEOPLE SKILLS
SOCIAL INTELLIGENCE

The emergence of a multi-billion-dollar social technologies industry over the past decade has given rise to many questions about how we understand, relate, and connect to one another.

At the most basic level, the mainstreaming of social platforms—Facebook, LinkedIn, and Twitter among others—has encouraged people to think in new ways about how they create and sustain relationships. Some recent studies[26] suggest that while social networks have provided people with many more connections, they foster fewer deep friendships. Additional questions have emerged regarding the ability of young people to develop and maintain face-to-face social skills during critical periods of social development when so many of their interactions are mediated through social platforms. Moving forward, social intelligence will be a critical skill both for managing relationships and adapting to new kinds of workplace organizations, including both off-line and online contexts.

New forms of digital labor, like micro-work and crowdsourcing, demand that people quickly establish rapport with distributed teams, frequently composed of colleagues they will never actually meet in person. The emergence of online labor platforms like UpWork, a site that matches virtual workers to online jobs and facilitates virtual management, are early indicators of a distributed approach to workplace organization that will almost certainly become far more common in the future. Those with greater social intelligence will likely have much better luck in connecting to opportunities. Along these lines, some have speculated that future work tasks might resemble film production projects, with a wide variety of uniquely qualified people coming together for a job and then dispersing after its completion. In a world where "fit" is often a primary criterion for competitive job selection, social intelligence becomes more important than ever.

While developing social intelligence is important for online success, it is also critical to success in the traditional sense. In face-to-face interactions, social intelligence is an increasingly important skill, informed by our growing understandings of human behavior, including the profit-margin implications of how well staff are treated. Conversely, lack of social intelligence is becoming less tolerable, especially in key supervisory positions.

Importantly, social intelligence will need to extend to international cultures and situations (see section on Cross-Cultural Competency for more on this subject). Trends in distributed work have followed a sharp increase in the number of multinational teams and projects that the average worker engages with throughout his or her career, and more flexible approaches will ensure that extremely diverse teams work at an individual, rather than unit, level. In this environment, the ability to connect across potential cultural differences will not only be a key factor organizational efficiency, but also as a basic component of a successful career and pleasant work environment.

Ultimately, social intelligence may become a widely recognized competitive advantage. As a growing number of rote tasks become automated, social intelligence is likely to remain a relative strength of human workers. With robotics and smart machines assuming a more central role in future work and production, we may see new emphasis on tasks that involve the interpersonal skills unique to humans. Forecaster Ian Pearson has speculated that this could take the shape of a "care economy," where social intelligence becomes central to the roles humans play in economies in general.

In the context of social technologies, more flexible work teams, and increasing automation, interpersonal skills and intelligence are poised to play an ever greater role in the ways we work.

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26. See: Turkle, 2012

PEOPLE SKILLS
SOCIAL INTELLIGENCE

BACKGROUND AND DEFINITIONS

Early research in management performance demonstrated that three clusters of competencies emerge during team interactions: emotional intelligence, cognitive intelligence, and social intelligence.[27] Social intelligence is often defined as "a keen awareness of the value of social connections, the ability to take another's perspective, and the capacity to engage in satisfying relationships".[28] It is similar to social competence in many respects,[29] but differs in that it hinges upon the ability to foster meaningful relationships with others.[30] Importantly, researchers tend to view social intelligence as a variable, rather than a fixed, cognitive ability, noting that it is not the quantity but the kind of social intelligence that matters.

Social intelligence manifests at the social and biological level. With respect to the first, modeling appropriate behavior in hypothetical situations can facilitate the development of social intelligence. At a popular level, the work of psychologist Daniel Goleman has been very influential in this space, and he has been involved in investigations into the biological underpinnings of interpersonal behavior suggesting that a certain class of brain cells called "mirror neurons" may facilitate social relationships by activating neural pathways when we interact with others.[31] This means that we may inherently possess the ability to empathize with and understand other people, making it is easy to develop social skills through proper training.

Social intelligence can be developed through independent coursework like Massive Online Open Courses (MOOCs), as well as through the tools mentioned above. Courses and coaching on politeness, giving and receiving constructive criticism, interpreting nonverbal communication cues, and general interpersonal communication have been successfully applied to developing aspects of social intelligence.

Social intelligence is closely bound to cultural norms, and therefore it is important to take cross-cultural differences into account when assessing and promoting the development of this skill. It could be very useful to compare results from different scales or adapting scales to cross-cultural contexts for more accurate results.[32]

ACQUISITION AND DEVELOPMENT

Training programs have been shown to be effective in the development and acquisition of social intelligence. For example, a recent study of an online curriculum in social intelligence found that the program increased the capacity for subjects to develop and maintain positive relationships with others.[33] Other studies suggest that social intelligence programs can help people pay more attention to others' emotions, have a greater ability to take the perspective of another, and report more self-efficacy in social situations.[34] While these programs utilize a variety of different techniques for developing social intelligence, they all emphasize that practicing these skills continuously across varying contexts is the most effective route to changing behavior.

27. Boyatzis, 1982
28. Zautra, Zautra, Gallardo, & Velasco, 2015 p. 2
29. Snow, 2010
30. Zautra, Infurna, & Zautra, n.p.
31. Goleman & Boyatzis, 2008
32. Gini, 2006
33. Zautra et al., 2015
34. Walton, 2014

ASSESSMENT AND EVALUATION

Measures of social intelligence typically assess how well an individual can understand and interact with others. To offset the potential limitations of self-assessment, evaluations can include other approaches, such as recording and analyzing interactions. Several recognized tools currently exist for evaluating social intelligence, including:

1. **The Social Skills Inventory** assesses verbal and non-verbal communication skills as they relate overall social competence. The validated scale is used in counseling contexts, as well as for management and leadership training, and measures the domains of emotional and social expressivity, sensitivity, and control.

2. **The Tromsø Social Intelligence Scale** was designed to overcome limitations in existing measures, namely self-report bias and inconsistency in the definition of social intelligence. The tool evaluates three central domains: social information processing, that is the ability to understand and predict other peoples' behaviors and feelings; social skills, including the ability to enter new social situations and social adaptation; and social awareness. The instrument focuses on assessing eight subscales of social intelligence: patience, cooperativeness, confidence, sensitivity, recognition of social environment, tactfulness, sense of humor, and memory.

3. **The Social and Emotional Intelligence Profile**, developed by the Institute for Social and Emotional Intelligence, is a validated instrument intended to identify an individual's social strengths and opportunities for development. Different formats have been developed for youth and adults, though it is most widely used in workplace settings, and in addition to self-report includes a 360-degree assessment of the individual. The instrument measures four modes across personal and social competencies: self-awareness, self-management, other awareness, and relationship management.

35. Riggio, 1989
36. Silvera, Martinussen & Dahl, 2001

PEOPLE SKILLS
VIRTUAL COLLABORATION

Distance work will grow in prominence in the next decade due to technologies that make it easier to share content from any location, more flexible work schedules to compensate for the demands of family life, and the growing awareness that traditional office environments do not usually offer the extended blocks of uninterrupted time necessary to complete knowledge-based tasks. Of even greater importance is that the very nature of work is changing. Work is being divided into micro-tasks that call for specialists, who can be based anywhere. The business world is capitalizing on this trend by eliminating some or all types of traditional office space—a trend that is increasingly common in Fortune 500 companies. At IBM, for example, approximately 40 percent of employees have no fixed office space, saving the company an estimated $100 million per year in overhead costs.

As with many social and business trends, the move toward virtual work brings challenges as well as opportunities. It offers flexibility in combining home and work tasks and saves commuting time and costs, but it also requires a new set of competencies.

First, remote collaborators will need to demonstrate a certain level of comfort with this arrangement in order for it to be successful. Numerous tools exist to facilitate remote collaboration, and more enter the marketplace all the time. There are instant message services, shareable virtual white boards, Google docs, and screencasting software that enables sharing screen contents virtually. A challenge for remote workers, however, will be in demonstrating and signaling presence. Some approaches to this include micro-blogging platforms that enable workers to share their current projects and keep colleagues advised of their availability. Web-based platforms now allow colleagues to create a virtual office on their screen. One example is TeamSpace, by Sonoco, which gives each worker an avatar and an office space that colleagues can "visit" throughout the day. There are also virtual conference rooms and kitchens for social moments. In these ways and others, virtual workers can create a sense of presence with their colleagues.

Some remote workers will look for ways to create a more embodied sense of presence in the office space. Telepresence robots are remote controlled, Wi-Fi enabled devices equipped with a screen, camera, and microphone. They can represent workers in an office space, allowing them to check in on colleagues, attend meetings, and have chance encounters and conversations that are usually excluded from the virtual work environment. Telepresence robots are still expensive, but their price is beginning to decrease to within reach for small and medium-sized businesses.

While one challenge of remote working is social isolation, virtual platforms can simulate a sense of ambient sociability. Researchers at Stanford's Virtual Human Interaction Lab examine the real-world social benefits of inhabiting virtual worlds such as Second Life. These researchers report that the collective experience of a virtual environment, especially one with 3D avatars, provides significant social-emotional benefits.

However, finding a forum for "real-world" interactions will become increasingly important for the growing band of digital nomads. One possibility is co-working spaces, where virtual workers gather to work in the same space, which offers something between the isolation of a home office and the public nature of a coffee shop. These spaces provide facilities, IT support, meeting rooms, and opportunities for developing a broad professional network. They also provide a social work environment, while at the same time helping workers maintain some of the structure of a working day. Co-working spaces are quickly becoming a familiar part of work culture, and are often be considered as preferable to traditional offices.

Managing virtual teams brings its own set of challenges. A company's physical space provides a work environment and offers a strong demonstration of its culture and values. Absent this physical space, managers will need to find ways of developing a sense of corporate culture.

PEOPLE SKILLS
VIRTUAL COLLABORATION

BACKGROUND AND DEFINITIONS

Virtual collaboration exists across space and time through both synchronous and asynchronous communication formats.[37] Synchronous communication occurs in real time and often resembles a face-to-face conversation. For example, instant messaging and video chats are examples of synchronous communication where individuals respond as if they were physically present. By contrast, asynchronous communication does not occur in real time; examples here are email and text messaging.

In both of these formats (and especially so for asynchronous communication), virtual collaboration provides the unique feature of reflection. In face-to-face interactions, responses are typically offered or demanded immediately due to proximity in an office space. In these situations, employees feel compelled to provide knee-jerk responses, and therefore might not reflect deeply enough for a more nuanced or thoughtful statement. By contrast, in an online environment, there is a helpful time differential for interactions, especially with text-based interactions. The time allowed for reflection is a tremendous benefit for employees in general but particularly for those working in team settings, because it gives team members ample time to craft a carefully-considered response. In addition, reflection gives individuals time to confirm facts, look up alternatives, and provide thoughtful, in-depth responses. The benefits of reflection also extend to shy individuals, those not proficient in the dominant workplace language, and global teams.[38] For example, in a recent study of virtual collaboration preferences, participants reported using different types of technology for different tasks. They preferred a less personal technology, like e-mail or discussion board, to establish initial contact and exchange personal information, but favored audio/video conferencing for making important decisions because it allowed for immediate feedback and real-time discussions.[39]

Virtual collaboration can also offer insights into team interactions through the power of data analytics. By using digital communication, companies are able to first record the types of interactions that occur between their employees and then ultimately assess these interactions to improve future collaborations. One can evaluate variables such as the number of participants, the length of interaction, time needed for an individual to study or read a particular document, etc. Analysis of these social interactions can help organizations better understand how their teams operate, what constraints hinder collaboration, and how to better facilitate future team collaborations.

Intercultural communication competence will likely play a large role in the success of virtual groups, since they may be more likely to have multinational members working from their home countries, and are almost certain to contain demographic diversity.

Sense-making, the ability to create unique insights that are critical to decision-making, will also be impacted by virtual collaboration. Not only can intercultural components complicate sense-making, but the nature of virtual communication sometimes requires more sense-making skills than traditional modes of communication. Social intelligence takes on a whole new meaning in the virtual world, where communications can easily be shorn of politeness and misconstrued. Certainly, new media literacy plays a bit of a role in virtual collaboration, at least in terms of properly using the technological tools.

Finally, virtual collaboration offers a way to return to the skill of writing. According to some researchers,[40] the written word has far more benefits in the corporate world than people currently allow. Corporations are driven by text-based interactions, which are a very powerful resource for providing institutions with written documentation of what people think. Writing is an oft-neglected key element in collaboration and should to be addressed as a positive function for team success. In face-to-face interactions, individuals can easily forget their thoughts and ideas. However, in collaborations that depend on texts (in the form of email and other writing), workers are able to capture everything from a fleeting idea to a well-constructed solution. Having all of this written data available provides the team with a tremendous wealth of information that they can analyze and return to in future discussions.

37. Karpova et al, 2009
38. Ubell, 2015
39. Karpova & Baran, 2009
40. Ubell, n.p

PEOPLE SKILLS
VIRTUAL COLLABORATION

ACQUISITION AND DEVELOPMENT

Many companies are recognizing the immense value of social software systems, such as virtual-worlds and internal communications networks. As a result, organizations like Google and Microsoft have made substantial investments in better understanding the dynamics of virtual collaboration through systems like Skype and Google Office. These tools offer tremendous opportunities, allowing companies to take advantage of the diverse knowledge and intelligence of their members and business associates, thus enabling them to respond more effectively within increasingly competitive markets.[41]

In addition to looking at the types of tools popularly employed in the virtual collaboration context, the topic of leadership in virtual groups has captured the attention of some researchers. A study investigating what contributes to the success of virtual learning teams looked specifically at the issue of leadership and found that diversified leadership roles influences both leadership effectiveness and team trust.[42] Another study examined how leaders emerge in a virtual context, and reported that the structure of a social network is a significant predictor of a person being perceived as a leader by other virtual collaborators. The results show that the most effective leaders are those who primarily assume a mediating role rather than directing or monitoring roles during virtual collaborations.[43]

ASSESSMENT AND EVALUATION

While there are measures of skills related to virtual collaboration, such as teamwork, group communication, and decision-making, there are not standard approaches to evaluating virtual collaboration as a discrete set of capabilities. In a related body of research from the field of education, experts stress that evaluations of collaborations should be ongoing, rather than static in time, as dynamics between colleagues, contractors or students can shift with changing goals and challenges. Also, drawing from education, researchers note the importance of evaluating collaborations according to workload distribution and the balance of contributors' relative strengths. Project management is a key skill, as the success of a particular collaborative effort can be measured by how tasks are distributed and goals are set. It is important to note that each organization needs to set its own benchmark for success, whether it is solid team collaboration, efficiency, or financial success, and determine how well they are achieving established objectives.

41. Sutanto et al, 2011
42. Chen et al, 2008
43. Sutanto et al, 2011

APPLIED KNOWLEDGE

Within the National Network's Common Employability Skills framework, Applied Knowledge Skills are those that demonstrate that "the engaged employee can logically analyze information in order to inform conclusions." This skill set includes a range of abilities including understanding written documents, clear written communication, mathematical literacy, ability to use both the scientific method and information technologies, to critical thinking and analysis. Indeed, many of the emerging skills we have focused on here have particularly strong roots in this kind of analytical thinking.

NOVEL AND ADAPTIVE THINKING

In a world of increasing global connectivity, market competition, and automation, a premium will exist for skills that facilitate quick and adaptive responses to unfamiliar circumstances.

As everyone and everything becomes more connected, the result is not just that we can do things faster, cheaper, or better. Rather, it is that the whole system becomes highly unpredictable—a change in one node will resonate throughout the whole. As the labor market continues to be defined by volatility, unpredictability, and complexity, workers will be even more frequently called upon to respond to novel and unexpected situations.

At the same time, smart machines will soon largely displace humans from tasks that are repetitive and mechanistic—tasks in which humans imitate machines and tasks that aim for scale and consistency of production. This will be true not just for manual manufacturing labor but also for white-collar and service work aimed at achieving grand scale. For tasks ranging from hammering nails on an assembly line to repeatedly answering the same question, humans simply will not have a competitive advantage over machines.

We have already come to accept machines in factories and on assembly lines, where they have taken over many manual tasks. But increasingly, we will rely on machines to perform repetitive white-collar jobs including language instruction or phone sales. For example, thousands of robots are already entering Korean schools to assist with language instruction. Similarly, within the health field assistive paramedical devices will become increasingly common, like the MIT-Manus robotic system, which assists with stroke rehabilitation by helping patients move their arms 800 to 1,000 times in a 45-minute session (compared with 60 to 80 times with a physical therapist).

Because insight, creativity, and adaptability are not easily automated skills, workers of the future will need to cultivate these traits to be successful in an increasingly mechanized environment.

APPLIED KNOWLEDGE
NOVEL AND ADAPTIVE THINKING

BACKGROUND AND DEFINITIONS

With the introduction of more technological instruments, software, and other programs into the workforce, tasks have become increasingly cognitive and less physical for humans. In addition, these cognitive tasks often require more than the work of an individual, and rely instead on whole teams to complete an assignment. At the same time, as individuals become progressively specialized, their expertise often does not extend beyond disciplinary or domain boundaries. Given these and other constraints, the novel and adaptive thinking skills used by teams and even human-synthetic teams will become increasingly important for the workplace.[44]

One adaptive thinking style that will be useful for humans interacting with robots, smart machines, and other forms of technology is "interactive team cognition."[45] Interactive team cognition, also referred to as collective cognition, posits that teams are dynamic systems where cognition emerges through interactions among team members as they coordinate and execute a task.[46] Cognition in a team situation is not the sum of the knowledge or capabilities across the individual team members but rather the result of the interactions between them and how they perform in the task environment.[47] Interactive team cognition has largely been examined through human-synthetic (computer) interactions.[48] These investigations have demonstrated how thinking as a team—even with technology serving as a team member—can improve communication and project efficiency in ways that cannot be replicated in purely technological programs.

ACQUISITION AND DEVELOPMENT

There are several different methods for acquiring and developing novel types of thinking like team cognition. One approach is concept mapping, which works by graphically representing cognition across team members. Participants are asked to select items related to a certain task and structure them hierarchically to develop a kind of spatial map.[49] Results from the mapping show how much knowledge overlaps between team members. Other types of pattern matching techniques have also been shown to reliably highlight which concepts or thinking that teams share and which areas lack communication. For example, shared network analysis explores how relational ties between team members impact the speed and proficiency of communication across an organizational network.[50] Regardless of the approach, it is important to keep in mind that all forms of development for novel and adaptive thinking skills follow an experience-based model rather than just individual knowledge acquisition. By focusing on this skill as a coordinated process, one is able to observe how team interactions at the individual level take place and change over time.

ASSESSMENT AND EVALUATION

Insofar as novel and adaptive thinking skills pertain to group interactions, evaluations of dynamic processes - that being how a team collectively develops and refines an idea—can provide more accurate information than retrospective accounts. Therefore, it is important to assess the group as a whole as it operates in real time.[51] Equally important is the inclusion of both group- and individual-level feedback, as individual perceptions may vary significantly.

There are a number of different approaches to evaluating group-level thinking and problem solving. "Team effectiveness" assessments look at performance process outcomes relative to a pre-determined set of criteria.[52] The "local shared mental model" approach evaluates an individual team member's thought processes as he or she interacts with others in the group.[53] Finally, there is "learning flexibility" or "protobation training," whereby team members increase their range of thinking and adaptability as they exercise certain cognitive skills in unique ways. Unlike shared mental models, this training process is intended to disrupt prior associations and thus encourage individuals to learn new adaptive skills.[54]

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44. Cooke et al., 2015
45. Cooke, Salas, Kiekel, & Bell, 2004
46. Cooke & Gorman, 2009
47. Latane, Williams, & Harkins, 1979
48. Cooke et al., 2013
49. Marks et al., 2000
50. Sorensen & Stanton, 2011
51. Cooke et al., 2013
52. Hackman, 1987
53. Hung, 2013
54. Gorman et al., 2012

APPLIED KNOWLEDGE
COGNITIVE LOAD MANAGEMENT

Today's world requires processing an unprecedented amount of data in our everyday lives. The ability to skillfully manage one's cognitive capacity becomes especially important as information from people, objects, and other sources continue to increase daily. Managing this tremendous amount of data so that it creates assets, rather than obstacles, will require workers to develop relevant practices and tools.

First, workers must learn to deal with the current information input fostered by the "culture of interruption" from sources like phone calls, e-mails, instant messages, text messages, tweets, RSS feeds, and other forms of distraction. Research demonstrates that information workers now switch tasks every three minutes on average throughout the day. As we learn how information overload intrudes on the focus required of many mental tasks, organizations and individuals will look for ways to reduce these distractions. Several tools are now available to help individuals stay productive in these kinds of cognitively overwhelming environments. For example, RescueTime offers a suite of applications that can block certain computer programs or websites for limited periods of time, offering a designated reprieve from workplace distractions. It can also monitor your working style, creating reports on how much time you spend on different applications, such as e-mail, throughout the week. Being able to visually quantify how alerts, messages, emails, and other sources contribute to cognitive overload will help workers to better allocate their time throughout the day.

Moreover, this sort of filtering will soon occur seamlessly, as our devices become so smart that they can measure our cognitive load and react accordingly. For example, researchers at Tufts University are prototyping brain computer interfaces to measure the levels of attention and emotional arousal evident in stockbrokers as they watch streams of financial data. The prototype also has an internal monitoring system: when the stockbrokers get overwhelmed by other tasks, the system recognizes this and simplifies the data presentation. Automated systems that monitor our exposure to information will become essential, certainly in high-pressure jobs, but also in all information occupations as cognitive overload becomes common to work and home life.

At the level of output, learning how to manage data will also help to streamline how information is packaged and disseminated. To deal effectively with the onslaught of data, workers will need to devise strategies to quickly extract and convey meaning to team members, managers, and clients. Visual representations of data, such as infographics, can help people communicate complex ideas in a clear, concise, and aesthetically engaging way. Recognizing the immense potential in quality visuals, online platforms such as Venngage and Visually allow people with no specialized skills to create compelling visualizations and highlight connections that might otherwise be overlooked in large data sets.

APPLIED KNOWLEGE
COGNITIVE LOAD MANAGEMENT

ACADEMIC BACKGROUND AND DEFINITIONS

Cognitive load theory (CLT) was first introduced by Miller (1956) to analyze and address the limitations of an individual's working memory when faced with processing vast amounts of information. Over the years, many researchers have expanded upon Miller's original formulation in order to examine the effects of attentional control[55] and multitasking[56] on cognitive load processes in the workplace.

Attentional control, also referred to as selective attention, is an individual's ability to choose what they do and do not pay attention to in any given context. In order to reach goals, people must actively select and focus on relevant information while simultaneously ignoring irrelevant information.[57] This may appear to be a relatively simple task—just pay attention to the stuff that matters—but attentional control is an active process that requires the constant use of one's working memory to filter, manage, and process high streams of information. Over time, and with increased amounts of data, input, distractors, and other factors, even the most cognitively diligent of workers will start to experience the pressure of such a high cognitive load and start to process irrelevant information. Thus ultimately leads to decreased performance rates and slower response times throughout the workday, and even leaving some to experience a "cognitive fog".

The ability to properly manage one's cognitive load is further compounded by the pervasive reliance on multitasking. Often referred to as task-switching in psychology and the new field of "interruption science", multitasking is a type of executive cognitive function that allows an individual to flexibly move from one task to another.[58] Like most psychological phenomena, multitasking comprises both positive and negative effects. On the one hand, research has demonstrated that high media multitaskers—individuals that use two or more types of media simultaneously—perform significantly better at tasks that integrate information from multiple sensory modalities than low media multitaskers.[59] Overall, however, current studies overwhelmingly indicate that multitasking, and media multitasking in particular, decreases performance,[60] interferes with socioemotional functioning[61] and, perhaps surprisingly, decreases the ability to effective switch tasks.[62] Given these and other severe consequences of high cognitive load, whether it be due to low attentional control or high media multitasking, it will be important for future workers to learn how to reduce the demand on their cognitive load.

ACQUISITION AND DEVELOPMENT

Although one cannot acquire a better cognitive load capacity, researchers are now investigating ways to ameliorate the deleterious effects of distractions like media multitasking on attentional control and cognitive load. One possible solution is to implement new technologies that filter or limit external distractions on computer browsers.[63] Using a program to block unnecessary interruptions appears to improve worker performance, particularly for knowledge workers that rely heavily on human-computer interactions.[64]

Recent studies suggest that workers may also benefit from practicing mindfulness techniques throughout the day.[65] Mindfulness is concerned with "being attentive to and aware of what is taking place in the present."[66] The most popular approach, Mindfulness Based Stress Reduction (MBSR), was originally created by Jon Kabat-Zinn (2005) in order to help patients with chronic pain and illness to manage their day-to-day stressors. Since then, MBSR and similar techniques have expanded beyond the medical context to the workplace with positive results. For example, practicing mindfulness in the workplace has been associated with fewer tasks switches,[67] increased job performance,[68] and enhanced cognitive flexibility.[69] Although MBSR is considered the gold standard for mindfulness practice, two other that have also demonstrated positive results in the workplace are WorkLife Integration Program (WIP) and Focused Attention (FA) training. workers to learn how to reduce the demand on their cognitive load.

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55. Lavie, 2010
56. Alzahabi & Becker, 2013
57. Lavie, Hirst, de Fockert & Viding, 2004
58. Gladstones, Regan & Lee, 1989
59. Liu & Wong, 2012
60. Rosen, Carrier, & Cheever, 2013
61. Becker, Alzahabi, & Hopwood, 2013
62. Ophir, Nass, & Wagner, 2009
63. Wang & Chang, 2010
64. Salvucci, Taatgen, & Borst, 2009
65. Levy, Wobbrock, Kasniak, & Ostergren, 2012
66. Brown & Ryan, 2003, p.822
67. Levy et al., 2012
68. Dane & Brummel, 2013
69. Moore and Malinowski, 2009

ASSESSMENT AND EVALUATION

While researchers have struggled to adequately assess the many dimensions associated with cognitive load, they have found it can be evaluated by measuring mental load, mental effort, and performance. In general, assessments of cognitive load fall under three categories: subjective measures, like self-ratings, surveys, and questionnaires that ask individuals to evaluate how well they execute a particular task; physiological measures, such as heart rate variability and galvanic skin response; and performance-based measures that examine how a participant's responses deteriorate when using finite cognitive resources to complete two or more tasks.

In addition, new technologies that filter out media distractions (described above) often include management applications that can track and analyze the correlation between types of distraction and performance over time. This kind of personalized data can help workers identify sources of interruption, understand how these distractions impact their work, and subsequently make better and more informed decisions to lessen their individual cognitive load.

Finally, there are several valid scales that can be used to assess mindfulness, a component of cognitive load, including:

1. **The Mindful Attention Awareness Scale** is a self-report questionnaire designed to assess core characteristics of mindfulness, such as awareness of and attention to what is taking place in the present. Studies have shown that the instrument is predictive of self-regulation and well-being.
2. **The Cognitive and Affective Mindfulness Scale** – Revised is a 12-item inventory that measures mindfulness during daily occurrences across four central domains: attention, awareness, present-focus and acceptance.
3. **The Five-Facet Mindfulness Questionnaire** is a self-report assessment that measures five component skills: observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience.

Cognitive load is a complex construct that is dependent upon many unique, individual factors. According to researchers in this field, the type of task, individual differences, and other factors like environment can all drastically influence cognitive load throughout the day. Therefore, it is important for a worker to learn what and how certain factors affect their own cognitive load so that they can then manage and modify the interruptions that significantly impact their work performance.

In addition to some of the techniques described above, there are several other approaches to managing cognitive load that have thus far been useful in learning environments and could potentially be adapted to the workplace. These include: 1) chunking information or grouping together items that have shared properties, 2) optimizing response times—the less time something is floating around unfinished in working memory, the fewer cognitive resources it requires, and 3) avoiding perceptual clutter that consume cognitive resources but don't add value to the message.

70. Paas et al., 2003
71. e.g. the NASA TLX; Hart & Staveland, 1988
72. DeJong, 2010
73. Brown & Ryan, 2003
74. Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007
75. Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006

APPLIED KNOWLEDGE
SENSE-MAKING

As smart machines are used for more routine manufacturing and service jobs, there will be an increasing demand for the kinds of skills that machines do not perform well. These are higher-level cognitive skills that cannot be engineered into mechanical systems. We call these "sense-making skills" or skills that help us to create unique insights that are critical to decision-making.

As computing pioneer Jaron Lanier points out, despite important advances in artificial intelligence research, major limitations remain. "If we ask what thinking is, so that we can then ask how to foster it, we encounter an astonishing and terrifying answer: we don't know." As we continue to negotiate the division of labor between humans and machines in the next decade, critical thinking or sense-making, will emerge as a necessary skill for workers across all industries.

The rise of smart machines corresponds with the emerging deluge of data, which incorporates flows of sensor measurements. Data-mining tools can now crunch millions of these measurements at once to find correlations, which can be used to match critical issues with desired outcomes. For example, electronic trading systems are often used to analyze huge amounts of financial data, searching for the factors that signal a good opportunity.

However, while data-mining and other tools can be effective at finding these kinds of connections, they cannot effectively place these findings in context. It takes a human being to assemble data and correlations and then meaningfully translate them into rich stories that garner attention.

Humans also integrate values, morals, ethics, and other preferences into their decision-making. In general, digital systems are much better at modeling objective measurements than subjective preferences. For example, the digital system designed to crunch financial opportunities would generally not recognize that tobacco manufacturing or fracking are potentially controversial investments for many people. It would require a human programmer to take this into account. Even then, it would be impossible for a digital system to explain why this might be the case.

Perhaps the most powerful application of sense-making is the ability to generalize principles that can be applied to novel situations. Looking again at the example of financial analysis, digital pattern recognition can successfully tease out countless useful correlations from historical data, but it cannot effectively project the results of a significant qualitative legal change. To intuitively understand a human system well enough to project the impact of changes in underlying motivations or approach is the exclusive domain of human sense-making.

APPLIED KNOWLEGE
SENSE-MAKING

BACKGROUND AND DEFINITIONS

Sense-making is often defined as a process through which individuals "work to understand novel, unexpected, or confusing events.[76] " Sense-making occurs when individuals or groups encounter certain cues, such as events, issues, or situations that are either ambiguous or run counter to their expectations. These cues can then disrupt perceptions or understandings of the world and prompt a strategy to make sense of these discrepancies.

The ability to use contextual cues to solve problems or clarify confusing situations is exceptionally important for the proper functioning of organizations.[77] There are several specialized forms of sense-making that play a crucial role in organizations, including "interpersonal sense-making" and "prospective sense-making." Interpersonal sense-making focuses on how interpersonal cues help employees draw meaning from their jobs and has been shown to increase positive attitudes in the workplace.[78] Prospective sense-making considers how future actions might influence the meaning-making process in others.[79]

Sense-making can also positively impact developing markets by providing ways for people to make sense of new organizations.[80] For example, Santos and Eisenhardt (2009) demonstrated how innovative technology firms used media outlets to position themselves as emergent leaders in Silicon Valley, helping potential consumers to make sense of their work. Other markets have also successfully wielded news outlets and social media to inform interested audiences and ultimately expand their customer base.[81] Comparative studies of organizations have also demonstrated that framing a particular market, technology, product, service, or business to address novel situations or unexpected issues engaged sense-making skills and resulted in increased productivity.[82]

The application of sense-making to increasingly complex problems is a recurring theme outside of academia. The Global Sensemaking Network, for example, collects volunteer experts "dedicated to helping humanity address complex, interrelated global problems—such as climate change, energy policy, poverty, and food security—by developing and applying new web-based technology to assist collaborative decision making and cooperative problem solving."

Sense-making is an internal, subjective process. It relies on verbal and nonverbal cues, including visual representations, which can be ambiguous and inexact. One main reason for misunderstandings and misinterpretations is that our experiences shape our interpretations, and, lacking common experience, disparate audience members may not share the same interpretation of events.

From this perspective, it seems clear that to improve sense-making within an organizational group, members need to become more familiar with each other. Members of a select demographic group, for instance, may share experiences with other in-group members that are not held in common with those outside of the group. This means that those within a demographic group will have a greater understanding of each other than of those outside of the group. To improve sense-making across demographic groups, it can be helpful to gain insights to the lived experiences of those from other demographics.

76. Maitlis & Christianson, 2014, p. 58
77. Weick, 1995
78. Wrzesniewski, Dutton, & Debebe, 2003
79. Gioia, Thomas, Clark, & Chittipeddi, 1994, p. 378
80. Weick, 1988
81. Kennedy, 2008
82. Dougherty, Borrelli, Munir, & O'Sullivan, 2000

APPLIED KNOWLEGE
SENSE-MAKING

ACQUISITION AND DEVELOPMENT

Sense-making uses a range of tools, but typically depends on the following three components: 1) multifaceted exploration; 2) frame-construction; and 3) experimentation. First, it is important to find, evaluate, and incorporate a diverse range of information. By approaching a problem from multiple perspectives, individuals gain insight into a potentially ambiguous situation.[83] Once gathered, this information can be used to construct a representation or coherent "frame" of the situation to reference throughout the sense-making process. Finally, one slowly tests this representation by modeling how it might influence outcomes and then makes appropriate changes to it with new evidence. Importantly, these three steps work across both individual and organizational levels, making it a flexible and functional way to develop sense-making skills.

A second type of training paradigm is the "nominal group technique," which pays attention to how status and power (sometimes glossed as expertise in the workforce) can limit how comfortable other team members feel in expressing their ideas. The nominal group technique works against these limitations by creating a means for people to anonymously display their views.[84] The technique is flexible and can include a range of approaches, such as allowing workers to vote anonymously on a group idea. The goal of this process is to pay attention and give voice to those individuals who might be silenced by the majority.

ASSESSMENT AND EVALUATION

In broad strokes, sense-making competencies capture how—and how well—people understand their complex, information-rich world so that they can act effectively within it. Because of the multi-faceted nature of sense-making skills—encompassing information retrieval, situational awareness, logic, adaptation to uncertainty, and the ability to ascribe meaning to experience—there are no holistic assessments of this competency.

However, existing models of sense-making suggest that there are discrete competencies that can be evaluated on a spectrum of relative success. For instance, in one sense-making model, individuals move through time and space and as they do encounter gaps, aberrations or ambiguities they must resolve or "make sense of" in order to proceed, physically or cognitively. In this formation, the ability to effectively cross the perceived gap is the marker of robust skill. In collective sense-making, by contrast, the unit of measurement is the group and how people engage with each other to create a better understanding of their world and work. A subset of competencies in this context might include the ability to extract cues from events, the ability to balance plausibility with accuracy, consensus building, information processing and dissemination, communication skills, interpersonal awareness, and digital search and synthesis agility.

83. Weick, 1995
84. Delbecq & VandeVen, 1971

WORKPLACE SKILLS

Within the National Network's Common Employability Skills framework, workplace skills are those that demonstrate that "the engaged employee is a problem solver and a decision maker." This skill set includes planning and organizing, problem solving, decision making, business fundamentals, customer focus and working with tools and technologies. Better known as "transversal skills", these are the skills employers consistently say they require in future employees.[85]

NEW MEDIA LITERACY

In the old paradigm of one-to-many communications, the concept of media literacy focused primarily on the ability to critically examine content. This underlying concept doesn't change in the realm of new media, but rather expands as the types of media in which people need to become literate have increased significantly.

New technologies and tools, from blogs and news articles to video production and gaming, create a need for literacies in these new media contexts. Workers will need to become fluent in assessing new media forms in order to understand how to receive information and subsequently interpret the world.

The ubiquity of visual displays means that expectations for the quality of visual communications will rise. Knowledge workers will be expected to communicate effectively using a variety of media platforms—video, simulations, models, and images, for instance. Static presentations of information of the past are giving way to infographics and dynamic simulations of data, as visualization plays an increasingly crucial role in company communications.

In particular, video will become pervasive in all aspects of home and work life as we move more deeply into the technological age. Understanding the new genres and conventions that emerge from video culture will become a key competency, in the same way that understanding the conventions of print material has long been essential. At one time, knowledge of fonts and layouts was restricted to a small set of print designers and typesetters. Then, word processing programs brought this capability to everyday office workers. Similarly, user-friendly video production and editing tools will bring a new language into the common vernacular.

The technological landscape is ever-changing. As a result, the tools and programs workers come to rely on will be quickly superseded. This constant state of change will require workers to be receptive to learning new software and techniques. Media literacy in this environment will necessitate high levels of adaptability and a willingness to continue learning throughout one's professional career.

With so many media options available, workers will need to discern which forms are most appropriate for collaboration, fulfilling different tasks, and relating to different audiences: which format works best when presenting to a board, to colleagues, or to customers?

The new media ecology will also place particular demands on digital identity management. Our activities leave digital trails across different media forms, both personal and professional. As online reputation becomes an important marker for credibility and trust, employees will need to pay close attention to the media they produce and think about their digital profile in a holistic way.

85. World Economic Forum 2016

WORKPLACE SKILLS
NEW MEDIA LITERACY

BACKGROUND AND DEFINITIONS

As information and communication technologies become more central to modern life, the more important it will be for organizations to identify and manage the development of skills required to use those technologies in the workplace. Within both academic and policy conversations, the concept of media literacy has been extended from its traditional focus on print and audiovisual materials to include the internet, gaming, and other new media forms.

New media literacy, comprised of the underlying skills of ascertaining credibility and identifying implicit messages in texts and visual representations, hasn't changed, except that perhaps a "knowledge of use" piece should be added to literacy for new kinds of media.[86] It stands to reason that if one does not know how to play video games, that person could not be considered literate in that skill.

Recent research in new media literacy suggests that the ability to evaluate content is one of the most important elements of this skill. As workers are overwhelmed with a range of texts, sources, and other resources online, they will have to learn to intelligently select material that is both useful and unbiased. This kind of critical evaluation is a difficult task that involves knowledge of the broader sociocultural, political, and even historical contexts in which this kind of media content is produced[87]

What has primarily changed with the advent of new technologies is the inundation of information from individuals rather than legitimate media outlets. Today, the sheer number of sources providing information on the internet demands a new emphasis on being able to ascertain source credibility.

ACQUISITION AND DEVELOPMENT

Media literacy may be understood as enabling people to accomplish the following tasks: 1) break the code of texts; 2) participate in the meanings of texts; 3) use texts functionally; and 4) critically analyze and transform texts.[88] Media literacy involves being able to draw from these four areas to develop a complex repertoire of capabilities and appropriately employ them in specific situations.

Mediated messages, or information conveyed by media, reflect the cultures in which the message is both produced and intended to be consumed. Investigations of these cultural dimensions of meaning-making necessarily transpire in a variety of contexts. Some argue that media literacy studies, cultural studies, and information or technology studies can no longer be taught independently of each other—they are all involved in the construction and consumption of new media.[89] Teaching underlying media literacy principles and modeling how to use strategies flexibly to solve different comprehension tasks becomes even more important as technologies rapidly change and literacy in new media forms becomes essential.[90]

Within industry, new media literacy is often covered at least in part by social media and communications training. The coding academy General Assembly, for example, offers a number of training options in this space. The project "New Media Literacies" at the Annenberg School of Communication and Journalism at University of Southern California tackles the task of publicly advancing new media literacy through a series of participatory culture projects. Additionally, the National Association for Media Literacy Education promotes new media literacy as a component of broader media literacy.

86. Warnick, 2002
87. Livingstone, 2004
88. Nixon, 2003
89. Luke, 2007
90. Coiro, 2003

ASSESSMENT AND EVALUATION

Drawing on a rich body of work evaluating both literacy and media literacy skills, several research groups in recent years have attempted to develop valid frameworks for assessing new media skills, principally in educational settings. Given the speed and unpredictability of technological development in this field, some stress the importance of adaptability over fluency in a particular format or application. Others, including UNESCO, stress the need to attend to context in terms of geography, policy, and access when evaluating individual-level competencies. Media Smarts, a civil society organization specializing in digital media, states digital literacy entails five key but nuanced concepts: media is a construction; audiences negotiate meaning; media have commercial implications; media have social and political implications; and each medium has a unique aesthetic format. The Knight Commission on the Communications Needs of Communities in a Democracy offers that new media literacy should include following skills: the ability to analyze messages in a variety of forms and evaluate the quality and credibility of content; the ability to create content, making use of a range of tools; apply ethical principles in one's own communications; and knowledge sharing. Other evaluation frameworks include:

1. **The Media and Information Literacy Framework,** developed by UNESCO, is a two-tiered assessment of national readiness and individual-level proficiency. On an individual level, the evaluation focuses on three central areas: access, or recognizing the demand and being able to search for and retrieve digital information; evaluation of the quality of media content; and creation, or the ability to utilize and monitor media.

2. **The ICT (Information Communications Technology) Literacy Assessment,** developed by Educational Testing Services, is designed to aid students and job seekers in evaluating their new media aptitude. The measure requires test takers to use basic technology to arrive at solutions, and in that way requires individuals to use technology tools to perform information management tasks, such as extracting specific information, using apps, and composing an email summarizing research findings.

3. **The iCritical Thinking Certification,** created by Educational Testing Services, is a credential intended to demonstrate an individual's competence in using digital information, devices, communications technologies, and systems. The assessment is designed to validate aptitude on specific technologies while performing tasks in skill areas, such as access, evaluation, integration, and creation. The instrument was developed for use in educational, governmental, and corporate settings.

4. **The IC3 Digital Literacy Certification,** developed by Pearson subsidiary Certiport, is a credential aimed at students and job seekers that measures competencies across computing fundamentals, key applications, and living online. The most recent generation of the program includes assessments of obtaining apps and understanding their relative strengths and limitations.

WORKPLACE SKILLS
DESIGN MINDSET

For as long as tools have been at our disposal, we have tried to design or "program" our world. New capabilities are on the horizon for designing our world on scales ranging from micro to macro—from our minds and bodies to our cities and ecosystems. Sensor networks, bio-monitors, pervasive computing, and a host of other new technologies provide us with the ability to translate more of life around us into data streams or chunks of information that can be analyzed, manipulated, and redesigned.

While we are far from being able to design everything around us, we are recognizing our responsibility to govern the human remade world and use new and powerful scientific tools to approach every challenge as a design problem. In the coming decade, design thinking will be a prerequisite skill for success.

New discoveries in neuroscience are highlighting how profoundly our physical environments shape cognition. Over the next decade, we will have the opportunity and the means to expand this beyond the experimental lab into schools, workplaces, public spaces, and homes. People will increasingly use new knowledge to design their work environments to achieve specific goals—high ceilings for expansive, big-sky thinking; low ceilings for detailed work.

Beyond cognition, we will be engaged in designing new organisms for specialized purposes using tools of biotechnology, such as dedicated bacteria for ocean cleanup. And at the larger societal level, we will increasingly be looking at social interactions and social networks as key features of the design ecology.

We can design interfaces that influence judgment and behavior, which can have a very literal effect in the workplace, as what exists as a physical or visual metaphor becomes cognitive reality. Joshua Ackerman, an MIT professor who has been studying the unconsciously perceived effects of our physical environment and artifacts, calls the use of texture, color, weight, and other physical qualities to influence thinking "tactile tactics." Incorporating tactile tactics into everyday interactions will reshape how individuals experience work.

WORKPLACE SKILLS
DESIGN MINDSET

BACKGROUND AND DEFINITIONS

Design thinking is an approach to problem solving that can be applied to both real-world situations as well as intangible services.[91] It is often described as "the actuation of thoughts and beliefs into organizational processes"[92] and integrates several key phases: 1) problem finding; 2) observation; 3) visualization and sense making; 4) ideation; 5) prototyping and testing; and 6) viability testing (Glen et al., 2015).[93] Importantly, design thinking is non-linear. So while these six phases are vital to the process, they do not necessarily need to be followed in that order. This makes design thinking a more adaptable form of thinking than other, more traditional forms. However, its flexibility should be not conflated with ambiguity—each step in this process is clearly delineated and essential to the final results.

Design thinking is also characterized as a human-centered capability in that it requires an individual to develop new insights and solutions to problems one might encounter on a daily basis. In order to understand these problems and other needs, design thinking underscores observational skills. By observing (and in some cases, even empathizing with) another person's experiences, we are better able to actively comprehend, engage with, and ultimately aid others.[94] Design thinking is not limited to creating things.

Professor Grant Hildebrand from the University of Washington's College of Built Environments is an architect who has been teaching design and architecture for 40 years. Prof. Hildebrand suggests three things are needed for quality design: 1) some degree of innate talent or ability; 2) an understanding of and ability to work within a hierarchy of related ideas and tasks; and 3) the confidence to perform each task within the hierarchy successfully. That is, design is a hierarchical process, beginning with the larger decisions and working to the smaller ones. Confidence is needed "to work out smaller choices" within the hierarchy. These three components are needed not only for architecture but for any sort of design, including a lecture, a camera, or a dinner.

A relatively new line of research has also started to examine the connection between design thinking and embodied cognition.[95] Embodied cognition posits that thinking depends upon our experiences of physically acting on and within the world.[96] More specifically, it attempts to explain how certain features of an individual, such as sensory perception, are influenced and sometimes determined by experiences with the physical world.[97] Cognition tasks are therefore not isolated within the brain, but interact with the world, the environment, and others in it.[98] Design thinking that incorporates this understanding of embodied cognition and the role of experience can greatly contribute to "creating conditions for technology-mediated human experience anchored in the sensing, feeling, and moving body."[90]

ACQUISITION AND DEVELOPMENT

There are various types of design thinking programs available for businesses, schools, and other organizations. Most likely, just getting employees or students to practice new types of thinking would be beneficial to increasing cognitive capacities. However, there are only a few reliably tested and validated programs thus far. The top two are described in more detail below:

1. **Three Gears of Business Design. T**his technique draws upon and integrates tools from the design and business world to promote empathy, deep user understanding, concept visualization, and prototyping. As its name suggest, this program uses three "gears" or stages to collaboratively build innovative business models.[100]

2. **The Innovation and Design Experience for All.** This is a three-day experiential learning program taught at Bryant University. The program has four main learning objectives: problem-solving with design thinking; develop brainstorming skills; create individual cognitive style; and communicate ideas in a group setting. Since the program's inception in 2012, it has demonstrably aided first year students in thinking more flexibly about design.[101]

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91. Johansson-Sköldberg, Woodilla, & Çetinkaya, 2013
92. Chen & Venkatesh, 2013 p. 1680
93. Glen et al., 2015
94. Glen et al., 2015
95. Smithwick & Sass, 2014
96. Rosch & Thompson, 1991
97. Downey, 2010
98. Kirsh, 2013
99. Loke & Roberson, 2013, p. 2
100. Fraser, 2009
101. Coakley, Roberto, & Segovis, 2013

EVALUATION AND ASSESSMENT

Design mindset is, in essence, an aptitude for creative problem solving and reflects a combination of divergent and convergent thinking. As such, assessments of this competency can draw on measures of creativity and innovative problem solving, including the following:

1. **The Torrence Tests of Creative Thinking** are established and widely used instruments that can be adapted for youth and adult populations. There are both figural and verbal versions of the measure, which assess skills such as emotional expressiveness, originality, elaboration, internal visualization, and abstraction.
2. **The Strategy Evaluation Matrix** is an educational tool used in design schools that is intended to help students assess creative strategies. In this model, each time students are introduced to a new design strategy, they are asked to reflect individually and collectively on how and why the particular creative approach is useful. This evaluation method serves to both assess student's fluency in design thinking and develop comfort in experimenting with multiple approaches.
3. **The California Measure of Mental Motivation** measures the degree to which college students and adults are cognitively engaged and mentally motivated toward intellectual activities. Participants are asked to agree or disagree with statements expressing familiar opinions, beliefs, values, expectations and perceptions that relate to the reflective formation of reasoned judgments. The test evaluates six domains: mental focus, learning orientation, creative problem solving, cognitive integrity, scholarly rigor and technological orientation.

An emerging body of research suggests that human-computer co-creative design merits distinct forms of evaluation. Rather than focusing on the novelty or ingenuity of a particular system or product, co-creative design thinking evaluates on the basis of the creative potential manifest in the human-computer interaction.[102]

102. See: Bown, O. 2014. Empirically grounding the evaluation of creative systems: Incorporating interaction design. In Proceedings of the Fifth International Conference on Computational Creativity, 112–119

WORKPLACE SKILLS
TRANSDISCIPLINARY APPROACHES

Over the next decade, technology and computational methods will become more prominent in all aspects of work, and professional fields will overlap more than ever. These intersections across lines of study and industry will be essential to tackling the most pressing problems in science, technology, business, and the economy. Narrow interest groups and specialists unable (or unwilling) to understand one another's terminology or to integrate data and concepts across disciplines create much of the gridlock in addressing global issues, such as climate change. As we recognize the complexity inherent to many of the most pressing issues facing our world, the next decade will see transdisciplinary approaches take center stage.

Global mindsets will also be valued as a key driver of innovation. Some of the most exciting developments of recent years have come from interdisciplinary practice: for example the way biomimicry (modeling natural processes) has been used to shape architectural design, or the application of engineering principles to establish the new field of synthetic biology.

Transdisciplinary thinking goes beyond interdisciplinary teamwork by integrating fields and perspectives rather than working jointly across disciplines. As writer and theorist Howard Rheingold explains, this skill is really about "speak[ing] the languages of multiple disciplinesbiologists who have understanding of mathematics, mathematicians who understand biology." Future workers will need to be equipped to think through different disciplinary approaches themselves.

A number of organizations, including IBM and IDEO, are beginning to talk about this skill in terms of a "T-shaped" quality. T-shaped people have both depth and breadth in their skill set. The vertical bar of the "T" represents depth in one field—for example engineering, design, or a social science. The horizontal bar represents the ability to collaborate across other disciplines and to apply knowledge in areas of expertise other than one's own.

This skill requirement presents a clear challenge for higher education institutions. Many are already responding by creating rich transdisciplinary programs that allow people to study and work with specialists across a range of fields instead of being limited to one traditional subject. For example, Design London—a strategic partnership between the Royal College of Art and Imperial College London - facilitates teaching and knowledge exchange between MA, MEng and MBA students. In the U.S., the California Institute for Telecommunications and Information Technology (Calit2) at the University of California's San Diego Campus brings together researchers from Science, Technology, Engineering and Math (STEM) fields with art, design, and other disciplines to tackle large-scale societal problems.

But the implications of this skill stretch further than formal years of education. As Jim Sphorer, director of Almaden Services Research at IBM explains, "transdisciplinarity also implies people who can learn and adapt more quickly, who are better life-long learners." As human productive life span increases, multiple careers and exposure to multiple industries and disciplines will become the norm. Curiosity and an openness towards continual learning throughout life will be crucial to cultivating this skill.

WORKPLACE SKILLS
TRANSDISCIPLINARY APPROACHES

BACKGROUND AND DEFINITIONS

The transdisciplinary approach transcends traditional disciplinary boundaries by integrating the natural, social, and health sciences to foster novel concepts, methods, and paradigms.[103] It also goes beyond the basic scaffolding of interdisciplinary work by including a participatory element. That is to say, members of transdiciplinary research teams work together collaboratively to generate, rather than just exchange, new types of knowledge.

In recent years, transdisciplinary approaches have become an increasingly important tool for lifelong learning,[104] technological advancement,[105] classroom knowledge production,[106] and even human-environment relations.[107] Moreover, efforts to incorporate transdisciplinary thinking across these and other contexts have been productive at the individual, organizational, and social levels. For example, an international research program conducted by the Swiss National Centre of Competence in Research used a transdisciplinary approach to examine the interplay of global change and sustainable development.[108] This decade-long project brought together experts from disparate specializations to productively collaborate and cooperate towards a common goal. Their findings indicated that not only was transdisciplinary thinking more useful than former interdisciplinary research models, but it also significantly improved knowledge production over time.[109]

Despite these findings and mounting evidence that demonstrates the utility and applicability of transdisciplinary approaches, this approach still faces many challenges. Most notably, there is not a common format for implementing this kind of approach across sectors (education, business, research, etc.), so collaborating parties must work together to develop a coherent approach suited to their work and aims.

The potential strength of a transdisciplinary approach lies in bringing multiple perspectives to bear on problems that single disciplines have been unable to resolve. Thus, transdisciplinary projects hold great opportunity for not only tackling challenges at scale but for creative problem solving, including the art of simply determining which disciplinary perspectives to include.

ACQUISITION AND DEVELOPMENT

Several models are currently used to promote transdisciplinary thinking in various contexts. The process of education for sustainable development emphasizes collaboration and experiential learning in the classroom and beyond.[110] Similar process-driven (rather than content-driven) approaches to education, such as the Sustainable Development Indicators Exercise, incorporate role-playing and practice group coordination, and simulate real-world tasks like distributing work.

Transdisciplinary skill acquisition programs should aim to create a common language, which will provide organization to team members and allow them to learn necessary aspects of other disciplinary languages. Sometimes referred to as a "methodology,"[111] this common language must recognize three tenets: 1) that there are different levels of reality to the problem depending on the laws that are guiding one's interpretation of the situation; 2) that one must follow non-classical logics or "a logic of the included middle" that allows us to move beyond a dichotomized approach; and 3) that complexity, or the fact that all systems are inherently connected and interact with one another, is required for success. These and other transdisciplinary training procedures successfully nurture collaborative learning and familiarize individuals with alternative modes of problem solving.

On the commercial front, transdisciplinary approaches are common in the health field, where certain medical conditions cannot be easily or simply resolved from the perspective and approach offered by a single disciplinary trajectory. For example, the National Institute of Health (NIH), National Institute on Minority Health and Health Disparities has a Transdisciplinary Center. Further, The Holistic Education Network offers information on transdisciplinary approaches including a collection of several links to external transdisciplinary organizations.

103. Soskelne, 2000
104. Canter & Brumar, 2011
105. del Cerro Santamaria, 2015
106. Balsiger, 2015
107. Lawrence & Despre , 2004
108. Wiesmann & Hurni, 2011
109. Hurni & Wiesmann, 2014
110. Walls & Corcoran, 2004
111. Nicolescu, 2010

ASSESSMENT AND EVALUATION

The strength of a transdisciplinary effort can be assessed on the basis of the different perspectives brought to bear on formulating problems, problem solving methods, and solutions. Evaluations should consider the extent to which the inclusion of different disciplines aid in developing solutions, as well as how perspectives across disciplines have been brought into collaboration. As there is no formula for a transdisciplinary approach or a clear delineation of what this skill set entails, there are no formal evaluations to measure these competencies in individuals or organizations. However, instruments that assess collaboration, team effectiveness, consensus building, communication, and creative problem solving could be used in service of transdisciplinary evaluations.

WORKPLACE SKILLS
COMPUTATIONAL THINKING

In the coming decade, we will see the beginning of a large-scale infusion of automated systems into everyday life. Already, numerous fields, from supply-chain management and military activity to city planning and agriculture, are affected by the integration of devices, sensor monitoring, and programmable processes. The pace of this shift will only increase with time.

To leverage the new generation of location-based computation and sensor networks, workers will need to understand their world in computational terms. Computational thinking, or the ability for individuals to see and manipulate connections across digital systems, will be an increasingly valuable asset.

With time, automation will extend to areas that may at first seem surprising. Laws, for instance, will increasingly take the form of mandated software protocols, embedded in everyday tools and designed to block users from engaging in behaviors deemed undesirable. For example, as automated vehicle prototypes begin to populate the roads, the way they operate will be a direct result of interactions with data inputs from other objects and activities around them.

Similarly, at the level of physical infrastructure, individual buildings, neighborhoods, municipal services, and even entire metropolises will be woven together into a close-knit web of programmed systems, dynamically sensing and reacting to local conditions. In this environment, local governance will include collective decision making about improving interactions among these systems using the outputs of regional sensor networks. The implementation of smart grid technologies gives a revealing glimpse of the potential power of using physical infrastructure as a platform for enabling smart cities.

Applications of computational thinking will evolve beyond simple digital systems. There are, for example, efforts currently underway to develop “programmable matter” or materials engineered at a molecular scale to take on new shapes and properties depending on how and where they are used.

This gets to what may be the ultimate application of computational thinking, namely the ability to program certain aspects of ourselves. As health sensors for monitoring and quantifying our biological, psychological, and neurological processes reach a critical price threshold, we can expect cheaper systems for analyzing and relaying personal health information to become commonplace. Not only will these feeds become integral to medical practice and research, but they will also serve as the basis for new turns in computational thinking that spur behavioral changes and potential health improvements.

WORKPLACE SKILLS
COMPUTATIONAL THINKING

BACKGROUND AND DEFINITIONS

Computational thinking offers a means to access solutions that are usually outside an individual's standard area of expertise. It is defined broadly as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information processing agent."[112] Computational thinking is not just relevant to computer science and adjacent fields—it also encompasses a range of cognitive and analytical abilities that can be used across all disciplines, making it one of the more fundamental skills for future workers.[113] Computational thinking not only brings together principles from across the STEM fields, it is also uniquely transdisciplinary in its incorporation of ideas from communications, psychology, and education.

The International Society for Technology in Education worked with the Computer Science Teachers Association to create a useful list of computational thinking characteristics.[114] These include, but are not limited to: 1) organizing and evaluating data logically; 2) using abstractions to represent data; 3) programming solutions with the help of algorithms; 4) identifying, evaluating, and executing possible solutions; and 5) transferring this process to other fields. Most current research is concerned with how to foster computational thinking and related cognitive skills, such as higher-order thinking, in early education.[115]

ACQUISITION AND DEVELOPMENT

Researchers have identified a number of different techniques for incorporating the development of computational thinking skills into the curricula of K-12 and higher education settings.[116] One approach to skill development mobilizes examples in a variety of general education courses, as well as sample classroom activities, assignments, and other assessment instruments.[117] This approach champions the "problem-solving learning environment" framework, which encourages students to learn to solve problems through causal reasoning, metacognition, and other skills. The goal of this model is to teach computational thinking skills[118] by having students analyze an authentic situation they might encounter in the real world. A new line of research is investigating the efficacy of developing computational thinking through non-traditional education programs, like massive open online courses or MOOCs. Preliminary results from these studies indicate that MOOCs could be a powerful resource for fostering computational thinking, among other skills.

112. Wing, 2010, p. 1
113. Wing, 2006
114. ISTE, 2011
115. Czerkawski & Lyman, 2015; Soh et al., 2015
116. Rubenstein & Chor, 2014; Shailaja & Sridaran, 2014
117. Perkovic et al., 2010
118. Lye & Koh, 2014

ASSESSMENT AND EVALUATION

As with research on how computational thinking skills are acquired, research on how these competencies are assessed has focused primarily on K-12 or other educational contexts.[119] Computational thinking extends well beyond the classroom to organizations, businesses, and other enterprises. However, training in these contexts is typically a part of broader IT training initiatives. Existing evaluation measures include:

1. **The Principled Assessment of Computational Thinking** is a National Science Foundation-funded effort housed at SRI Education that aims to develop standards for measuring student learning outcomes in computer science. The goal is to design, develop and validate assessments of computational thinking practices for the national Exploring Computer Science curriculum. The instrument is among the first to automate measures of computational thinking, learning outcomes, and initial indicators of skills transfer in student work.

2. **The REACT System (Real Time Assessment of Computational Thinking),** another National Science Foundation funded effort, is a cyberlearning tool designed to help teachers assess student computer science competencies. This embedded, formative assessment of design-based artifacts like programs is intended to advance learning sciences and enhance in-class and online learning by creating closed loop environments presenting real time information to students and teachers.

3. **The Scalable Game Design Arcade**[120] is part of a national program targeting middle schoolers that introduces students to computational thinking through game design. The program is intended to foster collaborative engagement in problem solving, creativity, modeling and communication. The accompanying evaluation framework, Computational Thinking Pattern Analysis, is designed to measure student learning and skills transfer in real-time orientation.

119. Basawapatna, Koh, Repenning, Webb, & Marshall, 2011
120. National Science Foundation, 2008

CONCLUSION

The results of this research have implications for individuals, educational institutions, and businesses.

To be successful in the next decade, individuals will need to demonstrate foresight in navigating a rapidly shifting landscape of organizational forms and skill requirements. They will increasingly be called upon to continually reassess the skills they need, and quickly put together the right resources to develop and update these. Workers in the future will need to be adaptable lifelong learners.

For their part, educational institutions at the primary, secondary, and post-secondary levels, must realize that their current structures are largely the products of technology infrastructure and social circumstances of the past. The landscape has changed and they now must consider how to adapt quickly in response.

Finally, businesses must also be alert to the changing environment and adapt their workforce planning and development strategies to ensure alignment with future skill requirements. Strategic human resource professionals might reconsider traditional methods for identifying critical skills, as well as selecting and developing talent. Considering the disruptions likely to reshape the future will enhance businesses' ability to ensure organizational talent has and continuously renews the skills necessary for the sustainability of business goals. A workforce strategy for sustaining business goals should be one of the most critical outcomes of human resource professionals and should involve collaborating with universities to address lifelong learning and skill requirements.

Ultimately, it is critical that stakeholder across all levels take an active role in shaping these future forces as they emerge. While there are clear forces in motion today, it is important to remember that the future has not been written yet, and that the best way to meet the future head-on is to help to shape it.

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For that to happen, our public systems must get a few essentials right: quality education for all children, expansion of economic opportunity, and a representative democracy with broad public participation. We support strategies to protect and restore our natural environment, and to prevent gun violence. And, we support artists and arts organizations that enrich our culture with stories from communities of color.

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