Education Advisory Board | Community College Executive Forum

Manufacturing

Rebranding for a Design-Driven Marketplace

Industry Futures Series, Volume 4

Community College Executive Forum

Project Directors

Lisa Geraci

Lisa Qing

Contributing Consultant

Jess Jong

Design Consultant

Nini Jin

Practice Manager

Sarah Zauner

Executive Director

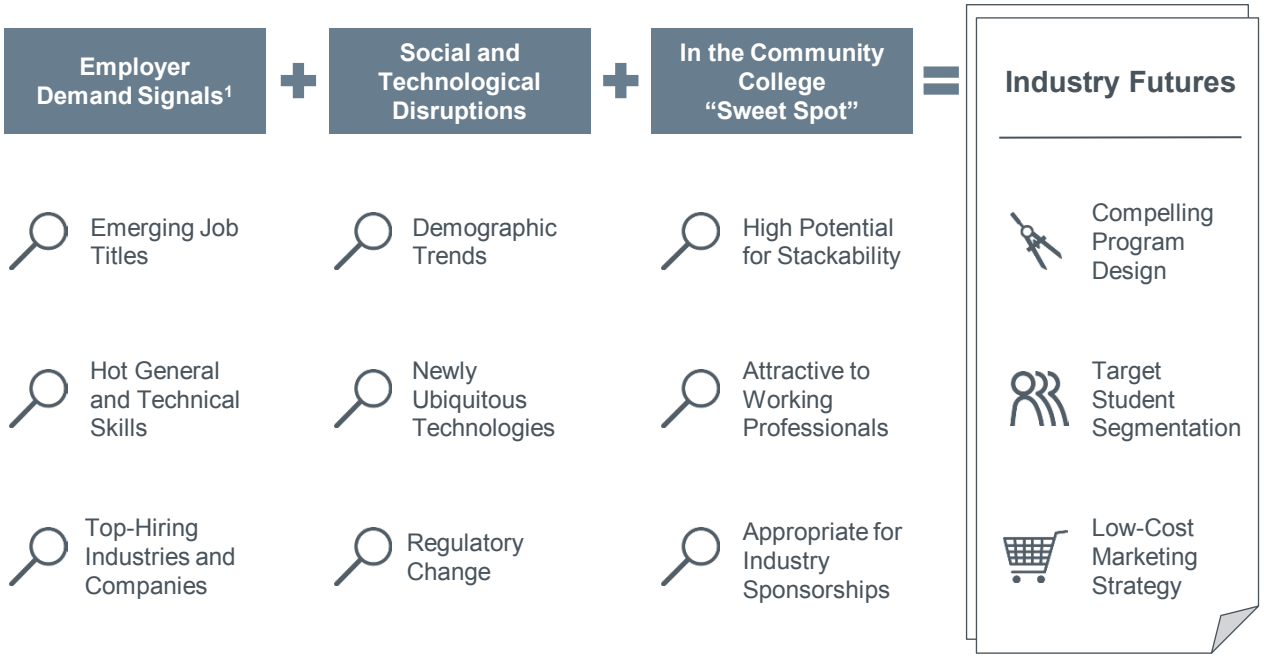
Chris Miller

Anticipating the Workforce Needs of the Next Decade

Volume Four in a Four-Part Series

As technology reshapes industries and the workforce prepares for a mass retirement of Baby Boomers, higher education must anticipate the training deficits of the future while continuing to respond to current employer needs. The Industry Futures Series combines an analysis of employer demand signals (available through a partnership with the labor market analytics firm Burning Glass) with an examination of the social and technological disruptions shaping the next decade's workforce. The methodology outlined below aims to identify opportunities for community colleges to launch or redesign programs that align with emerging student and employer demand.

Our Methodology for Identifying High-Demand Program Opportunities



The Industry Futures Series examines four opportunities for colleges to attract new students while addressing the needs of the local workforce. This final volume explores how to incorporate emerging design technologies into manufacturing programs to engage a new generation of students.

Four Opportunities for Community Colleges to Do Well and Good

1) The real-time labor market data in this report comes from the Education Advisory Board's partnership with Burning Glass for use of Burning Glass's proprietary Labor/Insight™ tool.

Study Road Map

1 The Evolution of U.S. Manufacturing

2 Design-Driven Programs in Manufacturing

3 Appendix: Assessing the Opportunity

Made in the U.S.A.

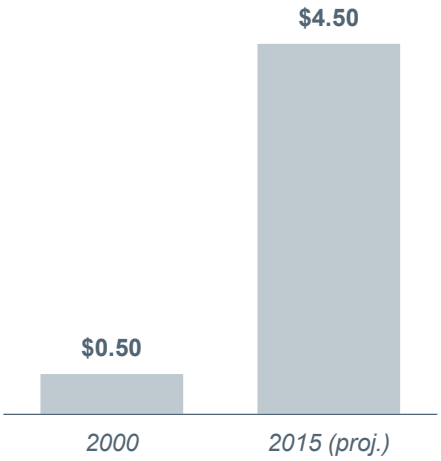
At the start of the Great Recession, manufacturing looked like an industry in decline, with jobs leaving the United States for countries with lower labor costs. More recently, however, companies have started to reevaluate the economics of offshoring. According to an analysis by the Boston Consulting Group (BCG), the average Chinese factory worker's wage in 2015 will be nine times what it was in 2000. Rising labor costs, combined with the growing expense of utilities and real estate in China's manufacturing hubs, have pushed even the CEO of Walmart—a company famous for finding cost savings—to declare that offshoring is reaching a "tipping point" beyond which it may no longer make economic sense.

In addition to accounting for the shrinking cost advantage of offshoring, companies bringing manufacturing back to the United States aim to shorten their supply chains and accelerate their speed to market. As these companies "reshore," BCG predicts the creation of over 600,000 domestic manufacturing jobs.

Manufacturing Jobs Returning as Economics of Offshoring Shift

Shrinking Cost Advantage of Manufacturing Overseas

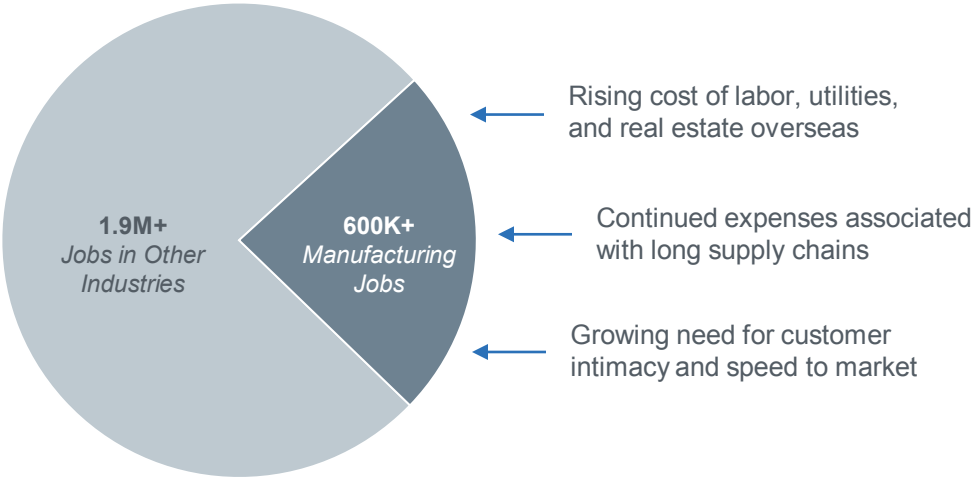
Average Chinese Factory Worker Hourly Wage



> In previous decades, investment mainly went to Asia. Wages were low. The price of oil was low. And new factories sprung up out of the ground. But today, some of those investments are nearing the end of their useful lives…The equation is changing [and companies] have defined the 'tipping points' at which manufacturing abroad will no longer make sense for them."
>
> *Bill Simon, CEO of Walmart*

Need for Speed to Market Bringing Jobs Back Home

BCG Projections of New U.S. Jobs Created by Reshoring



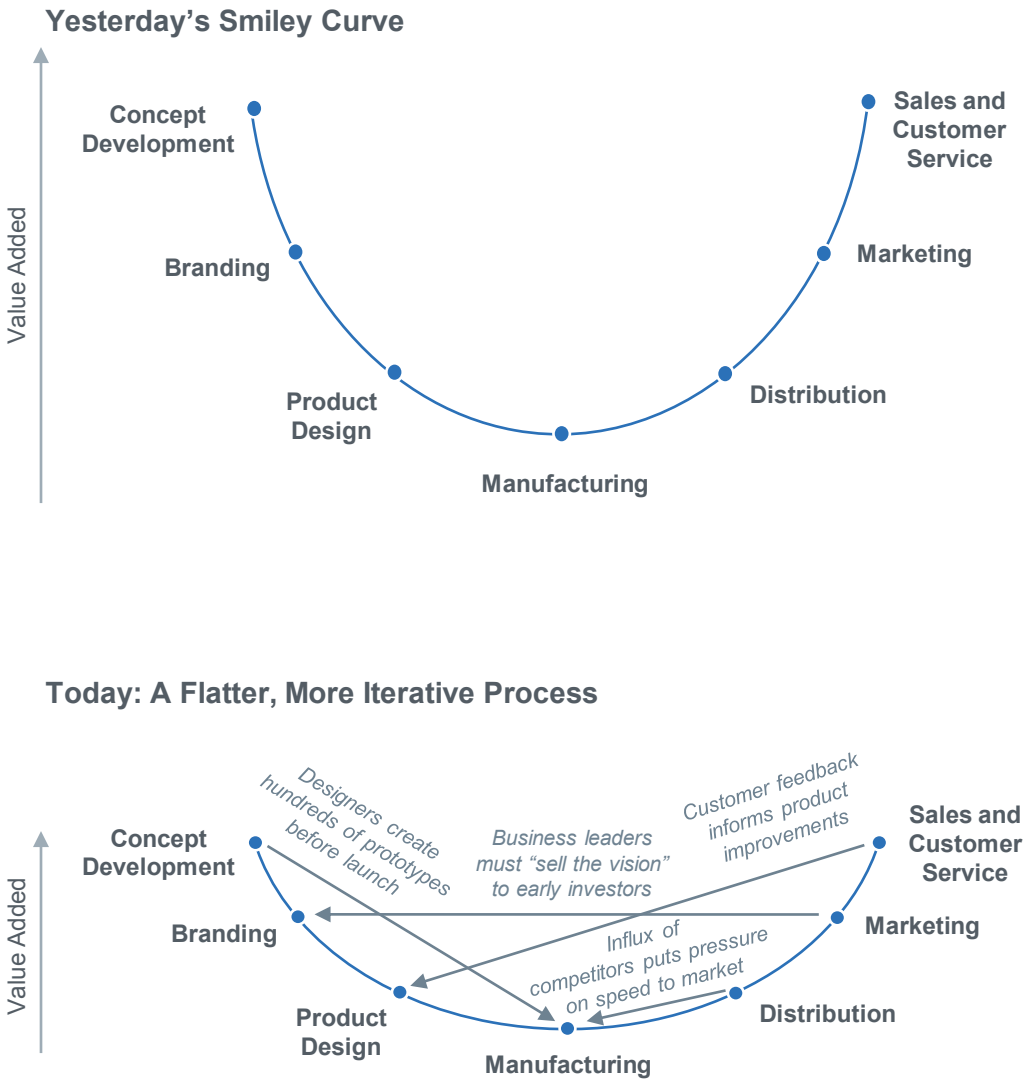
Source: Sirkin HL, et al., "Made in America, Again," Boston Consulting Group, Aug. 2011; Simon B, "A Job to Do: Retail's Role in an American Renewal," Walmart, Jan. 2013; Sirkin HL, et al., "Behind the American Export Surge," Boston Consulting Group, Aug. 2013; EAB interviews and analysis.

Not Just Factory Jobs

The trend toward reshoring also reflects changes in the production process. In the 1990s, Stan Shih, founder of the electronics company Acer, developed the model depicted here. Called the "Smiley Curve" because of its shape, this model maps each step in the production process from the initial concept development to the final sale. The height of each point on the curve reflects the value added at that step—and, accordingly, its profitability. Traditionally, U.S. companies have focused their activities on the two ends of the curve while offshoring manufacturing, the least profitable step in the center.

Today, the rapid pace of innovation has reshaped the Smiley Curve. Fast-moving companies can no longer afford to approach production one step at a time. Instead, they must sell products to investors even before they've been designed, and they must continuously redesign and re-manufacture those products in response to customer feedback. With all steps along the Smiley Curve happening simultaneously and repeatedly, manufacturing—once the trough of the curve—is now inextricable from the steps before and after it. Accordingly, companies that once outsourced manufacturing now seek ways to conduct it in-house.

Manufacturing Increasingly Integrated with Design and Marketing



Source: "Smile: Blu Dot's Hidden Innovation?" Surface & Panel; Casey L, "The Smiley Curve Has Lost Its Wisdom Teeth," *The Atlantic*, Mar. 2011; EAB interviews and analysis.

Innovative Manufacturing Gets Small

The Irish-American entrepreneur Liam Casey was among the first to predict the Smiley Curve's new shape. In 1996, he founded PCH International to connect Western brands with Chinese factories that could manufacture their product designs at low cost. Though PCH never became a household name, it served as a key link in the production of goods from U.S. companies such as Apple.

In 2012, Casey noticed a resurgence of interest in manufacturing among U.S. entrepreneurs. In response, he opened a San Francisco office for PCH International, which now houses two subsidiaries that cover different parts of the Smiley Curve. One subsidiary, Highway1, serves as an incubator that provides entrepreneurs with design mentors and prototyping equipment in exchange for equity in each product that goes to market. The second subsidiary, Limelab, serves as a product development consultancy that supports hardware companies from concept development to sales. The success of both Highway1 and Limelab reflects the growing integration of manufacturing with the rest of the production process.

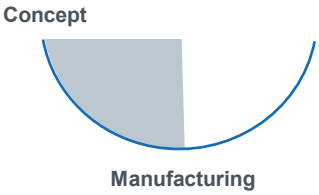
From Offshore and Large-Scale to Domestic and Speed-Based

- **1996:** Founded to connect Western companies with manufacturers in China
- **2012:** San Francisco headquarters opened to target start-ups and small technology businesses

Highway1
A PCH Solutions Company

Manufacturing Incubator

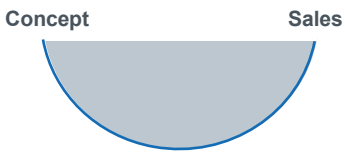
- Four-month intensive program turns entrepreneurs' ideas into products
- Participants receive workspace and access to prototyping and manufacturing equipment



LIMELAB
A PCH SOLUTIONS COMPANY

Design and Distribution Firm

- Offers a "complete supply chain solution" to aspiring hardware start-ups
- Distribution experts coordinate clients' fulfillment, inventory, and shipping needs



> [Entrepreneurs] stopped making things 10 or 15 years ago. They're starting to get inquisitive and curious again."
>
> *Liam Casey*
> *CEO, PCH International*

Source: Fallows J, "Mr . China Comes to America," *The Atlantic*, Nov. 2012; Segall L, "'Mr. China' Liam Casey Is Silicon Valley's Link to Asia," CNN Money, June 2012; "PCH International Launches Highway 1;" pchintl.com, June 2013; "Limelab —Product Design and Engineering Firm," limelab.com; EAB interviews and analysis.

Entering an Era of Customer Intimacy

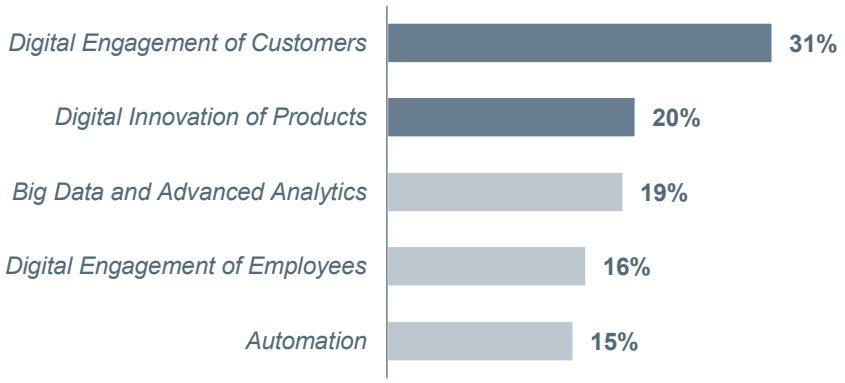
Companies especially value the integration of manufacturing and design. In 2013, McKinsey & Company named customer engagement and product innovation the two digital trends with the greatest potential to drive revenue growth. These two trends have combined to drive an explosion of interest in product customization.

With continued advances in digital technology, customization options continue to grow more sophisticated. For example, since 2012, the sneaker company Converse has invited online shoppers to design their own shoes by choosing colors for the fabric, rubber lining, laces, and even stitches. In 2014, a New Zealand-based start-up called Three Over Seven took shoe customization one step further, enabling shoppers to submit 3D scans of their feet for custom-tailored sneakers.

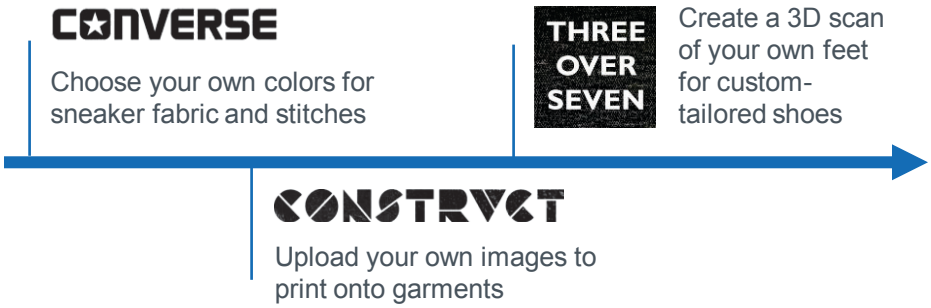
Customer-Centered Design a Growing Priority in Production

Share of Expected Revenue Growth from Top Digital Trends

McKinsey Global Survey of CEOs



Accelerating Toward Product Customization



Source: Brown B, et al., "Bullish on Digital: McKinsey Global Survey Results," McKinsey & Company, August 2013; "Design Your Own Chuck Taylor," Converse; "Create New," Constrvct; "What Is YouScript," YouScript; Kraft Foods, "Senior Brand Manager, Innovation," LinkedIn; EAB interviews and analysis.

Additive Manufacturing: The Key Link

Of all technologies enabling product customization, additive manufacturing is best positioned to transform production. Additive manufacturing, commonly called 3D printing, produces an object by joining layers of new material deposited according to pre-programmed data. It differs from conventional ("subtractive") manufacturing, which produces an object by removing the unwanted material around it.

Previously, companies used 3D printing to build preliminary prototypes while continuing to rely on conventional manufacturing for products headed to market. In the last few years, however, advances in 3D printing technology have enabled companies to manufacture consumer products through additive processes. Today, Mattel uses 3D printers to create toy parts, while Boeing uses them to build over 200 distinct aircraft components. Meanwhile, the Mayo Clinic has started to 3D print custom hip replacements.

As 3D printers become more affordable, they have also enabled small businesses to produce new designs. A basic machine that cost $20,000 three years ago costs less than $1,000 today, a price within reach for entrepreneurs with innovative ideas but limited capital.

Performance and Price of 3D Printing Exponentially Improving

No Longer a Tool for Flimsy Plastic Prototypes

MATTEL

3D-printed parts present in nearly all toys, from Barbie to Hot Wheels

BOEING

10 aircraft models each outfitted with over 200 3D-printed components

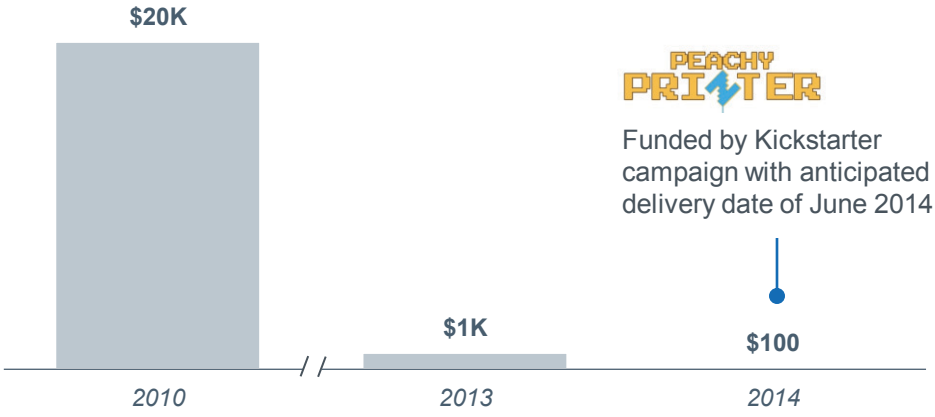
MAYO CLINIC

Piloting 3D-printed custom hip replacements for arthritis patients

Toys → **Airplanes** → **Body Parts?**

Suddenly Affordable for Small Businesses

Starting Price for a Basic 3D Printer



PEACHY PRINTER

Funded by Kickstarter campaign with anticipated delivery date of June 2014

Source: Bilton N, "Disruptions: On the Fast Track to Routine 3-D Printing," *The New York Times*, Feb. 2013; Dorrier J, "Peachy Priner Kickstarter Promises $100 3D Printer and Scanner—Can They Do It?" *Singularity Hub*, Sept. 2013; Boulton C, "Printing Out Barbies and Ford Cylinders," *Wall Street Journal*, June 2013; "3D Printer Helps Hips," Mayo Clinic; King R, "3D Printing Coming to the Manufacturing Space —and Outer Space," *Bloomberg Businessweek*; Jan. 2012; EAB interviews and analysis.

Artisans and Craftsmen Again

At the same time the 3D printer is lowering the need for capital, the market is clamoring for more customization and companies are competing on speed to market. Combined, these three trends pave the way for a new production model that favors niche manufacturers—small, agile businesses creating specialized products for highly targeted markets. Niche manufacturers have always excelled at customer intimacy. With advances in additive manufacturing technology, they finally have the means to meet demand quickly and affordably.

One industry that exemplifies this trend is beer brewing. Between 1994 and 2012, the number of craft brewers in the United States skyrocketed from just over 500 to 2,300. Their enormous success reflects their ability to respond to customer demand for specialized alternatives to the products of large breweries.

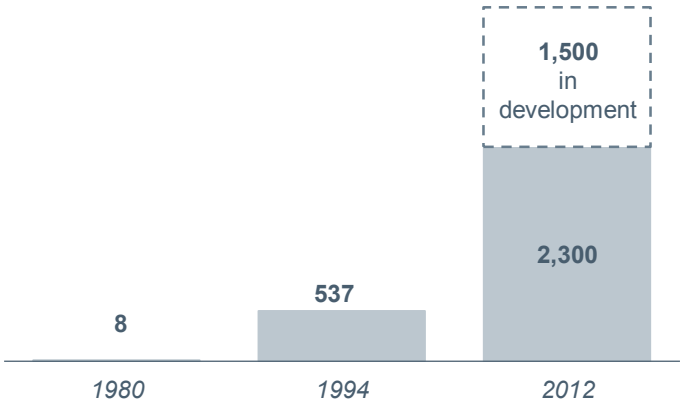
Emerging Technologies and Market Pressures Pave Way for Niche Manufacturing

Niche Manufacturing

Small Businesses Creating Specialized Products for Targeted Markets

An Example from the Brewing Industry

Number of U.S. Craft Brewers



Source: "The New Artisan Economy," Intuit & Institute for the Future, Feb. 2008; "History of Craft Brewing," Brewers Association; EAB interviews and analysis.

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Three Opportunities in Manufacturing Education

In light of the growing interest in niche manufacturing, this section explores three opportunities for community colleges to attract new audiences to manufacturing programs.

The first opportunity is the integration of 3D printing into manufacturing education, which allows colleges to update the skills taught in conventional manufacturing curricula.

The second opportunity is the introduction of emerging technologies into high school classrooms. As colleges rebrand manufacturing as a high-skill career, high school initiatives have had unexpectedly broad appeal, engaging future designers and entrepreneurs in career and technical education (CTE).

The final opportunity is craft brewing, an industry that exemplifies how the need for customer intimacy drives growth in niche manufacturing.

A New Technology, a New Audience, and a New Industry

3D Printing

- Design technology and prototyping certificates
- Entrepreneur outreach

Northampton Community College
IVC Irvine Valley College
GateWay Community College

K-12 Pipeline

- Emerging technologies in high school classrooms
- Mobile manufacturing labs

Sierra College
Northeast Wisconsin Technical College

Craft Brewing

- Beer mechatronics
- Small business management

Blue Ridge Community College
ABTech Community College
RCC

Source: EAB interviews and analysis.

Emerging Additive Manufacturing Stacks

In response to industry demand, forward-thinking colleges have introduced 3D printing into a range of design-focused manufacturing programs, from noncredit courses to associate degrees.

For example, Northampton Community College is home to a "FabLab," one of a global network of open workshops founded by the Massachusetts Institute of Technology. At the FabLab, local entrepreneurs can use 3D printers and other equipment for a small hourly fee. They can also take over 40 enrichment courses, ranging from a $30 introduction to the equipment to a $1,000 advanced course in guitar-building.

In response to demand from local industries such as aerospace engineering, Irvine Valley College built on its drafting program to develop a Design Model Making and Rapid Prototyping Certificate. This certificate enrolls over 65 students annually, ranging from high school students exploring future careers to retired manufacturing workers following changes in the field.

GateWay Community College teaches both additive and conventional manufacturing in its A.A.S. in Production Technology. Current manufacturing workers who update their technological skills commonly receive raises of up to $5 per hour upon program completion.

Programs Link Concept Development, Design, and Manufacturing

Northampton Community College

Entrepreneurial Outreach
FabLab

- 4,500 ft^2 space contains 3D printer, CNC router, woodworking lab, and other design equipment
- Entrepreneurs and enrichment seekers have access to 40+ noncredit courses and open labs ($10+/hour)

IVC Irvine Valley College

Emerging 3D Modeling Skills
Design Model Making and Rapid Prototyping Certificate

- Combines technical skills with artistic sensibilities to master conventional and emerging product design tools
- Mix of career starters and career changers find design jobs in diverse fields, from aerospace to woodworking

GateWay Community College

Design Principles for Manufacturing Veterans
AAS in Production Technology

- Mix of additive and subtractive manufacturing skills in product design and development
- Mid-career manufacturing professionals represent 90% of students and graduate with hourly salary bump of $1 to $5

Source: EAB interviews and analysis.

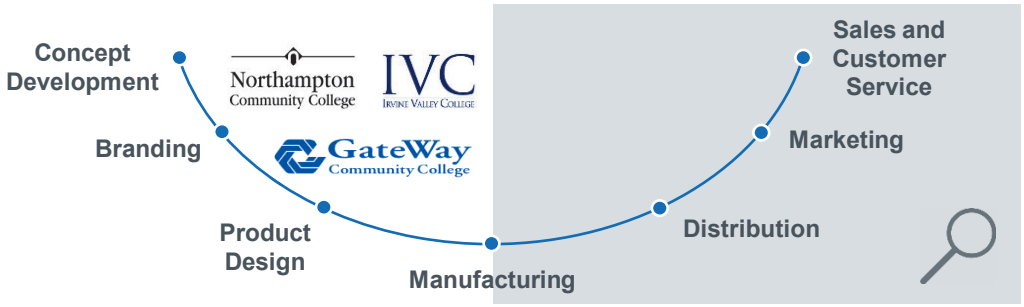
Opportunities Abound for Add-Ons

Though several colleges have established forward-thinking programs that combine concept development, product design, and manufacturing, few programs have integrated the right-hand side of the Smiley Curve—distribution, marketing, and sales.

Fortunately, most community colleges already teach these skills in academic programs outside of manufacturing and design. Leading colleges can mix and match existing offerings to teach the production process from start to finish.

For example, an associate degree program in industrial design technology could allow students to embed a certificate in logistics and supply chain management or, alternately, marketing and sales management. This interdisciplinary course of study would prepare graduates for a production process in which all steps, from concept development to sales, may need to occur at the same time.

Few Programs Connect Right-Hand Side of Smiley Curve



Embedding Distribution and Marketing Skills

Core Product Design Programs

- Industrial Design Technology
- Computer Aided Design
- Rapid Prototyping
- 3D Modeling

Certificate in Logistics and Supply Chain Management

- Principles of Exports
- Introduction to Materials Handling
- Principles of Purchasing
- Domestic and International Transportation Management
- Warehouse and Distribution Center Management
- Global Supply Chain

Certificate in Marketing and Sales Management

- Principles of Retailing
- Customer Relationship Management
- Business Correspondence and Communication
- Principles of Marketing
- Principles of Selling
- Advertising and Sales Promotion

Source: "Logistics and Global Supply Chain Management — Certificate," Houston Community College District; "Sales Marketing Associate Certificate," Dallas Community College District; EAB interviews and analysis.

Making Manufacturing Cool Again

In addition to revitalizing college-level manufacturing programs, emerging technologies can also engage a younger generation in manufacturing. Since 2006, the STEM Collaborative at Sierra College has installed 3D printers at six high schools. Because students with limited machining experience consider these devices safe and easy to learn, high school instructors have incorporated them into a broad range of classes, including pre-engineering, design technology, and even geometry.

Each year, several hundred high school students in Sierra College's service area take classes that use these 3D printers. Students who previously viewed manufacturing as dirty, dull, and dangerous now consider production a high-tech, high-skill process.

This initiative has not only introduced more students to manufacturing careers but also increased the diversity of students interested in the field. At Sierra College and its partner high schools, budding entrepreneurs are using 3D printers to create prototypes for new product ideas, while aspiring artists are using them to create sculptures.

3D Printers in High School Classrooms Expand and Diversify CTE Pipeline

SIERRA COLLEGE

- STEM Collaborative installed 3D printers at 6 partner high schools
- Printers range from $2,000 basic models to $17,000 industrial models
- Primarily used in pre-engineering, design technology, drafting, and mechatronics courses

The Ideal Device for Tech Novices

- ☑ Prior machining experience not required
- ☑ Few safety hazards compared to subtractive machines
- ☑ Limited material required to create compelling projects

Rebranding the Factory Job

"Kids who think manufacturing is a loud, dirty shop are now able to see things get made in the classroom. They understand that this is not 'old school' manufacturing but the future of manufacturing, which takes a high skill set and can be a really desirable job. Every kid who comes through my math class sees the 3D printer, asks about it, and wants to talk about it."

Jonathan Schwartz
Instructor, Colfax High School

An Emerging Pipeline of "Creative Types"

Budding Entrepreneurs

Colfax High School students printed a prototype for a ski boot sensor that monitors posture, evaluated by the product design firm Quirky with Bill Nye before a live audience at South by Southwest conference

Aspiring Artists

Students in Sierra College's Art & Innovation Club are printing parts for a human-powered kinetic sculpture that will race across land and water in a three-day "Kinetic Grand Championship"

Source: "Colfax Students Experience 'Quirky' Path to Inventive Careers," Sierra College, Mar. 2014; Fraser-Middleton K, "Innovative Partnerships Build Advanced Manufacturing Pathways," League for Innovation in the Community College, Mar. 2014; EAB interviews and analysis.

Taking the Classroom on the Road

Though educators agree on the value of exposing high school students to new technologies, few colleges can afford to provide multiple high schools with their own set of cutting-edge machinery. At the same time, transporting students from various high schools to one campus lab may be costly and cumbersome, especially across large service areas.

In 2011, Northeast Wisconsin Technical College (NWTC) developed an alternative solution: a mobile lab. The college outfitted a 44-foot trailer with computer numerical control (CNC) equipment and computers. Each week, a lab aide drives the trailer from school to school, allowing students at over 10 high schools to complete dual-credit courses in CNC fundamentals.

By introducing CNC equipment into dual-credit courses, the mobile lab has drawn substantially more high school graduates into NWTC's manufacturing programs. Before the lab's launch, these programs primarily enrolled mid-career manufacturing workers. Today, recent high school graduates account for over three-quarters of the college's manufacturing students.

Mobile Manufacturing Lab Expands Reach of New High School Equipment

Investments in Emerging Technology Tricky to Scale

Challenges Facing Colleges with Numerous Feeder High Schools

- Can't afford a new lab for every high school partner
- Can't afford student transportation from all high schools to one lab

A State-of-the-Art Lab Travels to 10+ Schools

Northeast Wisconsin Technical College

- 44-foot learning space outfitted with CNC lathe, CNC mill, and 13 computers
- Travels to 10+ rural high schools for class sessions and career fairs
- Students can complete two dual-credit courses in mobile lab (2 credits each)

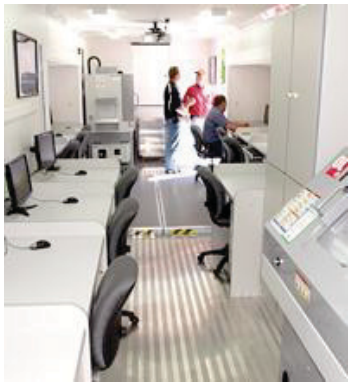
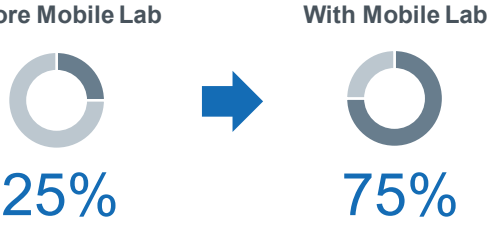


IMAGE CREDIT: NORTHEAST WISCONSIN TECHNICAL COLLEGE.

Building a High School Enrollment Pipeline

Students Age 18-24 as Percentage of All NWTC Manufacturing Students



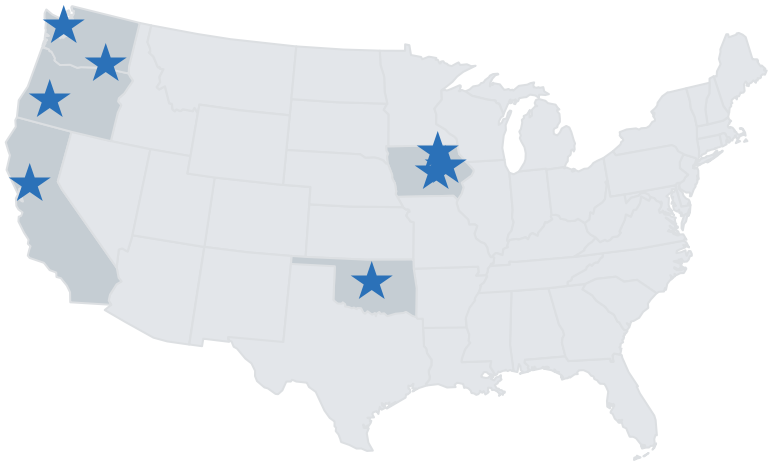
Source: "Computer Integrated Manufacturing Mobile Lab," Northeast Wisconsin Technical College; EAB interviews and analysis.

Enabling Intrinsically Local Industries

The trend toward niche manufacturing has driven a resurgence of local industries, including beverage production. In recent years, colleges have had great success with programs in viticulture and enology—grape growing and wine making, respectively. Unsurprisingly, most of these programs are located in the Mediterranean climates of the West Coast, though a few colleges in the Midwest have launched programs, too. However, a successful viticulture program requires a temperate climate and vast tracts of unused land, and few colleges have access to both.

A Vintage Year for Viticulture

Predictable Success Out West, Unexpected Demand in "Napa Prairie"



★ Select Viticulture and Enology Programs

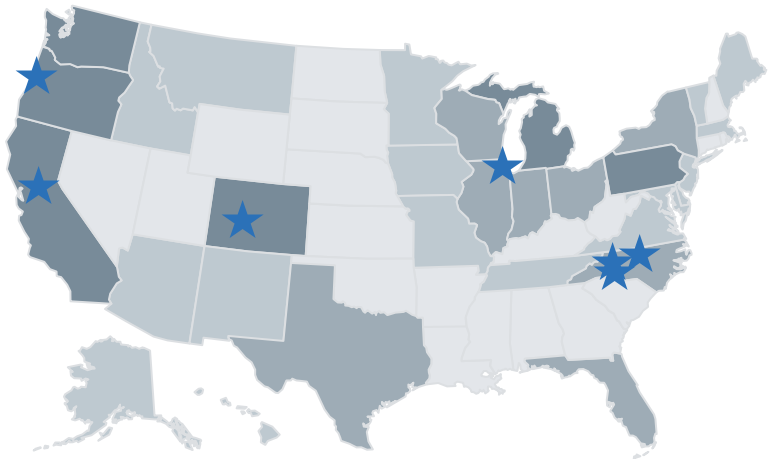
But Not for All Palates…
Weather and space requirements make viticulture a risky investment for most colleges

Inspired by the success of viticulture programs, colleges locked out of the wine market began to notice a related trend: craft brewing. The accompanying map reflects the density of breweries across the country, and it reveals that the beer industry spans far more of the country than the wine industry. Breweries may be particularly common in the West and Upper Midwest, but they exist across all regions.

In response to dramatic growth in the number of independent breweries (see page 11), several colleges have recently launched craft brewing certificates and degrees.

Brewing Without Borders

Density of Breweries and Brewing Programs in the United States, 2013



★ Select Brewing and Fermentation Programs

Number of Breweries
0-24 | 25-49 | 50-99 | >100

Source: "Mapping the Rise of Craft Beer," *The New Yorker*; EAB interviews and analysis.

Something's Brewing in North Carolina

In North Carolina, three colleges have launched complementary programs in craft brewing, each drawing on institutional strengths to develop a specialization within the field. Blue Ridge Community College built on its industrial services curriculum to develop a beer mechatronics degree, while the more rural Rockingham Community College developed an agriculture-focused degree, and Asheville-Buncombe Technical Community College (A-B Tech) developed a hospitality-focused degree. Pending the finalization of partnerships, a student who graduates from any of these programs may pursue a specialized certificate from the other colleges. They may also apply their credits toward a four-year degree in fermentation science at Appalachian State University.

Just one year after launching its A.A.S. in Brewing and Management, A-B Tech has had exceptional enrollment success. The program's first cohort reached capacity 20 minutes after registration opened, and students from seven states have already expressed interest in the next cohort.

Furthermore, A-B Tech's program has solidified the city of Asheville's reputation as the beer capital of the Southeast. Since the program's launch, several West Coast breweries, including Sierra Nevada and Oskar Blues, have opened new facilities in the area.

Partner Colleges Develop Stackable Certificates Reflecting Institutional Strengths

Three Complementary Brewing Specializations

Mechatronics — Blue Ridge Community College

Hospitality — A-B Tech Community College

Agriculture — Rockingham Community College

A.A.S., Brewing and Management

- General, Organic, and Biochemistry
- Beverage Management
- Fermentation Production
- Beverage Marketing and Sales
- Principles of Financial Accounting
- Sensory Evaluation
- Distillation Operations
- Legal Issues: Fermentation

Stack-On Certificates

Beer Mechatronics or Agriculture

Blue Ridge Community College; Rockingham Community College

Four-Year Transfer

B.S. in Fermentation Science

Appalachian State University

Signals of Success One Year In

A-B Tech Brewing and Management Program

80%	20	7
Students with bachelor's degrees or higher	Minutes it took program to reach full capacity	States with students interested in next cohort

Source: "Will Work in Beer," *Inside Higher Ed*, Jan. 2014; EAB interviews and analysis.

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Assessing the Opportunity

Where Can Your Institution Launch or Grow Manufacturing Programs?

Identifying Resources for Program Launch

1. Do we have capacity in (or resources to grow) existing manufacturing courses and learning facilities?

   Yes ___ No___

2. Do we offer coursework that spans the production process, including design, distribution, and marketing?

   Yes ___ No___

3. Can we make emerging technologies available to high school students in classrooms or mobile labs?

   Yes ___ No__

4. Do we offer any training, equipment, or other services that facilitate local entrepreneurship?

   Yes ___ No___

If you answered "yes" to two or more of these questions, please continue to the section below.

Generating Ideas for Program Design and Marketing

1. Can we introduce 3D printing and prototype design into conventional manufacturing programs?

   Yes ___ No___ *If "yes," see page 15.*

2. Can we develop community entrepreneurship and enrichment courses around emerging technologies?

   Yes ___ No___ *If "yes," see page 15.*

3. Can we accommodate electives in supply chain, marketing, and related fields within manufacturing curricula?

   Yes ___ No___ *If "yes," see page 16.*

4. Can we introduce hands-on competitions and entrepreneurship opportunities into high school CTE courses?

   Yes ___ No___ *If "yes," see page 17.*

5. Can we partner with nearby colleges to offer complementary certificates serving a niche local industry?

   Yes ___ No___ *If "yes," see page 20.*