

# The Dimensions of Defensibility

Human-Centered Design in an Automated Workplace



Dr. Wallace Walrod  
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Orange County Business Council

A Publication of OC Pathways and the  
Orange County Department of Education



OCpathways  
Partnerships for College and Career Success



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# FOREWORD

In 2014, the Orange County Department of Education (OCDE) led a consortium of fourteen school districts, nine community colleges, four regional occupation programs, and more than one hundred business and community partners in creating OC Pathways. With help from a California Department of Education grant, OC Pathways developed a regional collaborative to create and dramatically expand career pathway programs for Orange County high school and community college students in sectors such as engineering, healthcare and information communication technology, which are vital to our regional economy. OC Pathways facilitates deep, authentic, collaborative relationships among education, industry and community. One such relationship links OCDE with the Orange County Business Council (OCBC).

In 2018, in partnership with OC Pathways, OCBC launched an innovative effort aimed at providing foundational research that takes into account the labor market impact of major emerging technological advancements of our time – including automation, robotics, artificial intelligence and machine learning – in order to prepare Orange County’s students for a 21<sup>st</sup>-century future. “The Dimensions of Defensibility” is among the first research of its kind to comprehensively analyze the characteristics of jobs and how they relate to the forces of automation. It is also the first study we know of that, rather than focusing on what makes jobs vulnerable, begins to rigorously answer questions about what factors will make jobs defensible and that begins to parse out the key factors that will help workers stay relevant in an automated workplace.

The authors of this report, Dr. Wallace Walrod, OCBC Chief Economist, and Petersen Walrod, worked closely with Dr. Jeff Hittenberger, OCDE’s Chief Academic Officer, and OC Pathways Executive Director Amy Kaufman, to produce this OC Pathways research report, which offers thought leadership on the emerging connections among automation, the future labor market and human-centered design thinking.

Going forward, a region’s success will increasingly reflect the quality of its education and workforce development systems, which will in turn reflect how effectively state and local leaders design new strategies and paradigms for student success in this era of transformation. Our resolve is that this research will help fuel a more enriched and engaging educational environment for students and propel Orange County into a better future – and that the first fruits of this research will be seen in the thousands of local students developing both technical competencies and key defensible human competencies that will make their future jobs resistant to automation: leadership, creativity and problem-solving.

Al Mijares, Ph.D  
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# EXECUTIVE SUMMARY AND INTRODUCTION

Artificial intelligence (AI) and robotics are facilitating the automation of a growing number of “doing” tasks. Today’s AI-enabled, information-rich tools are increasingly able to handle jobs that in the past have been exclusively done by people – think tax returns, language translations, accounting, even some kinds of surgery.

-Amy Edmondson and Bror Saxberg, “Putting Lifelong Learning on the CEO Agenda,” *McKinsey Quarterly* September 2017

Without most of us quite noticing when it happened, the web went from being a strange new curiosity to a background condition of everyday life. Today’s emerging technologies – Artificial Intelligence, mixed reality combining the best of both virtual and augmented reality, robotics, cloud computing and others – may undergo a similar transformation in the near future. These “Human-Machine Partnerships” leveraging developing technologies will transform how organizations find talent, manage teams, deliver products and services, and support professional development.<sup>1</sup>

As technology continues to evolve, it is clear that automation and offshoring will be the largest threats to both long-term job creation and individual career development. Headline after headline spotlights developments in AI, robotics, self-driving cars and other technologies poised to replace human workers in many fields. In January 2018, for example, Amazon opened its first automated Amazon Go store, which uses cameras, sensors and a smartphone app to completely replace cashiers and checkouts. These trends, in all likelihood, will only accelerate for the foreseeable future. Even though only a small percentage of current jobs<sup>2</sup> can be completely and entirely automated using current technology, time-saving automated technologies are poised to radically restructure the way workers allocate their time.

Human-machine partnerships may not spell the end of human jobs, but they will autonomously drive society into a new era of work, one that may leave many old jobs behind. It is estimated that 49 percent of the activities that people are paid to do in the global

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<sup>1</sup> Institute for the Future: the next era of Human-Machine Partnerships

<sup>2</sup> Although the total number of occupations that are overwhelmingly vulnerable to automation are small, the number of jobs in vulnerable occupations such as truck drivers, waiters and accountants are very high.

economy have the potential to be automated by adapting currently demonstrated technology.<sup>3</sup> While less than 5 percent of occupations can be fully automated, about 60 percent spend at least a third of their time performing activities that can technically be automated.<sup>4</sup> The future will not just see jobs disappear, but entire activities completed with a fraction of the labor input.

All workers will have to adjust to new, transformed jobs, or new and more efficient approaches to the same tasks. However, some workers and sectors will be more impacted than others. For example, 73 percent of all jobs in the Accommodation and Food Services industry can be automated, compared to only 27 percent in Educational Services.<sup>5</sup> Sectors dependent on labor that is vulnerable to automation will likely see labor-saving technologies replace jobs over time; in some cases this will happen as a result of wide-spread implementation by major corporations while in other sectors new entrants will be required to disrupt and force the change through competition. The more routine work, labor or cognitive, that makes up the hours performed, the more likely that sector is to experience large-scale automation. Predictable physical activity, data processing and data collection account for 18, 16 and 17 percent, respectively, of all time spent at work in the United States.<sup>6</sup> All of these activities are either physically or cognitive routine, which makes them vulnerable to replacement by cost-saving technologies. Workers receive roughly \$2.7 trillion in wages to time spent in activities that are vulnerable to automation in the United States<sup>7</sup>; even if it is not cost efficient to implement all of the technologies that are feasible, the automated solution will always be an option, either as a boon or as a threat.



The future, then, will not just see jobs disappear; entire activities, such as routine customer service, will be enhanced, augmented or outright replaced by technology to the extent that

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<sup>3</sup> McKinsey Global Institute: A Future That Works: Automation, Employment, and Productivity

<sup>4</sup> Ibid

<sup>5</sup> Ibid

<sup>6</sup> Ibid

<sup>7</sup> Ibid

the human worker will accomplish in minutes what may have taken hours. What will remain and constitute the bulk of human labor, and consume the majority of human attention, will be a distinct type of labor that cannot be reduced to unambiguous sets of instructions. This presents a multifaceted challenge to society: How can workers in vulnerable jobs adapt? How can workers who are entering the automated workplace effectively leverage technology? How should future generations be educated and trained in respect to automation? On a more basic level, those who are trying to create a more effective response must ask themselves how the impact of automation can even be parsed out at all?

## MEASURING AND DEFINING POTENTIAL FOR AUTOMATION

In a 2013 paper, “The Future of Employment: How Susceptible are Jobs to Computerization?”<sup>8</sup>, Oxford professors Carl Benedikt Frey and Michael A. Osborne argue that automation is now “no longer confined to routine manufacturing tasks.”<sup>9</sup> As robots get both cheaper<sup>10</sup> and more advanced, they will be able to perform more and more traditionally “human” tasks. Frey and Osborne, however, note three kinds of tasks that humans can currently perform much more effectively than robots, tasks that will serve as bottlenecks for future automation.

First, robots’ relatively weak ability to perform complex perception and manipulation tasks reflects their struggles in unstructured work environments.<sup>11</sup> Robots lag behind humans in “handling irregular objects,” in the ability to recognize and fix mistakes, and in the fine manipulation of human limbs.<sup>12</sup> Frey and Osborne list Physicians and Surgeons, Dentists (general), and Athletes and Sports Competitors as examples of relevant Standard Occupational Classification (SOC) job categories with relatively low automation potential.

Second, robots still lag behind humans in performing creative intelligence tasks, despite the fact that AIs have been programmed to compose music and create drawings. “The principle obstacle to computerizing creativity,” Frey and Osborne claim, “is stating our values

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<sup>8</sup> This paper is also the source of the oft-cited statistic that 47 percent percent of American jobs are vulnerable to automation in the next two decades (268).

<sup>9</sup> Frey and Osborne 255.

<sup>10</sup> Osborne and Frey note that “over the past decades, robot prices have fallen about 10 percent annually and are expected to decline at an even faster pace in the near future” (261).

<sup>11</sup> *Ibid.*, 262.

<sup>12</sup> *Ibid.*

sufficiently clearly that they can be encoded in a program,"<sup>13</sup> an argument that makes a great deal of intuitive sense; human beings have argued about what constitutes artistic/aesthetic value for well over 2,000 years and have not come close to anything resembling a consensus.<sup>14</sup> They later expand the definition of creative intelligence outside of artistic production, arguing that "the low susceptibility of engineering and science occupations to computerization...is largely due to the high degree of creative intelligence they require."<sup>15</sup> Civil Engineers, Fashion Designers, Landscape Architects and Physicists are relevant SOC job categories with low automation potential.

Finally, humans still greatly outperform artificial intelligences at social intelligence tasks. Thus far, no artificial intelligence has been able to fully pass the Turing test<sup>16</sup> despite many attempts. Frey and Osborne argue that this is because they lack the "common sense information"<sup>17</sup> that humans intuitively possess and, because of this, jobs performing "generalist work requiring a high degree of social intelligence"<sup>18</sup> will resist automation. They list Clergy, Marriage and Family Therapists, Chief Executives, and Lawyers as SOC job categories that have an extremely low probability of being automated in the foreseeable future.

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<sup>13</sup> Ibid. Frey and Osborne cite Margaret Boden's research on creativity and AI.

<sup>14</sup> In Plato's dialogue *Ion*, Socrates argues that the title character's ability as a rhapsodist (a bard or traveling performer of poetry) does not come from his skills, knowledge, or superior understanding of Homer's epics, but from divine inspiration. From Plato onward, the concept of artistic inspiration as something spiritual or otherwise unexplainable by logic or science (especially from the Romantic era onward) has played a major role in how we understand the nature of creativity. How does one give an artificial intelligence something like inspiration?

<sup>15</sup> Ibid., 267.

<sup>16</sup> The Turing test, developed by Alan Turing in 1950, is a test of a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human. Turing proposed that a human evaluator would judge natural language conversations between a human and a machine designed to generate human-like responses. The evaluator would be aware that one of the two partners in conversation is a machine, and all participants would be separated from one another. The conversation would be limited to a text-only channel such as a computer keyboard and screen so the result would not depend on the machine's ability to render words as speech. If the evaluator cannot reliably tell the machine from the human, the machine is said to have passed the test.

<sup>17</sup> Ibid.

<sup>18</sup> Ibid., 266.

<b>Assessment of Computerization Limits, The Future of Employment: How Susceptible are Jobs to Computerization? (Frey and Osborne)</b>		
<b>Computerization Limits</b>	<b>O*NET Variable</b>	<b>O*NET Description</b>
Perception and Manipulation	Finger Dexterity	The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects
	Manual Dexterity	The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects
	Cramped work space, awkward positions	How often does this job require working in cramped work spaces that require getting into awkward positions?
Creative Intelligence	Originality	The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem.
	Fine Arts	Knowledge of the theory and techniques required to compose, produce, and perform works of music, dance, visual arts, drama, and sculpture.
Social Intelligence	Social Perceptiveness	Being aware of others' reactions and understanding why they react as they do.
	Negotiation	Bringing others together and trying to reconcile differences.
	Persuasion	Persuading others to change their minds or behavior.
	Assisting and caring for others	Providing personal assistance, medical attention, emotional support, or other personal care to others such as coworkers, customers, or patients.

Frey and Osborne conclude their paper by noting the “strong negative relationship” between automation potential and education attainment; in the near future, automation will mostly replace low-skill, low-wage jobs.<sup>19</sup> Workers will need to acquire “creative and social skills” in order to compete with machines.<sup>20</sup> The paper ranks more than 700 SOC job categories, called occupations, by automation potential. A job category with a low score, such as a 0.01,

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<sup>19</sup> Ibid., 267.

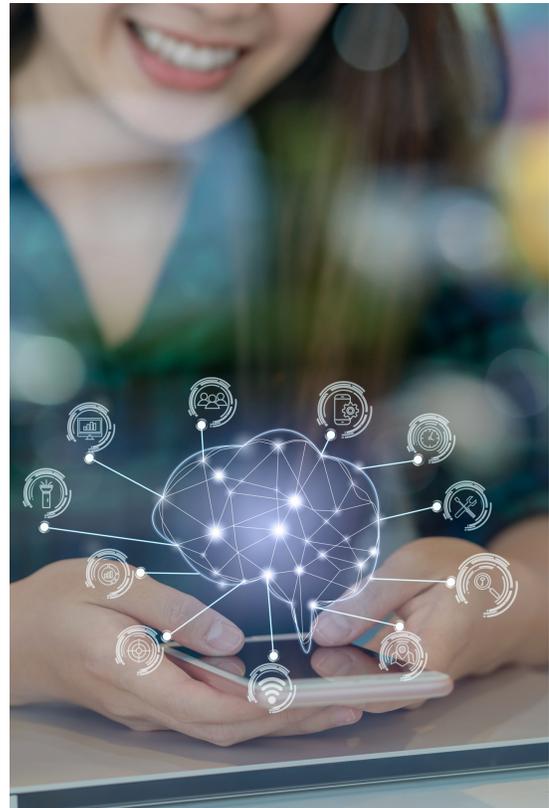
<sup>20</sup> Ibid., 269.

has a low potential for automation, while a job category with a high score such as a 0.99, has a 99 percent likelihood for automation based on existing technologies.

## DEFENSIBILITY, THE NEXT STEP TOWARDS UNDERSTANDING AUTOMATION

The term “defensibility” came into use among economists such as Janet Yellen to describe the impact of outsourcing and automation on the labor market. Defensibility measures what factors make a job less likely to be automated, whereas vulnerability to automation, the measure that is tracked by Frey and Osborne, analyzes what factors make jobs more likely to be automated. Defensibility, measured in this sense, allows for an examination of the statistical relations between occupational characteristics and an occupation’s vulnerability to automation. Previous analyses, on the other hand, have tended to focus only on the jobs that are most vulnerable to automation, which leaves policymakers with little information as to how to solve these problems.

Defensibility as a concept deeply explores the nature of jobs that are not vulnerable to automation, understanding what the tell-tale signs of a resilient job are, and why these jobs are resilient as such, while many are not. The analysis of defensibility seeks to make use of the growing understanding of how automation will impact the economy to help society anticipate and adapt to the new reality. This analysis begins with a set of the unexpected statistical relationships between workforce characteristics and what we call “defensibility,” the likelihood that an occupational characteristic is more or less invulnerable to automation and offshoring. These scores themselves are the result of a labor market model for how technologies function compared to human capabilities. These scores were tested against nearly 200 variables for each occupation identified by the Bureau of Labor Statistics as well as other data only available through cutting-edge labor market research that relies on aggregated job posting data. This research paints a more complete picture of how automation affects the labor market, and how Orange County businesses can prepare for future change.



Defensibility provides an educational strategy that focuses on developing non-automatable skills, values such as pride in quality of work and an internal locus of control, and active and investigative approaches to work. Automation offers a unique opportunity to educators because there are strong possibilities for alignment between what makes a worker an educated, effective citizen, and what makes a worker a strong contributor in the automated workplace. Although both hard and soft skills will continue to gain importance as automation continues to eliminate routine work activities, the long-standing division between the two categories is starting to break down as a result of automation. The line that might divide qualitatively evaluating a system, and thinking creatively, becomes blurred as technology makes data analysis more accessible through software programs such as Tableau, while elegantly and effectively using a piece of software as a “super-user” reflects the creativity of the worker. It might be more appropriate to think of some skills that are more humanized and highly transferable across highly defensible occupations, while others are more technical and job-specific.<sup>21</sup> Edmondson and Saxberg, writing for McKinsey, put it best when they note that future workers “will need to use complex cognitive skills for more and more of their time.”<sup>22</sup>

Analyzing relevant data, shown in the following table, shows a surprising amount of variation in how different dimensions of labor characteristics relate to defensibility. Automation research in the past has generally focused on skills and competencies, especially technical and career-focused skills. In other words, the focus (and the early consensus) has been that the capacity to operate in an automated workplace is the key to success. The findings that defensibility analysis has uncovered point in a different direction; the overlooked and less tangible dimensions of work identity possess, by far, the strongest statistical relationships with defensibility.

The value dimension, for example, has the strongest correlation with defensibility of any job characteristic. This can be understood to mean that workers who reported high levels of finding personal satisfaction for their job tended to have jobs that are more defensible. Interests and Abilities, on the other hand, have a much weaker relationship with defensibility. Whether a worker reported high levels of Interest and Abilities did not categorically impact the likelihood of having a high or low defensibility score. Instead, the specific variables within the dimension exerted the greater predictive power.

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<sup>21</sup> This distinction seems to be analogous to the distinction offered by Carl von Clausewitz in his landmark treatise on war, *On War*, between strategy (the art of using battles to win wars) and tactics (the art of using troops to win battles). Regardless, much of this report will refer to the hard-soft skill division for the sake of the present-day reader.

<sup>22</sup> Amy Edmondson and Bror Saxberg, “Putting Lifelong Learning on the CEO Agenda,” *McKinsey Quarterly* September 2017.

<b>Major Characteristics Averaged and Ranked by Correlation with Defensibility</b>	
<b>Characteristics</b>	<b>Value</b>
Values	0.52
Salary	0.52
Style	0.42
Skill	0.36
Activity	0.29
Knowledge	0.25
Interest	0.16
Ability	0.05

Skills, often the focus of popular perspectives on automation, only have a moderately high correlation with defensibility overall. Some specific skills such as Active Learning, Critical Thinking and Coordinating are strong predictors of defensibility, while others such as Equipment Maintenance, Installation and Troubleshooting, are actually among the strongest negative predictors of defensibility. Programming skills have only a weak positive relationship with defensibility, but occupations in the information technology job family such as Software Developers and Graphic Designers are among the most defensible of all occupations. To unravel this riddle, and to understand the larger force of automation and how it is impacting the labor market, one must go beyond the comfortable world of skills and into the other dimensions of defensibility.

- Four work values are highly defensible: Achievement, Recognition, Working Conditions and Independence
- Three work activities are highly defensible: Developing Objectives and Strategies, Thinking Creatively, and Providing Consultation and Advice to others
- Four abilities are highly defensible: Fluency of Ideas, Originality, Deductive Reasoning and Inductive Reasoning

Interests, the most influential model for analyzing psycho-social behavior in both labor market analysis and career guidance, reveal some of these clues based on the way that personality categories relate to defensibility. Artistic, Social and Investigate jobs are much harder to automate. In this context, the "Artistic" interest describes much more than painters and sculptors; many jobs from Adult Basic and Secondary Education Literacy Teachers and Instructors to Mechatronics Engineers have an Artistic aspect.

<b>Interest Categories Relationship with Defensibility</b>	
<b>Interest Category</b>	<b>Correlation with Defensibility</b>
Artistic	0.49
Social	0.47
Investigative	0.43
Enterprising	0.26
Conventional	-0.30
Realistic	-0.40

On the other hand, adapting to automation will in all likelihood be more demanding for a Conventional or Realistic person. This points to a key reality – adapting to automation will mean more than simply giving workers technical skills. The clear evidence of the unequal impact of automation on differing psycho-social categories is one of the most challenging findings of defensibility research. If a worker, by nature, possesses an inclination towards the Realistic or Conventional interest groups, it is very likely that adapting to automation will be much more personally demanding than for a worker who is by nature in the Social or Investigative category. Automating tasks and skills might be the immediate result of automation, but these data indicate that approaches to work, such as approaching work problems by carefully organizing them and utilizing existing frameworks to solve problems, may themselves be part of the defensibility story.

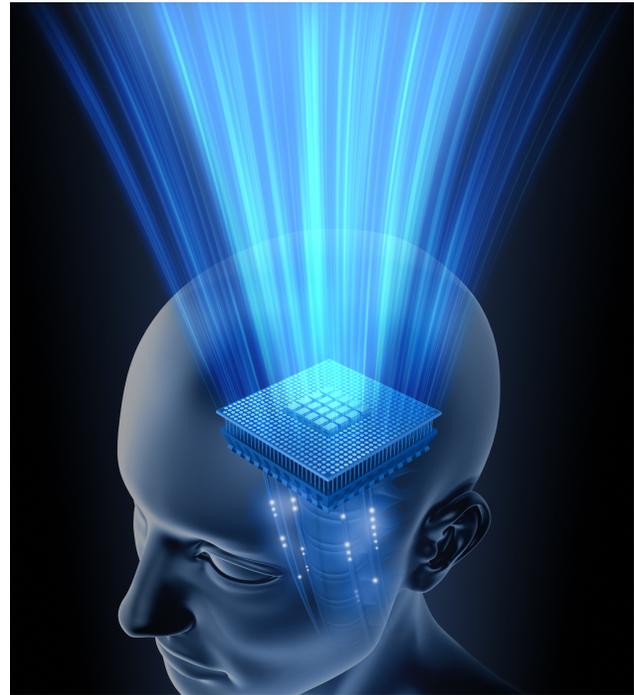
These defensible characteristics paint a complex but comprehensible picture. This kind of work may require a worker to use a variety of thinking skills in complex situations, or to impart wisdom on others. The worker is typically motivated through an internal locus of control, because they are working that job for the sake of fulfilling personal values. A combination of situational intelligence and social skills make them valuable contributors in a new workplace that increasingly emphasizes managing social networks over managing routine application of frameworks and management of details. Understanding how the allocation of labor will be transformed is only the first step to developing a new educational strategy, but it is still an important and powerful signpost.

## THE EDUCATIONAL DIMENSION

The vulnerability that exists across the board, from jobs that require no education to jobs that require decades of highly specialized training, is causing what might be the greatest labor market disruption since the industrial revolution. For many people, automation is perceived as something happening to cashiers or truck drivers, not them. One of the biggest issues posed by automation, as well as one of the greatest sources of confusion, is the fact that the routinized work that is vulnerable to automation is quite a large chunk of labor hours across

all levels of educational attainment. While jobs with lower educational requirements will certainly be the hardest hit, almost all five “job zones,” which are the categories that the Bureau of Labor Statistics uses to classify educational attainment requirements<sup>23</sup>, have some occupations that are projected to experience major impacts from automation. The implications of the much wider scale of automation for workers across a variety of education levels, and for the very nature of education, are vast.

Because routinized work is the most vulnerable to automation, it makes sense that there is a correlation between education level and defensibility. After all, the more ambiguous, complex and non-routine work is, the more training that is required to achieve competency. However, this relationship is by no means absolute; an estimated 31 percent of jobs opened in 2017 that require a Bachelor’s degree are vulnerable to automation. The percentage of vulnerable jobs that require a Bachelor’s degree or higher actually increased over the last four years. Many jobs that are opened today will not exist tomorrow. The demand that exists in the short-term may not be the best signal for crafting a long-term strategy that will help support workforce training.



The educational dimension also reveals a great deal of complexity regarding the impact of automation. Manual labor, for example, is expected by many researchers, such as the McKinsey Global Institute, to be one of the most vulnerable types of labor to automation.<sup>24</sup> As a general trend, this is confirmed by the fact that the majority of job openings that require a great deal of manual labor are in occupations where the labor is performed in a highly

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<sup>23</sup> The five job zones, which will be explored in more depth later in this report, are as follows: Job Zone 1 (occupations that require less than a high school diploma), Job Zone 2 (occupations that require a high school diploma and minor further preparation), Job Zone 3 (occupations that need medium preparation (extensive education and/or training, but not necessarily a Bachelor’s degree), Job Zone 4, (occupations that need considerable preparation, a minimum of a Bachelor’s degree), Job Zone 5 (occupations that need extensive preparation (minimum of a post-graduate degree)

<sup>24</sup> McKinsey Global Institute: A Future That Works: Automation, Employment, and Productivity

routinized way. Yet this uniform analysis of the labor market overlooks the possibility, hinted at by Frey and Osborne in their analysis of the computerization bottlenecks, that some types of manual labor are not so easy to automate. It also overlooks the reality that, for many jobs, the cognitive tasks end up being much more routine and easy to automate than the manual tasks, which often require at least some non-routine thinking. Research into the statistical relationships between occupational characteristics and defensibility that isolate for job zone reveals that among jobs with low levels of educational attainment, characteristics related to physical labor are actually among the strongest predictors of defensibility.

The appropriate guidance for individuals who wish to work in a job that does not require education might be different than for individuals who desire more education. This analysis isolates each of the five categories of educational attainment in order to understand this important question. Still, the defensibility prospects for workers who do not seek education are quite bleak, and educational attainment is one of the strongest predictors of defensibility. Less than 30 percent of openings in Job Zones 1 and 2, which are the job zones for workers who do not pursue any formal education beyond a high school degree, are expected to be defensible.

Today's education and training systems must assume the responsibility of preparing tomorrow's workers for an uncertain, increasingly automated future that will demand more complex cognitive abilities. How can educators best ensure that students develop the defensible, non-automatable skills (and other job characteristics) that will be crucial to success in these conditions? Educators will need to ask themselves several important questions:

- 1) What should be some of the key performance indicators for preparedness for defensibility? How should education prioritize these indicators?
- 2) What are the most fruitful directions for education to pursue, when considering the strategic outlook for preparing students for an automated workplace?
- 3) How can education shape the kind of workforce that will operate in this new environment? How can education help this workforce make the automated age better, safer and more human-friendly?

Over the past decade, educators have begun challenging conventional wisdom in order to accomplish these goals. Many aspects of traditional education, unfortunately, involve rote memorization, "plug and chug" application of equations and functions and other routine, repetitive cognitive activities that will not help students develop defensible characteristics. Movements like project-based learning, habits of mind, and integrated career pathways that weave together rigorous academic and career education have generated promising innovations in education. One emerging approach, human-centered design thinking, has exceptional potential to serve as a strong foundation for the future success of today's students.

Another aspect of the relationship between education and the defensibility of workers is the essence of what is taught in the classroom. The loss of the paper-pushing jobs is bittersweet<sup>25</sup>; while workers loathed the monotony and ennui that were produced by these jobs, there is also a certain safety in their routineness and predictability. Moreover, the structured and routine cognitive activity that defined them is a natural fit for what many people take away from traditional education, which is endless rote memorization and perpetual application of simple models. That is certainly not the goal of education, and the workers who have succeeded in the Investigative and Artistic categories of work probably managed to dig deeper and find something closer to the true goals of education. Nonetheless, the baseline cognitive activity that education imparts is highly structured and routinized. An alternative approach, design thinking, seeks to resolve this tension by creating a baseline that may be more well-suited for a workplace that has less and less paper-pushing, and increasingly emphasizes activities such as ideation.

The human-centered design thinking process has spread from the business world, where it originated, to education, healthcare and other fields. While the term can have different meanings in different situations, at its core design thinking is about using creativity to solve problems, as exemplified in the business setting by the late Steve Jobs.<sup>26</sup> As his biographer Walter Isaacson writes, Jobs' focus on creating beauty through design allowed him to "build a company that became the greatest force for innovation design – and the best proof of its importance – in our time."<sup>27</sup>

Jobs' 2007 iPhone keynote presentation provides a perfect example of the design thinking process in action, as Jobs gives his audience a glimpse at the iPhone's creation:

- He begins by identifying one major problem of c.2007 smartphones: an inconvenient user interface dominated by plastic buttons that are irrelevant to many applications.
- A similar problem, he notes, was solved decades earlier with the invention of the computer mouse to navigate "a bit-mapped screen that could display anything we want." Therefore, Apple would "get rid of the buttons and just make a giant screen."
- "How are we going to communicate with this?", Jobs asks. He rejects the possibility of carrying around a mouse and points out that a stylus would be inconvenient and easily lost.

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<sup>25</sup> The other side of this bittersweet development is the sweetness. Boredom is one of the most important sources of dissatisfaction in the workplace. This is especially true for the Millennial generation. One of the impacts of automation might be to make the workplace more stimulating, and open up more possibilities for genuine self-expression.

<sup>26</sup> Quoted in Walter Isaacson, *Steve Jobs*, p. 127.

<sup>27</sup> Walter Isaacson, "How Steve Jobs' Love of Simplicity Fueled A Design Revolution," *Smithsonian* September 2012.

- “We’re going to use the best pointing device in the world,” Jobs concludes, “a pointing device that we’re all born with. We’re born with ten of them. We’ll use our fingers.” He goes on to introduce the Apple touchscreen, which has revolutionized how we interact with technology.<sup>28</sup>

This short excerpt from Jobs’ presentation shows many of the key steps of the design thinking process: identifying problems, finding inspiration in previous innovations, brainstorming potential solutions, developing these solutions and applying them to the original problem. Just as important as any of these steps, the entire process is guided by an imaginative empathy with the consumer and a willingness to think through how they will use the product and what problems they might encounter. This process, of course, can apply to many fields beyond consumer product design. In a 2017 New York Times article, physician and journalist Dr. Amitha Kalaichandran notes the increasing use of design thinking ideas in Healthcare.<sup>29</sup> She points to one innovation in her own hospital: an orange “trauma team leader identification vest”<sup>30</sup> created

“by a nurse after a hectic gunshot trauma simulation, in which a huddle of highly stressed emergency room staff members spoke over one another and there were no clear roles. In particular, no one knew who was leading the trauma code. The orange vest became a routine part of emergency care at our hospital earlier this year, and the trauma team reports it has helped clarify who’s in charge and strengthened communication among members.”<sup>31</sup>

After describing several other examples of design thinking-related innovations in Healthcare, Dr. Kalaichandran concludes by arguing that “fostering simple innovations through design thinking in hospitals” can save “both dollars and lives.”<sup>32</sup>

Both of these examples illustrate design thinking’s tremendous potential to solve problems by “thinking outside of the box.” The design thinking process uses many of the skills – creativity, critical thinking, identifying and solving problems – that will be absolutely essential for future workers as automation takes over more and more routine tasks. While many of today’s work activities could be performed by machines in the near future, it seems highly unlikely that a machine could ever exhibit the kind of creative thought process that led to the

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<sup>28</sup> Apple did not invent the touchscreen, but they did popularize multi-touch technology, which allows users to use their fingers instead of a special stylus. The only truly successful pre-iPhone touch screen product was the Nintendo DS (released in 2004), a handheld game console that used a stylus.

<sup>29</sup> Amitha Kalaichandran, “design thinking for Doctors and Nurses,” *New York Times* 3 Aug. 2017.

<sup>30</sup> Ibid.

<sup>31</sup> Ibid.

<sup>32</sup> Ibid.

iPod's design. One section of this report covers the impact of design thinking on education, where it has become a growing trend for a good reason – encouraging the development of these skills gives students a strong foundation for adding a uniquely human, non-automatable value to their future employers.

## RE-FOCUSING STUDENT PREPARATION FOR THE JOB MARKET OF THE FUTURE

The current media narrative that workers need to learn tech skills in order to survive does not tell the whole story. The work situations that are increasingly left in the hands of actual humans are complex; workers will need to be able to make a positive impact by being able to analyze, understand and respond to these situations. The skills for doing so apply to more than using technologies. Workers will need to add value through non-skill work dimensions – by having the motivations, hybridized skills and abilities fundamental to success. This is where education can make its strongest impact, as curricula that support the development of these work dimensions will help shield future workers from automation. The design thinking approach offers a promising way forward for educators through its focus on creative problem solving.

The complete worker that can add value in ways other than providing routine labor is not just skilled – they have a set of motivations, knowledge areas and abilities that are fundamental to success. This is exactly where the education system can make its strongest impact. Curriculum that supports students developing these skills will help shield the individuals from the impacts of automation on the job market. Ultimately, both education and the labor market want critical thinkers, people who act on their civic and social duties, and people who seek to improve current conditions. Adapting to automation could be an unprecedented opportunity to transform the workplace into one more empathetic, creative and fulfilling. While it is one of the greatest challenges that education has ever faced, the tension between the goals of education and the need for direct, immediate action to prepare people for an automated workplace could result in a better long-term alignment between these conflicting mandates.

# THE DIMENSIONS OF DEFENSIBILITY

This report measures the result of testing nearly 200 variables that are recorded for every occupation via survey research performed by the Bureau of Labor Statistics, as well as other data that are available only through cutting-edge “bottom-up” methods of labor market collection that rely on aggregated job posting data, against the respective occupational defensibility scores. This produces a large array of measures of how strong or weak the statistical relationship is between the characteristics that define our work and the likelihood that a job is safe from replacement by automation. Using this research, it is possible to paint a more complete picture of the way that automation works and point to opportunities to improve the preparedness of Orange County’s future workers to gain a competitive advantage.

Across the entire labor market, the following characteristics correlate the most strongly with defensibility:<sup>33</sup>

- 1) Originality
- 2) Idea Generation
- 3) Values Achievement
- 4) Values Recognition
- 5) Requires Constant Learning and Up-Skilling
- 6) Requires Teaching Others
- 7) Requires Contributions to Strategy and Planning
- 8) Requires Data Analysis and Monitoring
- 9) Values Working Conditions
- 10) Requires Coordinating with Others

These characteristics vary from those that imply technical skills, such as analyzing and monitoring data, to those that are obviously linked to transferable skills, such as up-skilling, coordinating with others and generating ideas. Some describe an employee’s emotional connection to their job, such as valuing Achievement and Recognition. The most defensible characteristic is Originality, which expresses the very human but very powerful ability to create something – an ability which computers lack by definition.

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<sup>33</sup> The inverse of the vulnerability of an occupation to automation.

Significant diversity exists in the relationships between defensibility and different work characteristics. This is indicated by the fact that workers who truly value almost anything about their job – including Achievement, Recognition or Work Conditions – tend to have more defensible jobs, and that relationship is much more important than any other skill, knowledge base or even salary. Understanding the relationship between defensibility and worker characteristics is a necessary step toward fully understanding automation’s potential impact on the Orange County labor market. The first section of this analysis will highlight important statistical relationships within each dimension, parsing out the aspects of work that truly define defensibility – or vulnerability – to automation.

<b>Table 1: Dimensions of Defensibility<sup>34</sup></b>		
<b>Characteristic</b>	<b>Value</b>	<b>Meaning</b>
<b>Work Values</b> (Global aspects of work that are important to a person's satisfaction)	0.52	Strong, positive relationship with defensibility
<b>Salary</b> (Compensation offered for labor of specific occupation)	0.52	Strong, positive relationship with defensibility
<b>Work Style</b> (Personal characteristics that can affect how well someone performs a job)	0.42	Moderate, positive relationship with defensibility
<b>Skill</b> (Developed capacities that help the worker achieve a variety of things)	0.36	Moderate, positive relationship with defensibility

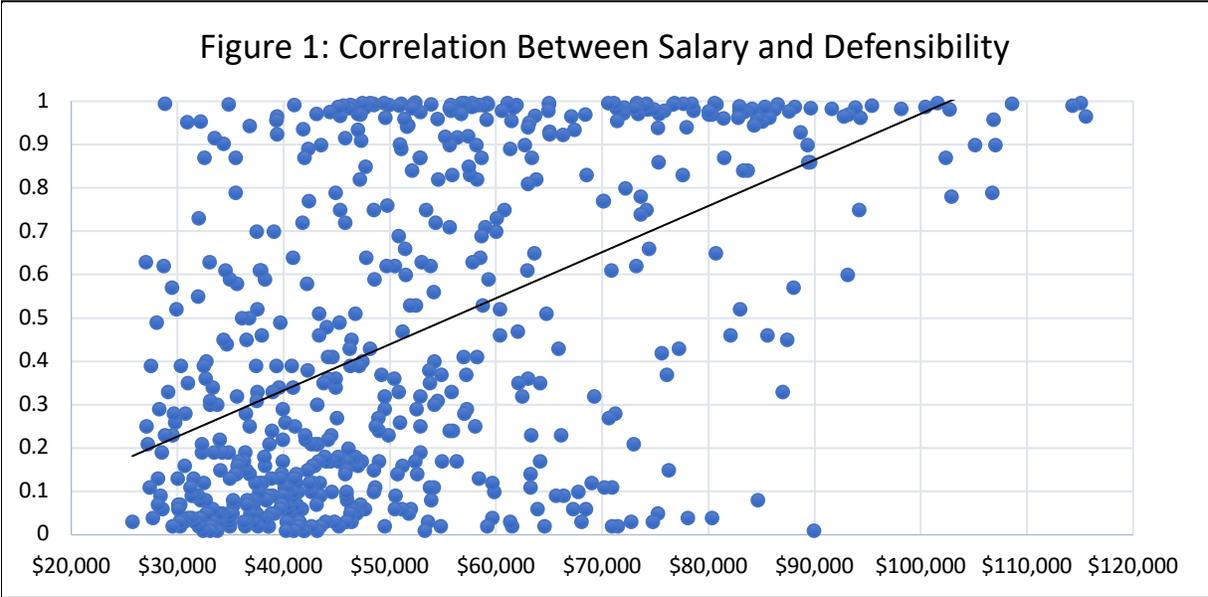
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<sup>34</sup> Research uses data from “The Future of Employment: How Susceptible are Jobs to Computerization?” For defensibility, as well as data from the Bureau of Labor Statistics for occupational characteristics. Labor market data is from Burning Glass

<b>Activity</b> (General types of job behaviors occurring on multiple jobs)	0.29	Mild, positive relationship with defensibility
<b>Knowledge</b> (Organized sets of principles and facts applying in general domains)	0.25	Mild, positive relationship with defensibility
<b>Interest</b> (Preferences for work environments and outcomes)	0.16	Weak, positive relationship with defensibility
<b>Ability</b> (Enduring attributes of the individual that influence performance)	0.05	Very weak, positive relationship with defensibility

**Salary**

*The average compensation for an occupation*



- Salary is an important index of labor scarcity, as workers with relatively rare, high-demand skill sets, such as technical skills related to information technology, earn high wages. The strong correlation between salary and defensibility implies a relative scarcity of defensible skillsets.

- Furthermore, because automation is expected to reduce demand for jobs that are not defensible, the strong relationship between salary and defensibility implies that the labor market has already begun to experience the supply and demand impacts of automation. Complete automation of a job might be the final result, but reduced wages, reduced demand and increased competition is a likely mid-term development as more workers compete for fewer hours.
- As a result, an occupation's salary is actually a stronger predictor of defensibility than characteristics that have a more obvious connection to defensibility, such as work values and activities. Salary itself is a very strong predictor of values, such as independence and achievement and skills such as Systems Analysis and Active Listening, which themselves are very strong predictors of defensibility. This relationship connects two of the most important predictors of defensibility. In other words, the most defensible characteristics are often those that are relatively scarce. An important question arises from this analysis: Why are these skills and values scarce?

### Work Values

*Global aspects of work that are important to a person's satisfaction<sup>35</sup>*

<b>Table 2: Work Values Relationship with Defensibility</b>	
<b>Value</b>	<b>Correlation with Defensibility, Entire Labor Market</b>
Achievement	.74
Recognition	.71
Working Conditions	.69
Independence	.66
Relationships	.39
Support	-.08

*Occupational Data Sourced from Bureau of Labor Statistics*

- Valuing Achievement, Recognition, Working Conditions and Independence are among the strongest predictors of an occupation's defensibility. Workers who thrive in a results-oriented environment, who feel that their occupation enables them to work at their highest capabilities, who value making their own decisions and who value

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<sup>35</sup> All definitions of occupational dimensions and characteristics come from O\*NET, the online portal for the Bureau of Labor Statistics.

opportunities for advancement and prestige are very likely to find the occupations and activities of the future world of work highly fulfilling.<sup>36</sup>

- The jobs that are among the most defensible occupy an intersection of personal interests and ambitions and career opportunities. The distinction between competency and motivation becomes somewhat blurred in an automated workplace. Constant up-skilling, for example, will be an integral part of the future world of work that depends on an individual's desire for growth, belief in self-efficacy, and ability to discover and leverage resources.

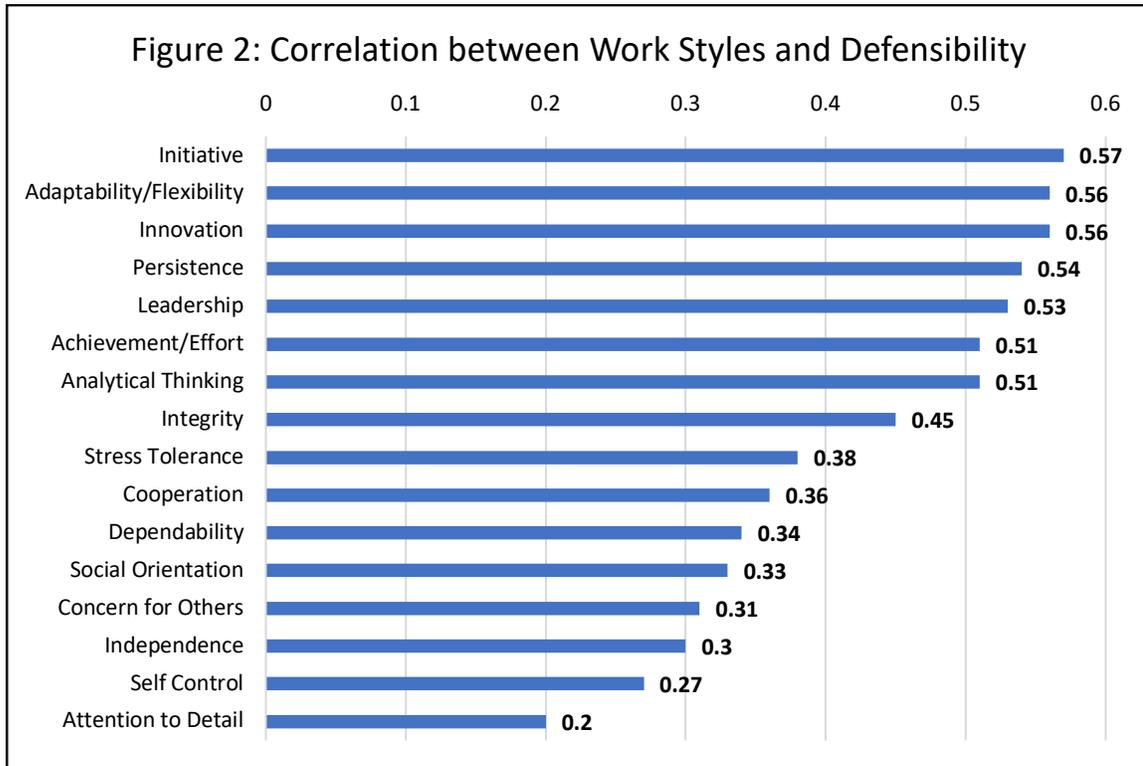


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<sup>36</sup> O\*NET [https://www.onetonline.org/find/descriptor/browse/Work\\_Values/](https://www.onetonline.org/find/descriptor/browse/Work_Values/)

## Work Style

*Personal characteristics that can affect how well someone performs a job*



*Occupational Data Sourced from Bureau of Labor Statistics*

- Work styles represent one of the most sophisticated parts of an occupation's requirement. Understanding the hierarchy of sophistication in the labor market, compared to salary, helps to explain why. There is a clearly observable hierarchy in the characteristics of jobs. For example, job postings with higher technical skill requirements consistently offer lower compensation compared to job postings in the same occupation with lower technical skill requirements. After all, a senior level worker will not very often work with the technical systems, and they are assumed to have the competency already. The styles that workers possess are at the other end of the spectrum; the very act of reporting work styles represents a higher level of sophistication of labor. Even in this category, there is a clear texture to the statistical relations that exist.
- The differences in defensibility among these high-level styles reflect one profound impact of automation. Styles such as Attention to Detail and Dependability do not strongly correlate to defensibility, while styles such as Initiative have a much strong correlation. This suggests that the most defensible work styles reflect a worker's

willingness to identify and capitalize on new opportunities, rather than maintaining the status quo.

### **Skills**

*Developed capacities to learn, solve complex problems, allocate resources efficiently, work with systems machines*

<b>Table 3: Statistical Relationships Between Defensibility and Skills</b>	
<b>Skill</b>	<b>Correlation with Defensibility</b>
Active Learning	0.67
Critical Thinking	0.64
Systems Evaluation	0.64
Systems Analysis	0.63
Learning Strategies	0.63
Judgment and Decision Making	0.63
Complex Problem Solving	0.62
Instructing	0.61
Coordination	0.60

*Occupational Data Sourced from Bureau of Labor Statistics*

- Individual variables within the skills dimension are among the strongest predictors of defensibility; but skills, when looking at the average relationship, are only a moderately positive predictor. This suggests that many current skills are vulnerable to automation and offshoring, and, in general, that the impact of automation has been felt very strongly and very directly in this category.
- Thinking skills, also becoming known as “essential skills,” are among the top predictors of defensibility. When looking at the average reported for thinking skills, 37

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<sup>37</sup> These include Active Learning, Critical Thinking, Complex Problem Solving and Judgement and Decision-Making

only nine occupations with an average thinking score below 3 also have a defensibility score above 0.9. Still, these nine occupations have very high requirements for skills related to creativity or interacting with other people, such as Management of Personnel Resources and Visualization.

- Childcare Workers
  - Craft Artists
  - Fine Artists, Including Painters, Sculptors, and Illustrators
  - Fitness Trainers and Aerobics Instructors
  - Floral Designers
  - Graphic Designers
  - Makeup Artists, Theatrical and Performance
  - Photographers
  - Radio and Television Announcers
- 
- One important example to look at is the case of the information technology sector. Software Developers do require high levels of Programming skills, but Programming skills actually tend to be relatively weak predictors of defensibility. This occupation, in addition to these requirements, also require Systems Evaluation and Systems Analysis skills at a level nearly three standard deviations higher than the rest of the labor market. These skills play a key role for Software Developers as well as seemingly unrelated occupations such as Human Resource Managers and Chief Executives, and they have a strong correlation with defensibility. High-level hybrid skills, such as Systems Evaluation and Systems Analysis, are important transferable skills that help explain why Programming, the skill, is a poor predictor of defensibility, but occupations in the information technology job family are not. This is a point worth considering when thinking about the impact of education on how workers are able to approach and solve real world problems.

<b>Table 4: Statistical Relationships Between Defensibility and Skills Involving Working with Physical Thinking</b>	
<b>Realistic Skill</b>	<b>Correlation with Defensibility</b>
Troubleshooting	-0.24
Operation Monitoring	-0.26
Repairing	-0.30
Equipment Maintenance	-0.31
Operation and Control	-0.32

*Occupational Data Sourced from Bureau of Labor Statistics*

- The skills that track the most poorly with defensibility across the entire labor market are those that involve dealing with physical things. This relationship corresponds with the fact that the Realistic Holland Code, the interest category that corresponds with work that deals with the physical systems or the outdoors, also tracks poorly with defensibility.<sup>38</sup>
- Operation and Control has the strongest negative relationship with defensibility of any skill in the labor market as a whole. Jobs like Adhesive Bonding Machine Operators and Tenders, Airline Pilots and Excavating and Loading Machine and Dragline Operators, which report the highest levels of importance for this skill, have an average defensibility score of only 0.31.

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<sup>38</sup> This relationship only holds when examining occupations across all job zones; when comparing occupations within job zones, skills that involve machines or physical things are often more defensible than jobs that involve highly routine cognitive labor. This trend is noticeable in Job Zones 1 and 2; the most defensible occupations in those zones are still those that combine expertise in areas such as science or quality control with those Realistic skills.

## Work Activities

*General types of job behaviors occurring on multiple jobs*

<b>Table 5: Statistical Relationships Between Defensibility and Work Activities, Top 3</b>	
<b>Activity</b>	<b>Correlation with Defensibility</b>
Developing Objectives and Strategies	0.63
Thinking Creatively	0.63
Provide Consultation and Advice to Others	0.61

*Occupational Data Sourced from Bureau of Labor Statistics*

- In general, work activities have a mildly positive relationship with defensibility, as increases in the importance of most activities correlates to slight increases in defensibility. There is evidence that suggests that having more activities listed as important is a good predictor of defensibility. But simply listing more of other dimensions such as values, or work styles, or even skills are still even stronger predictors.

<b>Table 6: Statistical Relationships Between Defensibility and Work Activities, Negative Predictors</b>	
<b>Activity</b>	<b>Correlation with Defensibility</b>
Repairing and Maintaining Electronic Equipment	-0.12
Resolving Conflicts and Negotiating with Others	-0.22
Getting Information	-0.25
Evaluating Information to Determine Compliance with Standards	-0.26
Drafting, Laying Out, and Specifying Technical Devices, Parts, and Equipment	-0.32
Performing Administrative Activities	-0.35
Estimating the Quantifiable Characteristics of Products, Events, or Information	-0.36

*Occupational Data Sourced from Bureau of Labor Statistics*

- Highly routine cognitive and manual activities rank as the strongest negative predictors of defensibility. While occupations that report high levels of importance for

these activities are highly vulnerable to technological disruption, this relationship does not hold for jobs where these activities are less important.

- All the other activities are middling positive predictors of defensibility, such as Updating and Using Relevant Knowledge, Monitoring and Controlling Resources and Evaluating Information to Determine Compliance with Others.

## Knowledge

*Organized sets of principles and facts applying in general domains*

<b>Table 7: Statistical Relationships Between Defensibility and Knowledge Areas</b>	
<b>Knowledge Area</b>	<b>Correlation with Defensibility</b>
Psychology	0.56
Sociology and Anthropology	0.55
English Language	0.50
Education and Training	0.49
Philosophy and Theology	0.48
Communications and Media	0.48
Therapy and Counseling	0.48

*Occupational Data Sourced from Bureau of Labor Statistics*

- The relationship between knowledge areas and defensibility, in some ways, reveals the most unexpected results about the impact of automation on the labor market: Knowledge areas that correspond to non-vocational sociology, psychology and humanities training areas tend to correlate more strongly with defensibility than vocational knowledge areas. This evidence appears to contradict the common strategy of emphasizing technical skills and vocational majors, at least on the surface.

**Table 8: Statistical Relationships Between Defensibility and Knowledge Areas, Vocational**

<b>Knowledge Area</b>	<b>Correlation with Defensibility</b>
Computers and Electronics	0.34
Sales and Marketing	0.20
Economics and Accounting	0.20
Chemistry	0.16
Mathematics	0.13
Engineering and Technology	0.13
Design	0.12

*Occupational Data Sourced from Bureau of Labor Statistics*



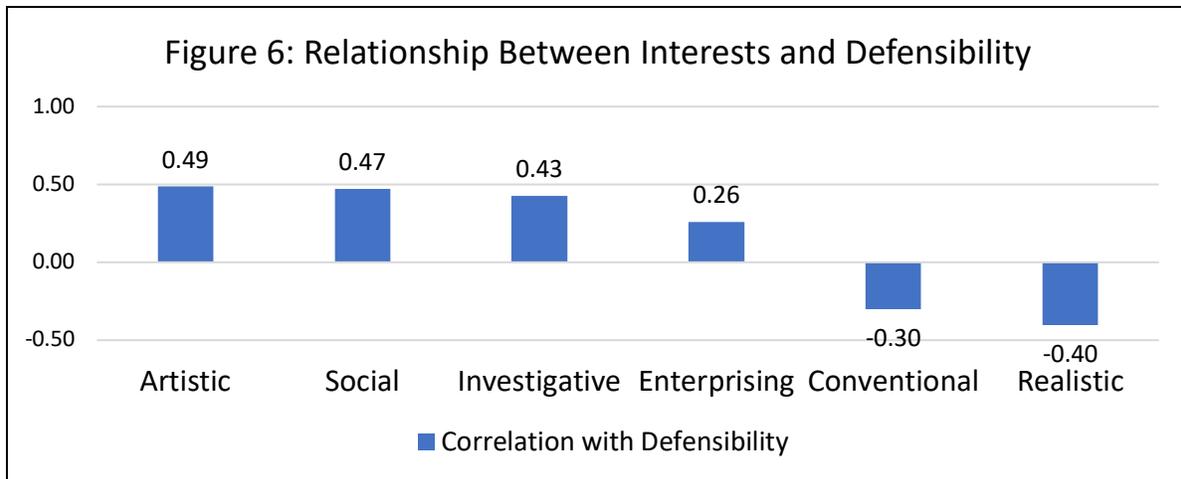
## Interests

*Preferences for work environments and outcomes*

**Table 9: The 6 Work Interests, or Holland Codes:**

- Realistic – Realistic occupations frequently involve work activities that include practical, hands-on problems and solutions. They often deal with plants, animals and real-world materials like wood, tools and machinery. Many of the occupations require working outside and do not involve a lot of paperwork or working closely with others.
- Investigative – Investigative occupations frequently involve working with ideas and require an extensive amount of thinking. These occupations can involve searching for facts and figuring out problems mentally.
- Artistic – Artistic occupations frequently involve working with forms, designs and patterns. They often require self-expression, and the work can be done without following a clear set of rules.
- Social – Social occupations frequently involve working with, communicating with, and teaching people. These occupations often involve helping or providing service to others.
- Enterprising – Enterprising occupations frequently involve starting up and carrying out projects. These occupations can involve leading people and making many decisions. Sometimes they require risk-taking and often deal with business.
- Conventional – Conventional occupations frequently involve following set procedures and routines. These occupations can include working with data and details more than with ideas. Usually there is a clear line of authority to follow.

*Occupational Definitions Sourced from Bureau of Labor Statistics*



*Occupational Data Sourced from Bureau of Labor Statistics*

- Interests have a wide spectrum of correlations with defensibility. As shown in the following chart, Interests has more dramatic differences between its most and least defensible variables than any other category.
- The fact that these categories have more or less distinguishable statistical relationships with defensibility is also important. Every day young people are recommended jobs on the basis that they took the Strong Interest Inventory and were assessed as, for example, "ICE" – Investigative, Conventional, Enterprising.
- Developing distinctive responses that are adapted to the very different automated workplaces that each of these groups face will be important; the proper guidance for Conventional-minded workers will likely vary compared to those who may find adaptation to the automated workplace to be easier, such as Social-minded workers.

## Abilities

*Enduring attributes of the individual that influence performance*

<b>Table 10: Statistical Relationships Between Defensibility and Abilities</b>	
<b>Ability</b>	<b>Correlation with Defensibility</b>
Speech Clarity	0.57
Written Expression	0.57
Written Comprehension	0.55
Oral Comprehension	0.55
Category Flexibility	0.55
Problem Sensitivity	0.54
Speech Recognition	0.53
Information Ordering	0.50
Memorization	0.48

*Occupational Data Sourced from Bureau of Labor Statistics*



<b>Table 11: Statistical Relationships Between Defensibility and Abilities, All Negative Predictors</b>	
<b>Ability</b>	<b>Correlation with Defensibility, Entire Labor Market</b>
Explosive Strength	-0.01
Visual Color Discrimination	-0.02
Dynamic Flexibility	-0.13
Hearing Sensitivity	-0.18
Auditory Attention	-0.20
Gross Body Equilibrium	-0.22
Depth Perception	-0.23
Spatial Orientation	-0.24
Gross Body Coordination	-0.26
Night Vision	-0.26
Finger Dexterity	-0.26
Stamina	-0.27
Peripheral Vision	-0.28
Sound Localization	-0.29
Glare Sensitivity	-0.29
Response Orientation	-0.30
Trunk Strength	-0.30
Dynamic Strength	-0.31
Multi-limb Coordination	-0.32
Static Strength	-0.32
Extent Flexibility	-0.32
Reaction Time	-0.34
Arm-Hand Steadiness	-0.35
Speed of Limb Movement	-0.35
Wrist-Finger Speed	-0.36
Rate Control	-0.39
Control Precision	-0.39
Manual Dexterity	-0.41

*Occupational Data Sourced from Bureau of Labor Statistics*

- Abilities have the weakest overall statistical relationship with defensibility of any work dimension. A job that requires more abilities is not necessarily more defensible. Abilities related to cognition and socialization, on the other hand, are positively correlated with defensibility.

- Four abilities that are particularly strong predictors of defensibility all relate to high-level human cognition:

<b>Table 12: Statistical Relationships Between Defensibility and Abilities, Strong Predictors</b>	
<b>Ability</b>	<b>Correlation with Defensibility, Entire Labor Market</b>
Fluency of Ideas	0.72
Originality	0.72
Deductive Reasoning	0.65
Inductive Reasoning	0.64

*Occupational Data Sourced from Bureau of Labor Statistics*

- These abilities, simply put, cannot be automated and will form the basis of non-routine cognitive work that will dominate tomorrow's job market. They relate strongly to the principles that define design thinking. It is important to ensure that abilities such as fluency of ideas and originality, are well-developed in future workers.
- These abilities also hint at why non-technical degrees might represent a surprising source of strength for higher education. A liberal arts student, for example, is very well-prepared for Fluency of Ideas by years of thinking of new ideas and arguments in the classrooms. However, almost any subject can be a conduit for young people to develop these skills.

## DEFENSIBILITY ACROSS JOB ZONES

Much of the media narrative around automation has focused on the elimination of low-skilled, low-wage jobs, such as the replacement of fast food cashiers with tablets that take orders, truck drivers with autonomous vehicles, or retail sales people with intelligent mobile phone applications. This does not tell the entire story. Jobs across the labor market – even those requiring extensive education – are vulnerable to automation. The table below lists the defensibility scores of the education-intensive occupations with the most job openings in 2017 along with their defensibility scores, and shows very serious vulnerability to automation even among jobs that require a bachelor’s degree. Occupations with defensibility scores lower than 0.5, an indication of high vulnerability to automation are indicated with red text, while occupations with defensibility scores lower than 0.9 but higher than 0.5, an indication of moderate vulnerability to automation, are indicated with orange text.

<b>Table 13: Common, Skilled Occupations – Are they Defensible?</b>			
<b>Occupation</b>	<b>Job Openings 2017</b>	<b>Average Education Requirement</b>	<b>Defensibility</b>
<b>Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products</b>	940,632	Bachelor’s Degree	0.15
Software Developers, Applications	723,023	Bachelor’s Degree	0.958
Medical and Health Services Managers	289,525	Graduate Degree	0.9927
Sales Managers	266,209	Bachelor’s Degree	0.987
<b>Management Analysts</b>	240,913	Bachelor’s Degree	0.87
<b>Accountants</b>	239,867	Bachelor’s Degree	0.06
<b>General and Operations Managers</b>	187,523	Bachelor’s Degree	0.84

Marketing Managers	187,256	Bachelor's Degree	0.986
Computer Systems Analysts	177,567	Bachelor's Degree	0.9935
<b>Market Research Analysts and Marketing Specialists</b>	168,201	Bachelor's Degree	0.39
Physical Therapists	167,802	Graduate Degree	0.979
Network and Computer Systems Administrators	123,858	Bachelor's Degree	0.97
<b>Insurance Sales Agents</b>	121,520	Bachelor's Degree	0.08
Database Administrators	121,403	Bachelor's Degree	0.97
Speech-Language Pathologists	117,168	Graduate Degree	0.9936
<b>Financial Analysts</b>	116,306	Bachelor's Degree	0.77

*Labor Market Data Sourced from Burning Glass Labor Insight*

This chart shows that slightly under 1,400,000 of the 4,100,000 jobs posted in 2017 that were analyzed are highly vulnerable to automation. Many occupations, such as Management Analysts, are mostly defensible but have automatable elements; the Management Analyst, on average, reports a level of importance for the work activity of Processing Information (which is routinized cognitive labor) that is almost two standard deviations above the rest of the labor market. Any job with a significant amount of time spent on routine-cognitive work activities is highly vulnerable to automation, including Accountants, Technical Writers and (unfortunately) Economists. While not in immediate danger of being automated, these jobs could change significantly in the near future.

Jobs with lower educational requirements are also becoming even more vulnerable to automation. Of the 271 occupations that require less than “middle-skills” training, a mere 7 have a defensibility score of 0.9 or higher – which would indicate a comfortable likelihood of that job persisting into the automated workplace. Even including middle-skill jobs, that figure

jumps to only 41 out of 438, just shy of 10 percent<sup>39</sup>, that would be comfortably defensible against automation.

This section of the report examines the complex relationships between defensibility and groupings of occupations based on education requirements. The results challenge assumptions about job defensibility by deconstructing the myth that automation will uniformly impact the entire labor market. The analysis begins by dividing the job market into five zones based on educational requirements:

- Job Zone 1: occupations that require less than a high school diploma
  - Examples: Dishwashers, Landscaping and Groundskeeping Workers, Waiters
- Job Zone 2: occupations that require a high school diploma and minor further preparation
  - Examples: Animal Control Workers, Hoist and Winch Operators, Public Address System and Other Announcers
- Job Zone 3: occupations that need medium preparation (extensive education and/or training, but not necessarily a Bachelor's degree)
  - Examples: Audio and Video Equipment Technicians, Dental Hygienists, Physical Therapist Assistants
- Job Zone 4: occupations that need considerable preparation (minimum of a Bachelor's degree)
  - Examples: Budget Analysts, Kindergarten Teachers, Software Developers
- Job Zone 5: occupations that need extensive preparation (minimum of a post-graduate degree)
  - Examples: Education Administrators, Postsecondary, Lawyers, Soil and Plant Scientists

## JOB ZONE LABOR MARKET INFORMATION

The job market approximates a normal distribution based on job zone; only a few jobs require either no preparation at all or an advanced degree, and the vast majority fall somewhere in between. Overall, 2017 saw more than 3,000,000 more openings across all job

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<sup>39</sup> It should be noted that this is a measure of occupations, whereas the rest of the analysis of this section analyses occupations as a number of job openings. The few occupations that are defensible in these categories, especially in middle skill jobs, tend to represent a relatively large share of the job postings.

zones than 2014, a 19 percent increase. Only a small fraction of this increase was seen in Job Zone 1 occupations; this category has stagnated due in part to the rise of part-time work, which is generally not well captured by online job opening statistics. Job Zones 2, 3 and 5 saw robust growth, while Zone 4 saw slow growth and slightly shrank as a percentage of overall job opening activity.

<b>Job Zone</b>	<b>2014 Jobs Opened</b>	<b>2017 Jobs Opened</b>	<b>Increase in Openings</b>	<b>% Change</b>
<b>1 - Less than High School</b> occupations that require less than a high school diploma	858,509	866,553	8,044	0.90%
<b>2 - High School diploma</b> occupations that require a high school diploma, and minor further preparation	5,303,673	6,307,597	1,003,924	18%
<b>3 - Middle Skills</b> occupations that need medium preparation (extensive education and/or training, but not necessarily a Bachelor's degree)	4,370,650	5,882,258	1,511,608	34%
<b>4 - Bachelor's Degree</b> occupations that need considerable preparation (minimum of a Bachelor's degree)	6,024,288	6,617,270	592,982	10%
<b>5 - Graduate/Professional Degree</b> occupations that need extensive preparation (minimum of a post-graduate degree)	1,550,954	1,974,686	423,732	27%
<b>Overall</b>	<b>18,108,074</b>	<b>21,648,364</b>	<b>3,540,290</b>	<b>19%</b>

*Labor Market Data Sourced from Burning Glass Labor Insight*

<b>Table 15: Meta-Data: 2014-2017 Openings Data by Job Zone, Share of Total</b>		
<b>Job Zone</b>	<b>(2014) Percent of Total Openings</b>	<b>(2017) Percent of Total Openings</b>
<b>1 - Less than High School</b> occupations that require less than a high school diploma	4.7%	4.0%
<b>2 - High School diploma</b> occupations that require a high school diploma, and minor further preparation	29.3%	29.1%
<b>3 - Middle Skills</b> occupations that need medium preparation (extensive education and/or training, but not necessarily a Bachelor's degree)	24.1%	27.2%
<b>4 - Bachelor's Degree</b> occupations that need considerable preparation (minimum of a Bachelor's degree)	33.3%	30.6%
<b>5 - Graduate/Professional Degree</b> occupations that need extensive preparation (minimum of a post-graduate degree)	8.6%	9.1%

*Labor Market Data Sourced from Burning Glass Labor Insight*

The percentage of defensible job openings increased from 53 percent to 55 percent between 2013 and 2017, with the majority of defensible jobs added in Zone 3. Nearly a third of this increase came from a single occupation: Registered Nurses. Aggregated Burning Glass job postings show that over 900,000 nursing jobs have been opened since 2014. These openings, however, only translated into 169,292 new actual jobs, reflecting a skills gap in this industry; employers are struggling to find suitable candidates for this position. Zone 4 actually saw a very slight decline in its percentage of defensible openings. Accountants, Insurance Sales Agents, Personal Financial Advisors, Market Research Analysts and Cost Estimators experienced a combined 37.6 percent increase in openings, from 594,830 postings in 2014 to 787,753 postings in 2017. These occupations have an average defensibility of 0.27 and spend a relatively large amount of time performing routinized cognitive work activities such as Processing Information, Performing Administrative Activities and Getting Information. Job Zone 2 also saw large increases in openings for highly vulnerable occupations such as Laborers and Freight, Stock and Material Movers, Hand; Security Guards; Cooks; and Data Entry Keyers. These surprising increases in demand for occupations vulnerable to automation might be a source of future correction as labor-saving

technologies. One thinks of the newly opened Amazon retail stores that notably have no human employees in the facility.

<b>Table 16: Meta-Data: 2014-2017 Defensible vs. Vulnerable Openings</b>					
<b>2014</b>			<b>2017</b>		
<b>Job Zone</b>	<b>Defensible Openings</b>	<b>Vulnerable Openings</b>	<b>Job Zone</b>	<b>Defensible Openings</b>	<b>Vulnerable Openings</b>
<b>1 - Less than High School</b> occupations that require less than a high school diploma	78,950	779,559	<b>1</b>	82,397	784,156
<b>2 - High School diploma</b> occupations that require a high school diploma, and minor further preparation	1,472,831	3,830,842	<b>2</b>	1,612,246	4,695,351
<b>3 - Middle Skills</b> occupations that need medium preparation (extensive education and/or training, but not necessarily a Bachelor's degree)	2,410,600	1,960,050	<b>3</b>	3,650,620	2,231,638
<b>4 - Bachelor's degree</b> occupations that need considerable preparation (minimum of a Bachelor's degree)	4,221,647	1,802,641	<b>4</b>	4,563,951	2,053,319
<b>5 - Graduate/Professional Degree</b> occupations that need extensive preparation (minimum of a post-graduate degree)	1,504,566	46,388	<b>5</b>	1,920,654	54,032
<b>Overall</b>	9,688,595	8,419,479	<b>Overall</b>	11,829,868	9,818,496
Percent	53%	47%		55%	45%

*Labor Market Data Sourced from Burning Glass Labor Insight*

# DESIGN THINKING IN CONTEXT

## DESIGN THINKING FOR EDUCATION

Design thinking has become an important, emerging field for education. The website TeachThought, self-described as “dedicated to innovation in K-20 education,” lists 45 different online design thinking resources for teachers.<sup>40</sup> The MOOC provider edX offers “a hands-on course for education leaders to learn about design thinking and explore how it can transform classroom learning and school communities.”<sup>41</sup>

Despite its popularity, design thinking remains difficult to define for both journalists and its own proponents. The Atlantic’s Jessica Lahey, for example, writes that “The lack of a clear definition makes explaining, evaluating, and studying design thinking a challenge.” IDEO Chicago Executive Portfolio Director Neil Stevenson has described design thinking as “a bundle of mindsets and philosophies all wrapped up in one term, which obviously has the potential to lead to ambiguity and misunderstanding.”<sup>42</sup> This confusion, unfortunately, can mask its true potential for revitalizing K-12 education. As Lahey writes, “When executed with a clear understanding of its purpose as a method for fostering empathy, creativity, and innovation, design thinking can be a powerful tool for learning and change.”

IDEO’s design thinking for Educators toolkit, which provides perhaps the clearest definition, defines design thinking as a teaching mindset with four major characteristics.

- 1) Human-centered design that “begins from deep empathy and understanding of needs and motivations of people.”
- 2) A focus on collaboration.
- 3) A fundamental sense of optimism “no matter how big a problem, how little time or how small a budget.”
- 4) A process of experimentation driven by a willingness to take risks.
- 5) The toolkit goes on to identify a five-step design thinking process.
- 6) The discovery phase involves understanding the specific challenge faced as well as research.

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<sup>40</sup> <http://www.teachthought.com/pedagogy/45-design-thinking-resources-for-educators/>

<sup>41</sup> <https://www.edx.org/course/design-thinking-leading-learning-mitx-microsoft-education-11-155x>

<sup>42</sup> Quoted in Lahey.

- 7) The interpretation phase involves using research and other findings to build a narrative for the project and identifying opportunities.
- 8) The ideation phase involves the creation and refinement of possible solutions.
- 9) The experimentation phase involves prototyping ideas and gathering feedback in order to improve them.
- 10) The evolution phase involves assessing the idea's impact and planning for the future.

In addition to basic common-sense ideas, design thinking offers several innovative ideas, such as a focus on the physical classroom space and its effects. The Design Thinking for Educators Toolkit, for example, opens with a case study of a second-grade teacher redesigning his classroom in order to improve student engagement and, ultimately, learning. Le Corbusier famously described a house as "a machine for living in;" viewing a school as a "machine for learning in," taking into account students' and teachers' needs, could have a significant impact on every aspect of students' experience on the school campus as well as in the community beyond the classroom.

Even more important, design thinking presents a compelling alternative to the "one size fits all" approach to education. The opening case study in IDEO's toolkit does not provide general advice about designing a second-grade classroom; its subject is one specific second-grade classroom whose teacher gathered feedback from students and redesigned the space according to their specific needs. IDEO's website highlights many similar projects that focused on solving specific problems. Design thinking is, without a doubt, the educational buzzword that The Atlantic describes it as. Education's previous buzzword, however, was "standardization," and design thinking can potentially solve many of the problems that standardization created. The K-12 system's focus on measuring student learning through standardized test scores, for example, encourages teachers to exclusively "teach to the test." Valeri Strauss, writing for the Washington Post, notes several negative consequences of this approach.<sup>43</sup> She argues that standardized tests:

- "Radically limit teacher ability to adapt to learner differences,"
- "Have led to the neglect of music, play, art and other nonverbal forms of learning,"
- "Penalize test-takers who think in nonstandard ways,"
- "Reduce teacher creativity,"
- "Perpetuate the artificial compartmentalization of knowledge,"
- "Block instructional innovations that can't be evaluated by machine."<sup>44</sup>

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<sup>43</sup> [https://www.washingtonpost.com/news/answer-sheet/wp/2017/04/19/34-problems-with-standardized-tests/?utm\\_term=.967e7296ab8d](https://www.washingtonpost.com/news/answer-sheet/wp/2017/04/19/34-problems-with-standardized-tests/?utm_term=.967e7296ab8d)

<sup>44</sup> Strauss has 34 problems with standardized testing in total.

Design thinking therefore offers an antidote to all these problems through its emphasis on innovation, creativity, interdisciplinary thinking and, most importantly, tailoring specific solutions to specific problems. While standardized tests, standardized curricula and standardized measures of student learning outcomes dominated the No Child Left Behind era, schools are now implementing innovations like human-centered design thinking as an important way forward, an alternative view of what education can be.

## DESIGN THINKING IN ACTION

IDEO is a globally prominent design company – they designed Apple’s first mouse and developed the first notebook-style laptop computer – committed to creating positive change through design thinking. While IDEO has worked with organizations in many different fields to solve a variety of problems, many of its most innovative strategies have come in the field of education. “Innovation in education,” according to IDEO San Francisco partner and managing director Sandy Speicher,

“requires the courage and creativity to take leaps at some of the most entrenched ‘truths’ we hold – the very premise of how our institutions are designed. The curriculum, space, tools, roles, infrastructure all offer an immense opportunity for design to make a difference.”

## K-12 CASE STUDIES

In 2016, IDEO and Google Creative Lab, London collaborated on a new way to teach young children the basics of coding and computer science. Paulo Blikstein, a Stanford University researcher involved in Project Bloks, described the collaboration as emphasizing computer science “as a new literacy for the 21st century, which is important for everyone regardless of your career path.”<sup>45</sup> Students learn coding through play, by connecting building blocks that can control the movement of robots, send messages to smartphones and perform other functions once assembled into physical “programs.” Each colorful block has a specific function, such as a direction arrow or an on-off switch, and is specifically designed to make

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<sup>45</sup> <https://www.wired.com/2016/06/google-thinks-future-code-toy-blocks/>

intuitive sense to young children. Project Bloks is an open platform and many of its components can be 3-D printed.

IDEO has also collaborated with the Lemann Foundation, dedicated to improving Brazilian education, to create a literacy-focused app as a potential solution to Brazil's serious functional illiteracy problem. Gatópolis, an app designed for students aged 4 to 7, uses language-based games to help children master reading and writing at a crucial stage in their development. In addition to the gameplay itself, IDEO developed a diagnostic tool that measures students' proficiency and gives teachers recommendations on how to help them learn more effectively. Google Play distributes Gatópolis at no charge.

## CALIFORNIA PARTNERSHIP ACADEMIES: MOVING THE NEEDLE

The California Partnership Academies (CPAs) are innovative three-year programs that combine career and academic preparation within the structure of a "school within a school." They have helped hundreds of thousands of students participate in highly enriched education that includes internships and other work experiences, along with enhanced academic experiences. Academy components include rigorous academics and industry sector-aligned career education, with a career focus, a committed team of teachers and active business and post-secondary partnerships.

Starting in 2017, the CPAs launched the "Moving the Needle" initiative, which is an effort to utilize human-centered design thinking to re-energize Academies and equip the next generation of Academy teachers and students to thrive in the rapidly changing world of the "Fourth Industrial Revolution." The CPAs, in partnership with the Orange County Department of Education, are training more than 800 Academy teachers on how to implement human-centered design thinking in their career pathway programs, as well as how to equip the students with these tools to help solve real-world problems. The nexus of community partners, dedicated teachers and students and administrative support has helped this program play a leading role in California education, shifting the paradigm from a dichotomy between academic and "vocational" education toward an integrated education that helps all young people prepare for both college and career. As the research in this paper suggests, this effort aligns well with the kinds of labor and models for problem solving that are likely to remain defensible in the Fourth Industrial Revolution. Each academy has a unique specialization, which itself reflects the need for human-centered design thinking considering that complex coordination among different departments and community partners is required.

## OC PATHWAYS: HOW MIGHT WE

The OC Pathways initiative was launched in 2014 with funding from the California Career Pathways Trust in order to integrate, coordinate, expand and enhance career pathway programs across Orange County. The consortium includes 14 K-12 districts and four ROPs, as well as 10 community colleges, several universities and scores of business and community partners, with the goal of equipping students for success in college, career and life.

The theme for OC Pathways in 2017-2018 was “How Might We,” which challenged the consortium to change the status quo by embracing the principles of human-centered design thinking. The basic premise is that teachers at all levels are designers, and the concept of designing learning experiences for others is the heart of education. The 2017 OC Pathways Showcase featured dozens of student-created STEM projects that demonstrated how educators and industry leaders are joining forces to educate and empower the next generation, using the concepts of human-centered design. It also featured leading thinkers who are applying human-centered design thinking, such as Gwynne Shotwell, President and Chief Operating Officer of SpaceX, and Tim Buzza, Vice President of Launch for Virgin Orbit.

These connections with important members of the design community allow the initiative to promote enriching educational experiences for students. Through internship experiences and unique connections with members of the community – including Swift Manufacturing and the e-Nable community, an international professional group that is advancing the use of 3-D printers to develop assistive devices – students learn to connect competencies with college and career pathways. OC Pathways provides resources to the consortium to help students experience design learning, creates a common purpose for educators in PreK-12 through higher education, and fosters a much stronger sense of connection between education and business and community partners.

## IDEATE HIGH ACADEMY

Design thinking is an integral part of the learning experience at Ideate High Academy in San Diego. The academy’s project-based curriculum utilizes the five-step design thinking process in order to promote “continuous learning in our rapidly changing and complex global society.” Students take design-oriented courses as well as traditional academic subjects, beginning with Principles of Engineering in 9th grade, followed by Design Intro and Social Entrepreneurship in 10th grade, Design II and an internship in 11th grade, and a senior project in 12th grade; Ideate’s curriculum exceeds the University of California’s A-G subject requirements. In addition to coursework, students lead conferences, exhibit their projects and learn from mentors at nearby public and private sector organizations. Ideate High

Academy plans to offer additional internships and other opportunities in partnership with UC San Diego, San Diego State University, Stanford University, the American Institute of Architects, Qualcomm, the Nissan Design Center and other organizations.

## EDUCATION AND JOB READINESS

Design thinking is just one example of how education must adapt to meet the changing needs of the labor market. This adaptation cannot be expressed in cutting back or supplementing a vocational program – or putting it in a convenient “job-readiness” box. The difference between the education that is needed in the 21st century and what exists now might be as large as the difference between the homeschooling in farming techniques and the public education that followed the industrial reorganization of society in the late 19th century. The changes that are occurring in the workplace as a result of automation are considered by researchers such as Frey and Osborne to be as impactful as the original industrial revolution.

Design thinking highlights the fact that “routineness” is a quiet but surprisingly large part of the status quo of education. Despite the fact that education has greatly, and successfully, emphasized critical thinking and teamwork, the traditional format still imparts a mindset that may no longer be appropriate for the workplace. Children are taught to learn the five-paragraph essay format, to memorize a series of dates and people, and to perform mathematical operations by rote. Only through an effort to pursue a new strategic outlook and the same kind of creativity and problem-solving that cannot be automated can this outlook change.



The evidence about the dimensions of defensibility shows the evolving importance of soft skills, social skills and analytical skills. However, it is also clear that hybrid skills – such as the ability to learn and utilize new skills, situational awareness and a locus of control that is internalized – are very important. Across almost all levels of educational attainment this is the case. There is a clear connection between new approaches, such as design thinking, and the skills that are needed to succeed in the automated workplace. The young people that go into the workplace, after all, cannot just slip into a box: the ones who succeed will have to help build and consolidate the techno-social systems that serve society.

# CONCLUSION

Automation presents a multifaceted challenge to society: How can workers in vulnerable jobs adapt? How can workers who are entering the automated workplace effectively leverage technology? How should future generations be educated and trained in respect to automation?

The striking finding of this study is that workers can adapt and education can effectively equip people with defensible skills. The key to these outcomes might be a surprise to some. Ultimately, it is not mastery of high-tech skills alone that will empower workers. Rather, it is the cultivation of our core human capacities that will make education systems effective and empower workers to adapt to the non-routine demands of the automated economy: communication, collaboration, creativity, critical thinking and character (sometimes referred to as The 5Cs). These human capacities can be cultivated with strategies that are already being implemented in some localities, strategies like human-centered design thinking and integrated career academies. We see momentum toward much broader adoption of these strategies.

The future of education must also take into account the rising importance of the nexus of human skills and technological skills. These skills clearly imply the use of technology to monitor, for example, the sales data that would be indicators of the health of a larger marketing and sales system. Even less obvious indicators, such as Active Learning, may still be accomplished more effectively with an online technology than without one. The new workers of tomorrow cannot afford to be agnostic towards technology.

Robots can replace many functions. But for the foreseeable future they will not replace the human capacity to respond in creative ways to non-routine demands in collaboration with diverse colleagues, taking into account the emotional dimensions of human needs and longings. Just as sending an email or a text message is far more time efficient than sending a letter, the multitude of time-saving technologies are not just replacing labor: they are allowing workers to do their job more quickly and more effectively. As Steve Jobs once said, it is the marriage of technology and the humanities “that yields us the results that make our heart sing.”

The stakes are high: if we do not start adapting now, the downside of automation will become worse and worse. An educational response to automation that remains at the granular or programmatic level cannot possibly address a problem that is this wide-ranging; the solution must start at the highest strategic level. This is where the purposes of employers and educators are clearly united. Both education and employers want to develop critical thinkers, students and workers who act on their civic and social duties and who seek to improve the systems and processes that constitute economic activity, if not society altogether. Ultimately, successfully adapting to automation is an unprecedented opportunity to positively transform both our educational system and workplaces of the future into spaces that are more empathetic, creative and fulfilling. However, that adaptation is not a luxury – it is a necessity for future success.



