PATHWAYS TO SHARED PROSPERITY

A FRAMEWORK FOR FORGING NEXT GENERATION MAKERS IN SOUTHWEST PENNSYLVANIA
Acknowledgments
We thank the Benedum Foundation for the financial support for the stakeholder engagement, survey, research and writing that led to this report. Stephen Herzenberg and Diana Polson of the Keystone Research Center were the primary authors of the report. Anne Sekula, director of the Remake Learning Council, provided conceptual guidance throughout, including sharing resources on maker education, helping to design the survey and interpret its results, and editing and sharpening the final report. Bernie Lynch, principal of Strategic Development Solutions, facilitated engagement with maker education programs that contributed to the development of the framework presented in the report; played the lead role, with assistance from Dr. Polson, in developing the visual representation of the framework; and helped develop the description in the report of competences fostered through maker education, drawing on the experience of the Made Right Here training program and Maker Professional apprenticeship. The working group on maker education within the Remake Learning Network, as part of its Make to Manufacturing Pathways Initiative, served as advisors to this project, providing input at the outset and feedback at interim stages. Consultant and graphic artist Lauren Zemering took the visual depiction of the framework from a sketch to the polished product presented in this report. Ryan Markel of the Pennsylvania State Education Association created the map on pages 14-15. Amy Bates of Strategic Development Solutions provided organizational support to the project. Stephanie Frank of Keystone Research Center laid out the report. Cover photo by Brian Cohen.

About Remake Learning Network
Remake Learning is a network that ignites engaging, relevant, and equitable learning practices in support of young people navigating rapid social and technological change. Established in 2007, the network is an open group of interconnected, creative, and innovative people and organizations in the greater Pittsburgh region. Our purpose is to spark and share best practices and new ideas, make it easier for neighbors and colleagues to help each other, reduce the duplication of efforts in the region, and leverage resources collectively for greater impact.

Youth in the digital age are pursuing knowledge, developing their identities, and seeking support differently. Acknowledging the significance of this shift, the founding members of the Remake Learning Network sought to help educators in- and out-of-school connect with today’s youth and develop learning experiences that engage them deeply and equip them with knowledge and skills that are relevant to the world in which they now live. More information can be found at www.remakelearning.org.

About the Keystone Research Center
The Keystone Research Center (KRC) was founded in 1996 to broaden public discussion on strategies to achieve a more prosperous and equitable Pennsylvania economy. Since its creation, KRC has become a leading source of independent analysis of Pennsylvania’s economy and public policy. KRC is located at 412 North Third Street, Harrisburg, Pennsylvania 17101. Most of KRC’s original research is available on the KRC website at www.keystoneresearch.org. KRC welcomes questions or other inquiries about its work at 717-255-7181.
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Maker empowerment: a sensitivity to the designed dimension of objects and systems, along with the inclination and capacity to shape one’s world through building, tinkering, re/designing, or hacking.

AGENCY BY DESIGN

In city after city, region after region, the [maker] movement offers a practical, inclusive, all-hands-on-deck approach to preparing for and shaping the future of manufacturing. For individuals, making engages students in both physical production and creative coding. As a common cause for makerspaces, community colleges, universities, and employers, the movement is helping deliver more relevant workforce development skills. And for the nation’s manufacturing and technology industries, making is stimulating a new, more creative approach that is reinventing the sector and making it more competitive. Ultimately, the movement is one modest way to renew the economy with broad engagement and experimentation at a time of uncertainty and division.

MARK MURO and PETER HIRSHBERG

Overview

A Network in the making – the Remake Learning Network. Southwestern Pennsylvania’s has over 250 “maker education” programs based in and out of schools that come together in the Remake Learning Network. Throughout the region, these programs educate youth and adults in makerspaces – creative spaces with modern tools for making things, where people can gather to learn, create, and invent – sometimes referred to as hackerspaces, hackspaces, and fab labs. The size of the network illustrates the strength of the “Maker movement” in Southwestern Pennsylvania. Together with great research universities, start-up companies, and an influx of global technology companies, the Maker movement is helping Pittsburgh become a center for innovation again. Despite the existence of the Remake Learning Network, however, many maker education programs have limited knowledge of other such programs. Most also have little connection to manufacturing businesses, which could offer a wide range of exciting and increasingly diverse career education, work-based learning, and future job opportunities.

Report purpose – a framework for network development. This report develops a framework that categorizes maker education programs and describes how they relate to one another and to “maker careers” within the regional manufacturing base. The framework is intended to help network members gain a better sense of each other, a first step towards creating a whole greater than the sum of its parts. The framework also aims to help the network achieve a living and organic partnership with the dynamic making economy, rather than being siloed in the world of education and disconnected from the economy’s fast-changing realities and needs. A “living framework” that strengthens connections among programs and between maker education and the economy can increase the positive impact of maker education on educational and economic outcomes.

A further purpose of this report, and of the framework, is to foster greater respect for “making.” In the United States over the course of the 20th century, a dichotomy emerged between white collar managerial and professional jobs and “blue-collar” positions. This dichotomy too often undervalued working with your hands, and underappreciated how much blue-collar work continued to include working with your head. The Maker movement and maker education have challenged old and flawed assumptions about those who think and those who do. They have brought new respect for “making,” increased awareness of its creative dimensions, and, potentially, renewed fluidity in career pathways between engineering and design and hands-on production – a throwback to the era when many CEOs began their careers as apprentices. If Pittsburgh with the help of its Remake Learning Network can embrace 21st century makers and the contributions they make to regional vitality, this can strengthen Pittsburgh’s rebirth as a center of innovation and a model of broadly shared prosperity.

A profile of regional maker programs. We conducted a survey of maker programs in the Southwestern Pennsylvania region – the first of what we hope will be many annual surveys that programs use as their tool for tracking network development and promoting collective reflection and performance improvement. The survey documented that many maker education programs remain largely siloed within the world of K-12 education and do not expose students to the maker economy. Indicative of this, programs rate career development low...
relative to other educational goals. The survey also documented that the region’s maker education programs:

- Operate out of a wide range of institutions from community based organizations, schools, libraries, museums, career and technical schools and community colleges.
- Include in-school and out-of-school programs, workshops, camps and others, with two thirds serving Allegheny County and at least some programs serving seven other counties.
- Use a variety of tools and materials within their makerspace, the most common being digital fabrication tools like 3-D printing and laser cutting (85%) and everyday objects, like cardboard or recycled materials (81%).
- Serve a variety of age groups from elementary school to adults. Seventy percent of programs responding serve High-school students and a healthy share of programs serve young adults (40%) and adults (33%), underscoring the potential for developing stronger connections to employers, jobs and career paths.
- Serve a diverse student population relative to the demographics of the region, with 17% serving primarily minorities, 10% serving minorities and whites equally, and two-thirds of programs serving girls and boys equally – a far cry from traditional shop classes.
- Offer courses spanning a wide range of levels, which we classify as exploratory, orientation, basic skills, advanced skills, and career entry. Most programs span the first three levels with only a few at the advanced skills and career entry levels.
- Most maker education programs (69%) work with other programs, and 79% point individuals to additional maker education programs. Only a few maker education programs, however, have multiple, dense connections to other programs.

In part because maker education better simulates the workplace than traditional classroom education, maker education programs in Southwest Pennsylvania seek to develop most of the basic competences sought by employers of makers.

- On a five-point scale, maker education programs rated teaching creativity a 4.9 and communication and collaboration and teamwork each a 4.8.
- The programs rated teaching flexibility and adaptability, and initiative and self-direction each a 4.7.

The competences taught by maker education programs grow naturally out of the pedagogy of maker education programs. Through the practice of hands-on learning and learning-by-doing, students advance their problem-solving skills. Through group projects students learn to collaborate with each other. Through project-based learning, students learn creativity and grit by imagining a product and iterating until they achieve it.

The survey responses on pedagogy also revealed an important gap. Three teaching approaches that would complement the highly rated teaching approaches, but require connections to employers, received low ratings for importance – “visits to making… workplaces,” “apprenticeship,” and “work-based learning.” (A further indication of limited connections to employers: only...
20% train for a specific occupation.) Better connecting maker education programs to employers has potential pedagogical benefits through the deeper integration of work-based learning – in summer jobs, internships, coops, and apprenticeship, or other variations – with education in school and community makerspaces. Work-based learning is a natural extension of learning-by-doing on tools in makerspaces and of project-based learning that results in a product.

Diverse opportunities exist in maker jobs and careers. Better connecting maker education to careers will not only serve our youth – it can fill a skill gap and make our regional economy healthier as the baby boom retires.

- Manufacturers need skilled workers for positions that rarely require a four-year degree – a projected 6,542 job openings annually in production jobs in the region. Manufacturing workers earn 9% more per week on average than comparable workers in non-manufacturing.
- Another 12,000-plus job openings exist annually in maker “occupational families” such as construction (5,422), installation, maintenance, and repair (3,927), architecture and engineering (1,350), and arts and design (roughly 1,000 jobs annually).

A growing share of manufacturing jobs will be at startups and at other advanced manufacturers who seek multi-skilled problem-solvers able to work as part of a team. Teachers and students need to understand that today’s job in manufacturing differ from those of the past – there are many fewer rote, dirty, and physically demanding jobs and many more monitoring, operating, programming, and repairing machines. Students also need to be taught that employers vary, and they should be on the lookout for ones that value their makers and offer training and advancement opportunities. Often, employers willing to engage with maker education programs – and to participate in career development and work-based learning – also support the development of their own employees.

The Make to Manufacturing framework. The framework, presented on the two pages in the center of this report, seeks to summarize and synthesize the information gathered about maker education programs in the region and how they relate to the maker economy and the job market. While a maker program based at an elementary school may not think of itself as a part of the Make to Manufacturing pathway, it is in fact beginning to provide children with skills that can eventually lead to maker-related careers. By understanding where a program fits into this framework, we can better connect young people inspired by making and maker education to opportunities to make a living, whether as an entrepreneur or in paid employment.

Recommendations for action. We offer three main ways to improve the Make to Manufacturing pathway in the region: by strengthening the connections of programs to each other; by strengthening the connections of maker education to employers; and by making career pathways to rewarding maker careers more visible and more credentialed.

1) Strengthen maker educator networks and peer learning: make Pittsburgh maker educators an exemplary community of practice committed to collective performance improvement
   a. Walk educators, participants, and parents through the framework by hosting sessions/events on “What’s Next for Me?”
   b. Develop customized posters for each program outlining “here are some maker education programs that you can take next.”
   c. Strengthen informal networking among maker educators.
   d. Create formal peer learning sub-groups
of maker educators.
e. Develop an affinity group of maker educators within CTE programs.
f. Develop an annual survey of maker education programs that includes information needed to produce network diagrams and measures of network strength.

2) **Strengthen the connections of regional maker education programs to employers and to makers in the economy**
   a. Survey member education programs to identify concrete, value-added roles for which they need additional engaged employers, e.g. to serve on curriculum committees, to provide mentors for students, for site visits, or to provide work-based learning (summer jobs, internships, coops, apprenticeships).
   b. Survey employers to ask them “would you like to connect to maker education?” and to inform efforts to connect with employers who say yes.
   c. Inventory and then convene and/or survey maker occupational associations and networks to assess the willingness of their members to engage with maker education programs.
   d. Encourage advanced maker skills and career entry programs that place participants in jobs to establish alumni associations whose members could serve as resources to connect the programs – and feeder maker education programs for younger ages – to the economy.
   e. Make explicit best practices for individual maker education programs to engage with employers and makers in the economy, customized for programs serving different age groups and at different levels.

3) **Make career pathways to – and among – rewarding maker careers more visible and credentialed**
   a. Develop regional career pathways starting in K-12 and through post-secondary education leading to specific employers and occupations as shown in the framework.
   b. Fill in gaps while supporting model programs.
   c. Promote use of micro-credentials (but don't let micro-credentials reorient programs towards developing narrow skills)
   d. Educate students to be smart about picking their employer.
   e. Invest in a Regional Maker Opportunity Center.
Introduction

Manufacturing in Southwestern Pennsylvania is going through a re-birth. While once the dominant employer in the region, deindustrialization shifted many factories in our region elsewhere, leaving a gaping hole in the economy for several decades. While eds and meds have since taken the central place in Pittsburgh’s economy, manufacturing is still alive and well. Many of the manufacturing jobs available for our children, however, will be unlike the ones of our fathers and grandfathers. While these emerging jobs will have the same goal – making the products people demand – most of them will require more (or at least different) skills, and be cleaner, due to new technology.

We are at the beginning of what some call the Third Industrial Revolution in which lower-cost digital tools like CNC machines, 3-D printers, laser cutters, robots and other devices will likely remake manufacturing and its jobs in profound ways. While the first industrial revolution brought with it a shift from an agrarian and craft economy to factories powered initially by steam engines, the second industrial revolution concentrated production in giant mass production facilities.

Today, technological changes are starting to move making into smaller factories and back into the hands of everyday people operating out of their basement, a community-based makerspace or a K-12 school. This “democratization of the tools” has made it possible to attract children of all backgrounds into maker education classes where they have opportunities to be creative, collaborate, and work with their hands, opening the door to “remake learning.”

As this transition from old to new manufacturing takes place and the existing workforce ages out, manufacturers need skilled workers – as many as two million qualified manufacturing workers will be needed nationally to fill this gap. And these jobs pay more than others – workers in manufacturing earn 9% more per week than other workers when you hold all else equal.1

Meanwhile, excitement exists in the Pittsburgh area about innovation and the Maker movement. The online newsletter Fast Company reports that “drawing on the prowess of the robotics engineering programs at the University of Pittsburgh and Carnegie Mellon, [Pittsburgh] has found a new calling, becoming one of the most encouraging spots for innovation in the country.”2 And the Pittsburgh Post-Gazette notes that Pittsburgh has become a “national focal point of the [Maker] movement.”3 The region’s broad, and growing, Maker movement connects to youth as well as adults – makerspaces and maker programs can be found in K-12 schools throughout Southwestern Pennsylvania, nonprofit community spaces, libraries and more.

There is a sense that maker education could spur the economy and create meaningful and well-compensated economic opportunities for people from all backgrounds. Educational programs, workshops, camps and competitions that integrate opportunities to use new tools, to “make” something, to learn-by-doing, and to work together – to move beyond just passively listening in a classroom seat – has spurred a renewed spark for learning among a growing number of our region’s youth. Maker education could help upend negative images of “making” left behind by the mass manufacturing economy and the destruction of families and communities wrought by its decline. It has the potential to draw young people from Fox Chapel to the Hill District to participate in Pittsburgh’s next industrial revolution.

Manufacturing employers today, both established manufacturers and start-up
companies, are looking for workers who know how to design a product, how to use digital and machine tools, how to collaborate with others and work as a team, how to solve problems and think creatively. This industry-driven need for workers skilled in these areas aligns with the skills taught in youth (and adult) maker programs throughout our region. For maker education programs to meet industry and learner needs, however, requires addressing the following two challenges:

(1) **Strengthening connections between maker education and training programs and manufacturing trainers and employers.** Strengthening these connections can deliver many benefits – bringing the realities of the world of work into the classroom, honoring and elevating the dignity of making and providing businesses, new and established, with a workforce second to none. While connecting more to employers, maker education programs should retain an emphasis on multi-skilling and fostering young people’s capacity for ongoing, lifelong, learning, not reorient to developing specific narrow skills that may be automated out of existence in a few years. Educators and manufacturers should together strive to escape old models of learning, jobs, and careers associated with semi-skilled mass manufacturing.

(2) **Strengthening connections among maker education programs:** creating stronger connections among the region’s maker education programs could begin to create a whole greater than the sum of the network’s parts. It could also help the network achieve a living and organic partnership with the dynamic making economy, rather than being siloed in the world of education, and disconnected from the economy’s fast-changing realities and needs. While beginning to give definition to a regional maker talent development “system,” strengthening connections among network programs should not subordinate programs’ educational and human development aspirations to meeting near-term skill needs of employers. It should aim to nourish, not sacrifice, the creative spark – the love of children and of learning – that is the core of the programs in the Remake Learning Network.

Through interviews, focus groups, workshops, a survey of members of the Remake Learning Network, and analysis of future maker careers in the region, we have put together a framework describing the current structure of maker education programs in the region, from elementary school to post-secondary, and describing potential pathways to maker-oriented occupations. We use the framework to identify gaps – e.g., limited emphasis on technical skills and career development and a lack of connections to employers among maker education programs – that need filling to strengthen pathways to maker careers. We encourage use of this framework to reshape, and strengthen, the emerging maker talent development system. Programs may see opportunities to partner with other programs to upgrade curriculum and pedagogy, to recruit from other programs or guide their own completers to the next level of maker education. Parents and students may see opportunities to go beyond ad-hoc participation in programs towards a sequence that opens educational and career opportunities. Employers may see opportunities to improve curricula, expose students to the workplace, or offer extended work-based learning with the potential to yield future employees.
The Remake Learning Network

The Remake Learning Network includes participants from more than 250 organizations – schools, museums and libraries, afterschool programs, colleges and universities, major employers, philanthropies and civic leaders focused on inspiring a generation of lifelong learners in Pittsburgh, West Virginia, and beyond. This network was developed through the support of foundations including the Grable Foundation, Macarthur Foundation and Benedum Foundation.

Remake Learning convenes several working groups, one of which is made up of organizations focused on maker education. This working group has a Make to Manufacturing Pathways Initiative, which aims to identify and connect regional maker learning experiences with post-secondary manufacturing careers and training. The Make to Manufacturing Pathways Initiative commissioned the development of this report, and the framework presented here, so that maker education programs and others can begin to see how they do or might fit into make(r education)-to-manufacture career pathways.

We conducted a survey in April 2017 of maker education programs in the Southwestern Pennsylvania region, with 30 completing the survey. The survey respondents included a range of institutions that run maker programs, with more than 11 types of institutions represented. Most heavily represented are schools (elementary through high school) and community-based organizations.

**Type of Institution Running the Maker Program**

<table>
<thead>
<tr>
<th>Institution</th>
<th>Percentage</th>
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<tr>
<td>Community-Based Organization</td>
<td>20%</td>
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<tr>
<td>High School</td>
<td>17%</td>
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<tr>
<td>Elementary School</td>
<td>10%</td>
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<tr>
<td>Middle School</td>
<td>10%</td>
</tr>
<tr>
<td>School District</td>
<td>10%</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>7%</td>
</tr>
<tr>
<td>Industry Association</td>
<td>7%</td>
</tr>
<tr>
<td>For-Profit Entity</td>
<td>3%</td>
</tr>
<tr>
<td>Career and Technical School</td>
<td>3%</td>
</tr>
<tr>
<td>Museum</td>
<td>3%</td>
</tr>
<tr>
<td>Library</td>
<td>3%</td>
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Source: Keystone Research Center maker survey analysis, April/May 2017
There was also a good mix of programs that do in-school programming (73%), out-of-school (60%) and other programs (camps, competitions, events, workshops) (see Figure 2 below).

Figure 3 shows the geographic regions that programs serve. Sixty-seven percent of programs serve residents of Allegheny County, followed by the City of Pittsburgh (40%). One or more programs serve youth in seven surrounding counties. The map on pages 14-15.
As Figure 4 shows, 70% of programs serve high-school students and a healthy share of programs serve young adults (40%) and adults (33%), underscoring the potential for developing more connections to employers, jobs and career paths. Fifty-eight percent of programs serve elementary school youth and middle school youth.

Maker education programs serve a more gender-balanced program than traditional shop classes and nearly three in 10 serve at least equal numbers of minorities as whites. Specifically:
- 66% of programs serve an equal number of girls and boys, 30% serve a majority of boys and 3% serve primarily girls. (Survey findings with no figure number listed next to them – such as this one – do not have a chart showing the same information.)
- Approximately 17% of programs serve primarily minorities, 10% serve minorities and whites equally and the rest reflect the race/ethnic diversity of their school, school district and/or county (majority white).

Most maker education programs (94%) have a makerspace that they use for teaching. Most makerspaces are in schools (63%), followed by afterschool spaces (22%), other spaces (22%) and libraries (19%) (Figure 5).

Programs use a variety of tools and materials (an average of five categories of tools) within their makerspace, the most common being digital fabrication tools like 3-D printers and laser cutter (85%) and everyday objects, like cardboard or recycled materials (81%) (Figure 6). Coding programs (78%), electronics (74%) and digital production tools (70%) are also used often.
Southwest Pennsylvania Maker Education Programs
That Completed the Remake Learning Network "Make-to-Manufacture" Survey

White = No information
Red = K-8
Orange = K-8 & High School
Yellow = High School
Green = High School & Post Secondary
Blue = Post Secondary
Purple = K-8 & High School & Post Secondary

Note: For the map we included all organizations that started a survey (42) but for the survey analysis we only included organizations that finished the survey (30).
**Figure 5**

Space Where Makerspace is Located

*Other category included intermediate unit, retail center, community spaces, a stand-alone maker space.*

Source: Keystone Research Center maker survey analysis, April/May 2017

**Figure 6**

Tools and Materials Used in Maker Programs

Source: Keystone Research Center maker survey analysis, April/May 2017.
Maker programs identified teaching creativity and innovation as most important (4.8 on a 5-point scale – 5 being very important and 1 being not important at all) (Figure 7). Also, very important to the programs in our region are using more effective teaching methods including learning-by-doing and peer learning, developing hard-to-measure non-technical skills like persistence and collaboration and youth engagement/empowerment (all 4.7). These high priority goals relate to the most distinctive dimensions of the Maker movement and pedagogy. Rated least important (but still considered important) were technical skills development (4.2) and career development and awareness (4.0).

Our survey results found that most (69%) maker education programs work with at least one other program in the region and 79% point their graduates interested in making towards other programs, training programs, or schools. At the same time, the connections among programs are not dense (Figure 8). Similarly, only 41% of programs, work specifically with job training programs, employers or industry associations (Figure 9). There is room to boost interactions between Southwestern Pennsylvania’s maker education programs and the manufacturing world.
Figure 8

Connections Among SW PA Maker Education Programs Surveyed

Note: This diagram shows a line between any two Maker Education programs surveyed if either of the program mentioned the other entity in its response to the April 2017 Remake Learning Network survey of SW Pennsylvania Maker education programs.
Source: Keystone Research Center maker survey analysis, April/May 2017.

Figure 9

Connections Between Maker Education Programs and Trainers, Employers and Industry Groups

Note: This diagram shows a line between a Maker Education program and training program, employer or industry group if the program in its response to the April 2017 Remake Learning Network survey mentioned the training program, employer or industry group.
Source: Keystone Research Center maker survey analysis, April/May 2017.
Competencies for Future Opportunities in Making

What are the key competencies taught to students in maker education programs? Are these skills relevant for manufacturing and other jobs looking forward? The literature on maker education has a variety of ways to categorize the skills being taught in the Maker movement. Perhaps most important is what Agency By Design terms maker empowerment – learning "a sensitivity to the designed dimensions of objects and systems, along with the inclination and capacity to shape one’s world through building, tinkering, re/designing, or hacking.” This develops dispositions in students described as “understanding oneself as a person of resourcefulness who can muster the wherewithal to change things through making.”

By transforming the material world, youth learn how to be proactive, problem-solving agents for change. This basic benefit of maker education would be a welcome characteristic for many employers, maker-related or not. In fact, the World Economic Forum reports that the top three skills needed for jobs in 2020 are 1) complex problem solving, 2) critical thinking and 3) creativity.

As noted, Pittsburgh region maker education programs rate teaching creativity most important. They also rate "hard-to-measure technical competences,” which include complex problem solving and critical thinking, high.

Here we summarize competencies often taught in maker education programs into two broad categories, soft skills and technical skills, each of which has two sub-categories:

**Soft Skills**

1. **Basic soft skills** are necessities in maker-related occupations and beyond, and center around work ethic, reliability and social skills. These include: punctuality, accountability and reliability (showing up consistently and on time and being reliable); showing initiative and being able to self-direct; social and cross-cultural skills (can the individual work well with other people); and flexibility and adaptability in new situations.

2. **Maker soft skills – critical thinking, innovation and collaboration skills:** critical thinking skills and the ability to problem solve; creativity and innovation skills; collaboration and teamwork; and communication skills.

**Technical Skills**

3. **Knowledge of the making process:** The Maker movement teaches individuals the process of making. This includes: project planning; design; applied math and technological skills; understanding how to use tools in making; and knowledge of basic manufacturing concepts.

4. **Knowledge of digital tools and diverse materials:** knowledge of and facility with maker tools such as design technology, additive technology, laser technology, other computer-controlled machine tools, and electronics; and ability to work with a range of materials (wood, plastics, metals, etc.)

Maker education programs in the Pittsburgh region ranked how important soft skills were in their maker programs. While all the soft skills were considered relatively important, maker soft skills – creativity, communication and collaboration skills – rose to the top (Figure 10). (We didn’t ask explicitly about persistence but now we know to do that next time!) The technical skills ranked most important were design and project planning (both 4.6) (Figure 11). Design thinking has been
recognized by scholars as an especially distinctive feature of maker education. Defined as “a problem-solving framework that helps learners define problems, empathize with those facing or addressing those issues, develop prototypes of possible solutions and hone those prototypes through multiple iterations,” design thinking includes both design and project planning.
From Competency to Pedagogy

Competencies and skills learned through maker education are not acquired by accident. Rather, they are a direct result of maker pedagogy. Figure 12 below shows that maker education programs in our region value pedagogy typically associated with the Maker movement. Hands-on learning ranks high (at 5 – “very important”) while traditional classroom learning in which the teacher lectures and students listen ranks low (2.4).

The six teaching approaches rated most important out of 13 were:
1) Hands-on activities and learning-by-doing (5.0)
2) Encouraging students to figure things out through trial and error. Try/fail/iterate (4.7)
3) Individual project based learning in which students engage in the process of making from the beginning of the process (ideation) to the end (built product) (4.6)
4) Group-based project learning in which youth work together to solve a problem, engage in a project or make a product (4.5)
5) Peer learning in which youth share what they know with each other (4.5)
6) Learning-by-leading and mentoring, through which youth are given the opportunity to lead and teach others as they learn (4.1)

The strong link between the competencies that individuals learn in maker education programs and the pedagogy of those programs is clear in these responses. Students learn problem-solving skills through actively solving problems. They learn creativity by imagining an end product, and then figuring out how to make it. They learn how to collaborate, work well with others and pull on each other’s strengths through group projects and peer learning. This pedagogy shifts individuals from passive receptacles of information to active and engaged problem solvers. This shift just happens to foster the most sought-after skills needed in tomorrow’s economy.

The survey responses regarding teaching approaches also revealed an important gap. Three teaching approaches that would complement the highly rated teaching approaches, but require connections to employers, received the second, third, and

![Figure 12: Importance of Teaching Approaches to Maker Program](image)

*Source: Keystone Research Center maker survey analysis, April/May 2017.*
Pittsburgh has a variety of Maker Education Programs available to individuals of all ages and education levels. The diagram on the right can be used to map these programs to demonstrate how they help guide participants towards Manufacturing Training and Maker Related Occupations.

We are casting a broad net to ensure that all of Pittsburgh’s neighborhoods and surrounding communities can be part of the Maker Movement.

There are many maker education programs in the Pittsburgh region whose goals are to teach new ways of thinking, introduce new skills, and promote the use of digital tools. Competencies gained from participating in maker programs are dependent on the program, but many of the skills learned can be seen to the right:
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DID YOU KNOW?
Many people working as engineers don’t have a formal engineering degree. Maker related occupations are growing, and many people have the opportunity to move up the chain and continue professional development once in a position.
fourth lowest ratings for importance: “visits to making workplaces,” “apprenticeship,” and “work-based learning.” These approaches would also further develop competencies sought by manufacturers. Strengthening employer connections and the number of high-school and out-of-school programs that incorporate these three approaches would further advance maker pedagogy within the Remake Learning Network and the value of the network as a talent pipeline for manufacturers with good jobs.
Future Opportunities in Making

One part of our framework shows making careers for which maker education could help prepare youth. To develop this part of our framework, we needed to know what opportunities for gainful participation in the economy as “makers” will exist in the future, as entrepreneurs, independent contractors, or via traditional jobs, as well as via employment. More than in most parts of the economy, this question is difficult to answer in the maker economy because of the pace of change in technology, automation, and skills, and the growing potential of disruptive business models.

The uncertainty surrounding future occupational demand – what jobs will exist for today’s school students 10, 25, and 50 years from now – is one reason that educators should seek to develop broad general competencies likely to have market value regardless of future disruptions in business organization and skill requirements. Maker education does just that.

Maker Occupational Families

We first assess demand for future makers using official government occupational projections summarized in the “Inflection Point” report commissioned by the Allegheny Conference. Table 1 and Figures 13 and 14 (p. 27) summarize information from the “Inflection Point” on demand in five occupational families (out of 22 occupational families listed in that report), which we label “Maker Occupational Families”: (1) Production, (2) Installation, Maintenance and Repair, (3) Arts, Design, Entertainment, Sports and Media, (4) Architecture and Engineering and (5) Construction. While none of these five have high “projected growth rates” for employment, four of them (all except the arts) are considered “high demand” because the age of today’s workforce will lead to many retirements, and therefore job openings, in the next decade.

Table 1. Maker Occupational Families, All Occupations

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>62,906</td>
<td>5%</td>
<td>6,542</td>
<td>5%</td>
<td>-1%</td>
<td>10.4%</td>
</tr>
<tr>
<td>Installation, Maintenance, and Repair</td>
<td>46,691</td>
<td>4%</td>
<td>3,927</td>
<td>3%</td>
<td>5%</td>
<td>9.5%</td>
</tr>
<tr>
<td>Arts, Design, Entertainment, Sports, and Media</td>
<td>14,054</td>
<td>1%</td>
<td>1,496</td>
<td>1%</td>
<td>2%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Architecture and Engineering</td>
<td>22,736</td>
<td>2%</td>
<td>1,350</td>
<td>1%</td>
<td>3%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Construction</td>
<td>57,739</td>
<td>5%</td>
<td>5,422</td>
<td>4%</td>
<td>5%</td>
<td>15.7%</td>
</tr>
<tr>
<td>Subtotal of Five Maker Occupational Families</td>
<td>204,126</td>
<td>17%</td>
<td>18,737</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total - All Occupational Families</td>
<td>1,185,368</td>
<td>4%</td>
<td>127,604</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Burning Glass, “Inflection Point”, Table 1, p. 8.
As a group, these five occupational families will have annual openings of nearly 19,000 in the 2015-25 period. About a third of these openings fall in the “production” category, with construction accounting for a bit less than a third, and installation, maintenance and repair for nearly a quarter. Architecture and engineering plus the arts and design category account for a bit more than half as many jobs as production today but less than half as many of the openings (because retirement rates and turnover in architecture and engineering will be lower).

As Table 1 shows, the five maker occupational families vary substantially by unemployment rate. Arts/Design and Architecture/Engineering, the two maker occupational families that include mostly the college educated and professionals, have unemployment rates much below the three other categories, within which most workers do not have a college degree (Construction, Production and Installation, Maintenance and Repair). While construction occupations had the highest unemployment rate when the data were extracted (nearly 16%), the impact of this is mitigated by the fact that it is easier for unemployed construction workers to get new jobs than manufacturing workers. This reflects the project-based nature of construction work and the existence of portable credentials (apprenticeship and many more specific certifications) and hiring hall mechanisms that match skilled workers who need a job with contractors who need skilled workers. Maker jobs in production currently lack widely recognized portable credentials and sector- and occupation-specific job-matching institutions.10

Table 2 extracts information from the “Inflection Point” on what the Federal Reserve Bank calls “opportunity occupations” – occupations paying more than the median wage and in which more than half the occupations do not require a bachelor’s degree. Three maker occupational families (highlighted in caps) account for nearly half (43%) of all opportunity occupation employment in the region. Helping students that do not earn a four-year college degree acquire maker competencies gives such students a legitimate shot at a job that pays above the median.

<table>
<thead>
<tr>
<th>Occupational Family</th>
<th>Employment</th>
<th>Projected Growth Rate</th>
<th>% of All Opportunity Occupation Employment, Regionwide</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTRUCTION AND EXTRACTION</td>
<td>54,358</td>
<td>6%</td>
<td>18%</td>
</tr>
<tr>
<td>Healthcare Practitioners and Technical</td>
<td>47,834</td>
<td>12%</td>
<td>16%</td>
</tr>
<tr>
<td>Office and Administrative Support</td>
<td>45,556</td>
<td>-3%</td>
<td>15%</td>
</tr>
<tr>
<td>INSTALLATION, MAINTENANCE AND REPAIR</td>
<td>40,680</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>PRODUCTION</td>
<td>35,802</td>
<td>2%</td>
<td>12%</td>
</tr>
<tr>
<td>Transportation and Material Moving</td>
<td>25,431</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Opportunity Occupations in Three Maker Occupational Families</td>
<td>130,840</td>
<td></td>
<td>43%</td>
</tr>
<tr>
<td>Total</td>
<td>305,558</td>
<td>5%</td>
<td></td>
</tr>
</tbody>
</table>

Note: “Opportunity Occupations” within each occupational family defined as those paying more than median wage, with fewer than 50% of postings requiring a Bachelor’s Degree requiring a bachelor’s degree.

Source: Burning Glass, “Inflection Point,” Table 4, p. 9.
Figure 13

Distribution of Employment by Maker Occupational Family, 2015

- Construction: 28%
- Production: 31%
- Architecture and Engineering: 11%
- Arts, Design, Entertainment, Sports, and Media: 7%
- Installation, Maintenance, and Repair: 23%

Source: Keystone Research Center based on Inflection Point Report, table 1, p. 8.

Figure 14

Share of Maker Annual Openings, 2015-25

- Construction: 29%
- Production: 35%
- Architecture and Engineering: 7%
- Arts, Design, Entertainment, Sports, and Media: 8%
- Installation, Maintenance, and Repair: 21%

Source: Keystone Research Center based on Inflection Point Report, table 1, p. 8.
Specific Maker Occupations

Appendix Table A1 presents information from the “Inflection Point” report on demand in 26 detailed occupations. Based on Appendix Table A1, Figure 15 aggregates information on detailed occupations into five broad categories: production, precision machinist, architects and drafters, engineering and engineering technicians, and maintenance and mechanics. The figure shows that all five categories have some at least one occupation (in two cases a supervisory occupation) with a median wage of at least $49,000. Every one of the 26 occupations has a median wage of at least $29,020 – roughly $14 per hour for a full-time, full-year worker. At the high end, the engineers and engineering technician category has one occupation (“engineers, other”) that pays a median wage of close to $100,000 ($94,610). The three lowest-paid groups have the most openings. (The “Inflection Point” report does not contain information on demand in individual design occupations and thus they are missing from the last figure. To add them into our “framework” we rely on on-line job listings discussed in the next section.)

Where the Maker Movement and On-Line Job Listings See Demand

Standard job projections use occupational categories defined in most cases decades before the Maker movement emerged. Below, we extract additional insights into future maker careers from three other sources: the insights of Maker movement leaders, the placements made by two Pittsburgh maker training programs, and on-line job listings.

The “Maker City Handbook” lists the following maker occupations and skills as in demand:
- Welding and fabrication
- 3-D printing and scanning
- CAD/CAM and graphics

Figure 15

Projected Annual Openings and Median Wages in Five Groups of Specific Maker Occupations

Higher paid occupational groups have fewer annual openings than lower paid groups -- but all groups have at least some jobs with a median wage of around $50,000.
• Sewing and textiles
• Programming and coding
• Wood shop and CNC
• Machine shop and CNC
• Fluid power systems

In Pittsburgh, “Made Right Here” (MRH) operates a maker training program and an apprenticeship (the latter for “Maker Professionals”). The distribution of 156 placements by Made Right Here over the past several years (Table 3) reveals some distinctive patterns. Ten percent of the placements are “self-employed,” high for a training program; additional placements have resulted in workers becoming partners in a new startup. About 15% of the MRH placements are as designers and engineers-scientists and another 12% as mentors-trainers. Made Right Here thus places people in a wider array of positions than traditional manufacturing training.

New Century Careers (NCC), a highly regarded non-profit manufacturing training provider established in the early 2000s, places many of its graduates as in computer-controlled machine operators, machinists (including as precision machining apprentices), and production technicians.

<table>
<thead>
<tr>
<th>Occupational Family</th>
<th>Number of Placements</th>
<th>Share of Placements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Assembler-Fabricator</td>
<td>31</td>
<td>20%</td>
</tr>
<tr>
<td>2) First Runger*</td>
<td>20</td>
<td>13%</td>
</tr>
<tr>
<td>3) Trainer-Mentor</td>
<td>19</td>
<td>12%</td>
</tr>
<tr>
<td>4) Designer</td>
<td>16</td>
<td>10%</td>
</tr>
<tr>
<td>5) Self-Employed</td>
<td>16</td>
<td>10%</td>
</tr>
<tr>
<td>6) Robotic Operator-Technician</td>
<td>14</td>
<td>9%</td>
</tr>
<tr>
<td>7) Other Production Worker</td>
<td>11</td>
<td>7%</td>
</tr>
<tr>
<td>8) Digital Tool Operator</td>
<td>10</td>
<td>6%</td>
</tr>
<tr>
<td>9) Engineer-Scientist</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>10) Machinist</td>
<td>6</td>
<td>4%</td>
</tr>
<tr>
<td>11) Apprentice</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>Total Placements</td>
<td>156</td>
<td>100%</td>
</tr>
</tbody>
</table>

*First Runger describes entry-level jobs that are a foot-in the door. These include positions such as assistant, laborer, intern, etc.
Box 1 summarizes information on occupational demand from online job listings in established and emerging maker occupations.

Box 1. Maker Demand for Designers and Emerging Occupations from Online Job Listings

On-line job listings provide additional information on demand for makers. In listing jobs, employers sometimes use long-established job titles and sometimes list “emerging occupations” not yet recognized by the “Standard Occupational Code” (SOC) system. As well as extracting information on emerging occupations from online job listings, we also identified data on designers (since the “Inflection Point” did not do so), and some information on engineers and precision machinists—wage ranges listed with online job openings are in the same ballpark as wages in official government occupational data. Unless otherwise stated, wages shown below are for “median wages.”

From payscale.com
• Product designer – $76,881

From mynextmove.org
• Commercial and industrial designer – $67,790
• Mechanical engineer – $84,190
• Industrial engineer – $84,310
• Electronics engineering technicians – $62,190
• Robotics Engineer – $97,300
• Robotics Technician – $55,610 (this now has an SOC code – https://www.onetonline.org/link/summary/17-3024.01)
• CNC machine tool programmers, metal and plastic – $50,580
• Tool and die makers – $51,060

From indeed.com
• Laser production operator – average of $14.67 per hour ($30,514 annually for a full-time, full-year worker) per year
• Laser technician – average of $16.36/hour or $34,028 annually
• Additive manufacturing technician – average of $15.80/hour or $32,864 annually.

Taken together, information from “the Maker City Handbook,” Made Right Here and New Century Careers, and online jobs listings highlights that some of today’s (and tomorrow’s) maker skills-in-demand resemble past skill demands, while new demands exist for the skills to operate and maintain new digital tools and to work with varied materials. The nature of skill demands points to the value in maker education of breadth in technical skills combined with basic and maker soft skills that foster adaptability and flexibility. Students who emerge from high school or a year or two of postsecondary education with broad soft and technical skills will be poised to move along a wide array of career pathways, and able to shift direction and try another route if progress along a first pathway stalls.
How Does the Focus of Regional Maker Education Programs Relate to Future Demand?

How do our profiles of future occupational and skills demand relate to the current emphasis of maker education programs surveyed? For the most, they don't relate in an obvious way because only 20% of the programs surveyed (six total) trained makers for specific occupations. This highlights again the gap between most maker education programs and employers.

Of those programs that do train for specific occupations, 83% (five of six) said they train makers to be designers; 67% (four) said they train entrepreneurs, engineers, entry-level production workers, machinists and robotic operator-technicians; and, finally, half (three) said they train assemblers/fabricators and digital tool operators (Figure 16).

Programs that do not train for specific occupations believe that the skills and competencies which they teach would serve the following occupations: designer (86%), entrepreneur (82%), assembler-fabricator (64%) and robotic operator-technician (55%) (Figure 17).

Based on these survey results, regional maker education programs generally seek to open a world of possibilities for students not funnel them into narrow production jobs or any other specific direction. That is laudatory. To give students better chances to experience that world of possibilities, however, the gap between most programs and the job market needs to narrow in two ways. As students proceed

![Figure 16](image)

**Specific Occupations Trained for by Maker Programs***

*Only includes maker programs that train for specific occupations.

Source: Keystone Research Center maker survey analysis, April/May 2017.
beyond exposure and orientation to making, and as they move into high school and beyond, stronger emphasis on career development seems warranted. Second, the connections to actual employers and the world of work needs to be strengthened – including to capture the educational benefits of bringing the real world of making into the classroom.

**Maker Career Paths**

The general competences developed by maker education programs and the evolution of the manufacturing sector described in Box 2 point to a potential “unfreezing” of career pathways for future makers. It should become easier for makers to work in a production job but then migrate to design or engineering – or to do the reverse, perhaps to make a product they helped design. It should also become easier – at least in smaller and less bureaucratic manufacturers – to move in and out of management positions. There will be a less detailed division of labor with status defined more by your making capabilities than by your degree or class background.

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*Figure 17*

*Includes maker programs that do not train for specific occupations. Source: Keytone Research Center maker survey analysis, April/May 2017*
Box 2. Pittsburgh Manufacturing’s “Make-Over”
Casting a Wide Net to Draw Talent Into 21st Century Making

In recent decades, manufacturing has suffered a widely discussed “image problem” that makes it more difficult to recruit capable and motivated young people. The Maker movement and maker education programs can help change the image of manufacturing – of 21st century “making” – in the Pittsburgh region. Pipelines leading to jobs in manufacturing will be able to cast a wider net, tapping talent from all communities and fueling the region’s innovation engine.

We can’t – and shouldn’t – duck the objective reasons that parents and students have shied away from manufacturing. While the sector still pays more than other industries, the pay advantage of manufacturing is a fraction of what it was 40 years ago. As families and communities in Southwestern Pennsylvania know full well, people in manufacturing suffer displacement from good jobs at higher rates than other industries. Many people also associate manufacturing with hot, dirty physically demanding work. Many startups and other advanced manufacturers have more in common with an air-conditioned medical research lab – or a makerspace.

It’s not just the physical realities of manufacturing jobs that are changing. So are the human relations, especially in higher tech manufacturers. Compared to the rote manufacturing jobs of the past, future makers will enjoy.

- More intrinsically rewarding work.
- A reintegration of thinking and doing, reversing the efforts (never fully successful) of “scientific management” to deskill jobs and separate thinking and doing during the age of mass production.
- More fluidity and movement among occupational categories and a blurrier line between “college track” and non-college track jobs.
- Less hierarchical relationships. We won’t see the end of organizational politics (sorry about that), but we already see in startups a shift to status based on how well peers and colleagues think you do your work not where you got your degree (or if you have one).

A recent academic survey of manufacturers corroborates what Pittsburghers who interact with startups already know – high-tech manufacturing companies have high skill requirements but don’t fact significant skill shortages. Word-of-mouth plus a visceral positive, not negative, response to the feel of the workplace mean that they get their pick of great young people.

Pittsburgh’s maker education programs can support and accelerate this “Make-over” to help the region’s manufacturers walk the new walk, and attract people from all communities. Maker education programs can foster awareness of the whole “world of career possibilities” in programs from elementary education through programs for adults. They can develop broad soft and technical skills in basic and advanced training programs – giving participants multiple take-offs for rewarding careers. And they can collaborate to create a more fluid “framework” and network for lifelong learning, enabling people to keep their skills and enthusiasm current, and to redeploy their talents more easily if their current job, contract, or business ends.
Overview of the Make to Manufacturing Framework

Now that we’ve outlined future maker occupations, let’s turn to the framework. This framework aims to serve as a tool for many audiences: for maker programs to see where they fit in the regional maker talent development ecosystem and economy; for parents whose children thrive in maker camps and classes but who do not know where maker education could lead; for students who love to make things but don’t know if maker skills could translate into a job or how to increase the chance that it might; and for manufacturing employers who need new pools of talent, want candidates with a passion for the work, and are eager to partner in career development and work-based learning that could boost the flow of students from maker education to their company. The goal is that this framework acts as a “living tool” to help identify gaps, foster alignment across programs, and support individual and collective reflection on pedagogy and program effectiveness.

The framework figure in the center of this report shows the basic maker framework in pictorial form. The image on the left represents maker education programs in the region. The images on the right represent manufacturing training and careers. The framework illustrates the weak link at this point between maker education and manufacturers (represented by a dotted line between the left and right images). While some programs have strong connections to employers, it is not the norm. This linkage needs to become a well-constructed bridge to ensure that youth learning critical maker skills connect with opportunities for work. This will be facilitated by stronger relationships and partnerships between maker education programs and manufacturing employers/training programs.

Let’s start with the maker education network (the right triangle image on the left, the hypotenuse of which faces to the northwest). The triangle image represents maker programs in the Southwestern Pennsylvania region and it moves individuals from left to right as they get older. The triangle shows that maker education programs move youth and adults through various stages of learning while casting a broad net for participation. This broad net allows individuals of all ages to become part of the Maker movement, tapping their interest and deepening their enthusiasm for making, while enabling those with an interest to enter a pathway to a maker career.

We identified the following levels or stages of maker education, shown as you move vertically within the triangle:

- **Exploratory**: Introducing individuals to the world of making and hands-on learning.
- **Orientation**: Engaging individuals in maker pedagogy and maker learning through activities or an introductory course.
- **Basic Maker Skills**: Teaching, usually through projects and “learning-by-doing,” beginner maker competencies: e.g., critical thinking and problem solving, core maker technical skills such as project planning and project design, and introductory technical skills (how to operate specific digital tools and work with specific materials). Allows participants to learn the process of making and assess whether it is something that they want to pursue more deeply.
- **Advanced Maker Skills**: Teaching advanced maker skills, including digital tool operation, product design and other technical skills. Deepens life/innovation skills through teamwork and project-lead opportunities.
• **Career Entry**: Prepares individuals to enter a career and/or provides them with work experience in making.

Most programs serving elementary school youth (birth to 5th grade category on the triangle) are at the exploratory and orientation levels, providing an introductory exposure to the world of making. Some youth in their later elementary school years begin to learn basic maker skills. Many maker programs serving middle- and high-school youth also allow newcomers to explore and gain an orientation to making. Some also begin to teach basic and advanced maker skills. Some programs teaching high-school youth go further, beginning to expose youth to the world of maker careers and even to work experience (e.g., through summer jobs) at the career entry level. Programs for people 18 and over tend to teach at all levels, although those maker programs focused on older adults rather than youth (typically defined as up to age 24) tend to move from purely educational to more career-focused maker skills with the potential to lead to employment.

The Remake Learning maker education network is made up of programs that span this triangle, in terms of both age groups served and levels of teaching. Due in part to the convener (the Remake Learning Network is focused on K-12 education and youth), and reflecting the lack of connection between the Maker movement and manufacturing trainers and employers, the majority of maker education programs fall into the bottom left part of the triangle (elementary through high school as well as exploratory to basic skills). This bottom part of the triangle engages and acts as a sieve, filtering “in” those most interested in climbing to the top of the maker education triangle. The region could benefit from more heavily populating with programs the top of the triangle, potentially through deeper connections between maker education and the maker economy.

The right part of the figure (the rotating ball) shows career pathways which include traditional post-secondary schooling, apprenticeship, and other training for specific occupations and careers. Each of these options can lead towards an actual job with, ideally, one or multiple career pathways to higher-paid, more skilled positions if the individual desires it, has the skills or aptitudes, and has access to on-the-job learning and/or additional maker training needed to move up. The chart in the bottom right hand corner of the figure shows a list of maker-related occupations and their salaries. (The chart in the framework blends data on occupations and wages from all the sources cited above – occupational projections, online job postings, and placements by the Made Right Here training program – and for that reason does not always agree precisely with the earlier figure that uses only information from occupational projections.) This chart is color coded to show occupations that are projected to grow a lot or a little over the coming years.

The strength of connections between youth maker programs and maker career training and manufacturing employers determines how well the maker ecosystem functions to move talented youth educated in the region’s maker programs into the manufacturing jobs and careers of the future.
Recommendations for Action: Strengthening Pittsburgh’s Talent Development System for 21st Century Makers

This project developed the framework described in the last section so that maker education programs can see how they fit into the regional talent development system that will lead some students today into maker careers that last into the 2070s (if they are in elementary school today). It also developed the framework, and conducted a survey of maker education programs, to identify “gaps” in Pittsburgh’s talent development system for makers and ways of improving that system. This section outlines three main ways to improve the system: by strengthening the connections of programs to each other; by strengthening the connections of maker education to employers; and by making career pathways to – and among – rewarding maker careers more visible and more credentialed.

1) Strengthen maker educator networks and peer learning: make Pittsburgh maker educators an exemplary community of practice committed to collective performance improvement

Pittsburgh maker educators are distinguished by passion for their work, stirring students’ excitement about learning while cultivating broad competencies that improve students’ chances for success wherever the future takes them. Yet many of these programs know little about other programs, those that teach similar skills as well as others that might precede or follow theirs. The lack of dense connections among maker educators creates opportunities for improvement of individual programs through peer learning. It also creates opportunities for improvement of the network – once maker educators see the overall framework of which they are a part, they can work more explicitly on improvements of their part of this framework and synergies with other programs.

Here are some specific recommendations for action to improve maker education programs and make the network more effective for learners and for employers.

a. Walk educators, participants, and parents through the framework model by hosting sessions/events on “What’s Next for Me?”

The “framework” outlined here will remain an abstraction to maker educators unless they engage with it and come to own it as a tool for performance improvement. A starting point for such ownership would be to walk educators through the framework, getting them to spell out in more detail where they fit and encouraging them to see it as a “living framework” that they can modify and enhance. To further consolidate the framework as a living tool, educators could then walk their participants and parents through the framework, focusing on where students might go next after they complete their current program. In some cases, sessions with parents could be done in teams of maker educators from two or more programs.

b. Develop customized posters for each program outlining “here are some maker education programs that you can take next”
c. Strengthen informal networking among maker educators

Informal networking could include monthly happy hours, pot lucks that rotate among the houses of educators in a specific geographical area, visiting other maker educators’ classes at least once a semester, or similar mechanisms.

d. Create formal peer learning sub-groups of maker educators

Another way to strengthen connections among programs would be to create self-organized, peer learning sub-groups that bring together maker educators that teach similar courses, feed into one another, operate in close geographical proximity, or based on other criteria. For similar courses, for example, educators could work on curriculum development and lesson planning together, and sit in on each other’s lessons.14

e. Develop an affinity group of maker educators within CTE programs

Maker education programs for school-age children in the region include some for students in vocational or “career and technical” education. Most, however, are for students in college-bound tracks or outside schools. Some CTE educators fear that maker programs could threaten their job security and worry that non-CTE teachers may not have the sensitivity to safety issues inculcated into CTE programs. From a long-term perspective, maker education has potential to elevate the status of CTE programs because it brings renewed respect for learning-by-doing and for careers that blend working with hands and head. The Remake Learning Network should develop an affinity group of maker educators within CTE programs and partner with this group to develop a plan for helping regional CTE educators en masse to embrace maker education rather than be threatened by it.

f. Develop an annual survey of maker education programs that includes information needed to produce network diagrams and measures of network strength

2) Strengthen the connections of regional maker education programs to employers and to makers in the economy

Pittsburgh’s advanced manufacturers stand to benefit, potentially a great deal, from the region’s network of maker education programs. Already, these programs implement one of the “Inflection Point” report’s (p. 17) recommendations for action to strengthen the regional economy: “Focus on the development of emerging, cross-cutting skills and competencies.” To fully tap the potential of regional maker education as an inclusive pipeline for diverse makers requires strengthening the connections between maker education and both employers of makers and people who earn a living through making (whether as employees, entrepreneurs, contractors, or through self-employment). As it stands, our research revealed that many maker education programs are “siloed” within the world of K-12 education. For example, many do not rate career development high as a goal and only 20% train for specific occupations.15

Stronger connections with industry should enhance maker pedagogy in the region. Exposure to the workplace and to makers in the economy motivates students because they discover that what they are learning has a real-world application. Formal work-based learning (e.g., internships, coop programs, summer jobs, and apprenticeship) takes project-based learning, learning-by-doing, teamwork, and support from mentors beyond what is possible in a school, library or community makerspace.

To strengthen connections to employers and makers in the economy, the Remake Learning
Network could

   a. Survey member education programs to identify concrete, value-added roles for which they need additional engaged employers (e.g. to serve on curriculum committees, to provide mentors for students, for site visits, or to provide work-based learning (summer jobs, internships, coops, apprenticeships).

   b. Survey employers to ask them “would you like to connect to maker education?” and to inform efforts to connect with those who say yes

This survey could target manufacturers already engaged with regional workforce boards, apprenticeship programs, industry partnerships, training programs with a significant record of placement in manufacturing (e.g., New Century Careers), and BOTS IQ. The survey could identify employers interested in providing managers, engineers, or other occupations to serve in the employer roles identified by maker education programs.

   c. Inventory and then convene and/or survey maker occupational associations and networks to assess the willingness of their members to engage with maker education programs.

Connections to the economy can be made through direct connections to makers and maker groups, as well as through employers. Such maker groups could include industrial designers, engineers, tool-and-die makers, journey-workers in manufacturing and in the construction trades, and others. These groups could strengthen career development programs – current makers can tell educators and students how they went from school to their current position – and serve as mentors for students.

d. Encourage advanced maker skills and career entry programs that place significant numbers of participants to establish alumni associations whose members could serve as resources to connect the programs – and maker education programs for younger ages that feed into the programs – to the economy.

e. Articulate effective practices for individual maker education programs to engage with employers and makers in the economy, customized for programs serving different age groups and at different levels.

3) Make career pathways to -- and among – rewarding maker careers more visible and credentialed

Within a broad recommendation to “Focus on Upskilling Talent in the Region,” the “Inflection Point” report (p. 17) included the more specific recommendation to “create explicit pathways to upward mobility.” The report notes that such pathways are critical to “…ensuring employers have an adequate talent supply and that workers have opportunities to advance. Too often existing pathways are unclear…” Employers can create explicit pathways to advancement within their firms, within industries and across industries. Alignment and clear expectations between employers and training providers can accelerate workers’ advancement into higher value roles.” This recommendation is especially important for maker careers because jobs and pathways change quickly, and existing pathways are even more opaque than in other fields. While the primary responsibility for action in these areas must come from employers, maker educators and the Remake Learning Network can assist with the development of more explicit and credentialed career pathways in the following ways.
a. Develop regional career pathways starting in K-12 and through post-secondary education leading to specific employers and occupations as shown in the framework

While seeking to avoid bureaucratic rigidity in course sequencing, the development of these regional pathways should lead to formalization of possible routes along which students and workers may increase the competencies for specific maker occupations. At the post-secondary level, to take one specific example, regional career pathways would make more explicit the potential for people with a Maker Professional apprenticeship credential to advance into more specialized apprenticeships that lead into specific higher-paid occupations (such as tool-and-die maker). As well as helping adults map their future pathway, visualizing advancement from entry-level maker jobs to higher paid occupations also helps students and parents see that any manufacturing starting job need not be an end point.

d. Educate students to be smart about picking their employer

While the world of workforce development tends to emphasize employers picking workers, graduating students and workers already in the job market often have some ability to choose among employers. The company that wrote the “Inflection Report,” Burning Glass, drives home this point through its “Glass Door” website (https://www.glassdoor.com) which shows worker ratings of companies as places to work. A large economic literature documenting “good employers” (e.g., Trader Joe’s, Costco’s) and less good employers within the same industries also drives home that young makers would be wise to seek out employers that invest in their workers, support mentoring on the job, and offer opportunities to acquire additional credentials and to advance.16 The Remake Learning Network should develop a handbook with material on being smart job shoppers that can be incorporated into career development programs for potential makers.

e. Invest in a Regional Maker Opportunity Center

Employers, makers, and the region will all flourish if the Pittsburgh-area leads the nation by investing in, honoring, and fairly rewarding future makers. Improving the quality of maker jobs and support structures that help makers navigate changes in employer, or moves from entrepreneur to self-employment to contractor to employer – and back again – will also work magic in terms of the number and quality of young people that want to become makers. Given time, “the market” and word of mouth work well in guiding career choices among youth. One entity that could help the
region achieve a good careers/great workers equilibrium in the labor market for makers is a “Maker Opportunity Center.” Across the country, “worker centers” in other occupations (such as the “Restaurant Opportunities Center”¹⁷) have sought to ensure enforcement of basic labor standards while also offering training for workers and partnering with exemplary employers. This same formula – with more emphasis on the training and partnering including the creation of referral services for makers that help them find new paid gigs – could help Pittsburgh become THE city for 21st century makers. It would also be a powerful boost to the region’s innovation economy and to the effort to broaden Pittsburgh’s new prosperity to include more people.
Endnotes


7. An MIT survey of manufacturers in 2012-13 found that 81.2% of employers rated “cooperation with other employees” as “very important,” and 64.2% rates “ability to work in teams” very important. Paul Osterman and Andrew Weaver, “Why Claims of Skills Shortages in Manufacturing Are Overblown,” Economic Policy Institute, Issue Brief #376, March 26, 2014, p. 6. Found at: http://www.epi.org/publication/claims-skills-shortages-manufacturing-overblown/


10. Even in skilled occupational families (precision machining and industrial maintenance) in which employers continued to report shortages throughout the Great Recession and early recovery, displaced manufacturing workers rarely find reemployment within the same occupational family in manufacturing within the next up-to three years. This points to the
underdeveloped sectoral re-employment and career institutions. For data and additional discussion, see Stephen Herzenberg and Mark Price, *Critical Shortages of Precision Machining and Industrial Maintenance Occupations in Pennsylvania’s Manufacturing Sector*, Center for Workforce Information and Analysis, Pennsylvania Department of Labor and Industry, December 2010.

11. The trainer-mentor placements are partly an artifact of the fact that the program operated for its first few years out of the Bakery Square Tech Shop, a for-profit membership-based makerspace that hired some Made Right trainees to mentor and train other Tech Shop members.

12. In the last two recessions and early recoveries, displacement rates in manufacturing (the share of workers with three or more years of experience who lost jobs in the previous three years) were more than double displacement rates in the overall economy. Manufacturing displacement rates equaled about 10% in 2001-03 and 2009-11, dropping to 4.6% in 2011-13. Keystone Research Center analysis of the Bureau of Labor Statistics Displaced Worker Survey.

13. Specifically, the 2012-13 MIT survey of manufacturers found that “high technology” firms had higher skill demands than other manufacturers but significantly lower long-term vacancies as a percent of total “core workers.” Osterman and Weaver, “Why Claims of Skills Shortages in Manufacturing Are Overblown,” Economic Policy Institute, 2014, p. 8.

14. In Japan, joint lesson planning and improvement – “lesson study” – is a tried-and-true practice. Under this approach, teachers develop a lesson plan, observe a peer teaching the lesson, then reflect as a group on how to improve the plan. See James W. Stigler and James Hiebert, *The Teaching Gap: Best Ideas from the World’s Teachers for Improving Education in the Classroom* (New York: Free Press, 1999).

15. A disconnect from the economy is not unique to maker education programs. The “Inflection Point (p. 17) highlights the “uneven” connections between employers and training providers and tasks employers with supporting “…a more effective and sustainable model to enable education and training providers to better understand changing skill demands.”


17. On the Restaurant Opportunities Center multi-pronged model for raising labor standards and job quality – working with enlightened employers and training workers, while also seeking to enforce basic labor standards, see http://rocunited.org/our-work/#advocacy
### Appendix

#### Table A1. Profile of Specific Maker Occupations

<table>
<thead>
<tr>
<th></th>
<th>Employment 2015</th>
<th>Salary 2015</th>
<th>Projected Growth Rate</th>
<th>Projected Annual Openings</th>
<th>% Required BA</th>
<th>Location Quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance &amp; Repair Workers, General</td>
<td>15,378</td>
<td>$37,800</td>
<td>3%</td>
<td>1,227</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Assemblers</td>
<td>7,430</td>
<td>$29,020</td>
<td>-1%</td>
<td>790</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervisors - Production &amp; Operating Workers</td>
<td>5,503</td>
<td>$58,620</td>
<td>0%</td>
<td>485</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinists</td>
<td>4,567</td>
<td>$37,270</td>
<td>11%</td>
<td>483</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helpers - Production Workers</td>
<td>3,466</td>
<td>$29,180</td>
<td>-4%</td>
<td>452</td>
<td></td>
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</tr>
<tr>
<td>Welders, Cutters, Solderers &amp; Brazers</td>
<td>3,691</td>
<td>$38,840</td>
<td>3%</td>
<td>368</td>
<td></td>
<td></td>
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<tr>
<td>Industrial Machinery Mechanics</td>
<td>3,677</td>
<td>$46,920</td>
<td>20%</td>
<td>342</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervisors - Mechanics, Installers &amp; Repairers</td>
<td>3,355</td>
<td>$64,320</td>
<td>2%</td>
<td>251</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical &amp; Electronic Equipment Assemblers</td>
<td>2,294</td>
<td>$31,340</td>
<td>-3%</td>
<td>249</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting, Punching &amp; Press Machine Operators</td>
<td>1,921</td>
<td>$36,020</td>
<td>-15%</td>
<td>192</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Engineers</td>
<td>3,112</td>
<td>$81,880</td>
<td>2%</td>
<td>176</td>
<td>98%</td>
<td>1.13</td>
</tr>
<tr>
<td>Mechanical Engineers</td>
<td>2,548</td>
<td>$84,190</td>
<td>10%</td>
<td>163</td>
<td>99%</td>
<td>1.11</td>
</tr>
<tr>
<td>Computer-Controlled Machine Tool Operators</td>
<td>1,499</td>
<td>$37,830</td>
<td>16%</td>
<td>163</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grinding, Lapping, Polishing &amp; Buffing Machine Tool Operators</td>
<td>1,258</td>
<td>$35,860</td>
<td>-11%</td>
<td>141</td>
<td></td>
<td></td>
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<tr>
<td>Electrical Engineers</td>
<td>2,045</td>
<td>$85,980</td>
<td>2%</td>
<td>110</td>
<td>98%</td>
<td>1.2</td>
</tr>
<tr>
<td>Electrical &amp; Electronic Engineering Technicians</td>
<td>1,268</td>
<td>$52,560</td>
<td>-9%</td>
<td>74</td>
<td>14%</td>
<td>1.01</td>
</tr>
<tr>
<td>Architectural &amp; Civil Drafters</td>
<td>1,261</td>
<td>$50,280</td>
<td>-15%</td>
<td>71</td>
<td>28%</td>
<td>1.59</td>
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<tr>
<td>Mechanical Drafters</td>
<td>1,205</td>
<td>$48,750</td>
<td>0%</td>
<td>68</td>
<td>13%</td>
<td>1.74</td>
</tr>
<tr>
<td>Tool &amp; Die Makers</td>
<td>581</td>
<td>$44,250</td>
<td>-2%</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics Engineers</td>
<td>1,065</td>
<td>$74,770</td>
<td>-3%</td>
<td>55</td>
<td>90%</td>
<td>0.51</td>
</tr>
<tr>
<td>Architects</td>
<td>807</td>
<td>$78,020</td>
<td>4%</td>
<td>47</td>
<td>99%</td>
<td>0.52</td>
</tr>
<tr>
<td>Electrical &amp; Electronics Drafters</td>
<td>534</td>
<td>$58,410</td>
<td>2%</td>
<td>31</td>
<td>2%</td>
<td>1.21</td>
</tr>
<tr>
<td>Computer Numerically Controlled Machine Tool Programmers</td>
<td>248</td>
<td>$46,590</td>
<td>19%</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineers, Other</td>
<td>407</td>
<td>$94,610</td>
<td>11%</td>
<td>26</td>
<td>91%</td>
<td>0.63</td>
</tr>
<tr>
<td>Industrial Engineering Technicians</td>
<td>388</td>
<td>$49,360</td>
<td>4%</td>
<td>24</td>
<td>7%</td>
<td>0.66</td>
</tr>
<tr>
<td>Mechanical Engineering Technicians</td>
<td>363</td>
<td>$49,100</td>
<td>3%</td>
<td>22</td>
<td>22%</td>
<td>0.96</td>
</tr>
<tr>
<td><strong>Total, Selected Occupations</strong></td>
<td><strong>69,871</strong></td>
<td><strong>6,094</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Inflection Point, Table 26 and 27, pp. 33 and 34