

Math for Manufacturing

Workforce and Higher Education Partnerships



The University of Texas at Austin
Charles A. Dana Center

Case Study: Virginia

The Virginia Community College System, the Community College Workforce Cooperative, Blue Ridge Community College, and Manufacturing Industry Partners

Key Takeaways

- Virginia's community colleges, employers, and trade associations are partnering to address the shortage of skilled workers in manufacturing, by making it easier for Virginians to be trained and job ready.
- As the leading provider of workforce development training, the Commonwealth's community college system assists manufacturing employers in connecting with the appropriate education and training programs. The system also helps colleges stay connected to employer needs by creating relevant curriculum that lead to in-demand industry certifications and degrees.
- A new coalition of three community college partners is working to meet the demands of the shipbuilding industry in the Hampton

Roads area, which has persistent hiring and training needs in manufacturing, welding, and electrical maintenance.

Like many states, Virginia has a system of independent community colleges that offer workforce development support to local employers. Since 1998, the Virginia Community College System (VCCS) has been tasked with coordinating workforce training at the postsecondary level. As such, VCCS oversees efforts to promote collaboration, communication, and engagement between the community colleges and local industry, and to develop affordable and accessible postsecondary certification and degree programs that lead to well-paying jobs. Several Virginia community colleges have designed and delivered innovative workforce training programs to support an efficient pipeline of job-ready workers.



Themes Across Math for Manufacturing Case Studies

The Charles A. Dana Center published four case studies in 2022 as part of the Math Education for Manufacturing Initiative. The case studies highlighted innovative state, region, and local partnerships between manufacturing, higher education, and community leaders. The partnerships addressed a critical talent pipeline shortage for economic and workforce development, and identified necessary mathematics skills and instructional practices for successful entry-level to mid-level manufacturing employment.

The following themes emerged in the case studies.

1. Gaps in students' mathematics skills and application were not readily identified as a prevailing problem to successful entry-level to mid-level manufacturing employment. Revisions to mathematics requirements, curriculum, and/or pedagogy were a part of a holistic technical program redesign.
2. Manufacturing employers increasingly sought the inclusion of core competencies in technical program redesign. Competencies most often cited as critical to successful employment were interpersonal skills, creativity, teamwork, communication, problem solving, and leadership.
3. The ingenuity of state, region, and local partnerships amplified the availability of physical, human, intellectual, and financial resources to address the demand for skilled manufacturing employees with the appropriate mathematics knowledge and background to succeed in the workplace. Read the case studies:

<https://www.utdanacenter.org/our-work/higher-education/collaborations/math4-manufacturing>

This case study explores the role of VCCS as an intermediary partner connecting employers with the appropriate community colleges across the Commonwealth. It also highlights two community college–industry partnerships: 1) a new regional collaborative supporting the shipbuilding industry; and 2) Blue Ridge Community College’s collaboration with employers to design and support multiple education and training pathways into high-demand manufacturing jobs.

Background

Virginia is home to more than 6,700 manufacturing firms, employing over 230,000 residents. The average industry worker earns almost \$60,000 per year.¹ The Virginia Economic Development Partnership identifies manufacturing as a key industry, specifically in the areas of advanced materials, aerospace, automotive, and wood products.² To attract and retain employers in this high-growth sector, the Virginia Chamber of Commerce saw the need to increase the supply of advanced manufacturing talent.³

The Virginia Community College System is a major provider of workforce training across the Commonwealth. Each of the system’s 23 autonomous community colleges has its own workforce development program that responds to the needs of local employers within its assigned geographic service region. Having an aligned system with a centralized administrative office helps to leverage the power and resources of each college, ensuring employers can find the customized training they need and that all students are provided with a range of career options through open enrollment programs.

Individual colleges within the system have also found ways to partner with the manufacturing industry. In 2021, three Virginia community colleges—Paul D. Camp, Thomas Nelson, and Tidewater—formed the Community College Workforce Cooperative (CCWC) to provide a “one-stop shop” for employers in the

¹ <http://va-manufacturers.eimpactv2.report/reports/view/5e14a7715a135133004c47fa>

² <https://www.vedp.org/key-industries>

³ <https://blueprintvirginia.org/wp-content/themes/blueprint2030/inc/BPVA2030-FINAL.pdf>

Hampton Roads region, which includes 11 cities in the Virginia Beach and Norfolk area. With several large shipbuilding companies and their suppliers in this region, these colleges leverage their individual strengths, share resources, and are better positioned to support large-scale workforce development needs.

Another institution, Blue Ridge Community College (BRCC), enhanced its offerings to benefit more students and employers. Its advanced manufacturing training options provide students with the critical mix of knowledge and skills needed to secure well-paying jobs. BRCC serves more than 3,000 credit and 300 non-credit students in the Shenandoah Valley area, which is home to over 250 manufacturers.

Supporting Shipbuilding Employer Needs Through Pre-Hiring Training Programs

The Virginia Community College System assists employers/industry in expanding, staying competitive, and maintaining a highly skilled workforce. It is frequently the first point of contact for employers that require specific job training or need customized education solutions. VCCS also provides resources to colleges to increase their ability to create new training programs; obtain new equipment, materials, and simulations to improve student experiences; and hire faculty with relevant expertise. Its multidimensional advocacy role aligns to the six-year strategic plan that focuses on eliminating equity gaps and establishing the community college system as the “primary training provider for businesses seeking to ensure a sustainable supply of workers with the skills and credentials required to be competitive.”⁴

To help more Virginians develop the necessary skills and earn the credentials required by local manufacturers, the Commonwealth offers education subsidies for short-term credentials in high-demand careers. Eligible certifications and degrees are based on labor market data and employer input. Below are two examples of these types of programs.

⁴ VCCS Opportunity 2027. https://vccsdvl.wpengine.com/wp-content/uploads/2021/03/Opportunity-2027_Final-Draft_3-18-21.pdf

- **FastForward:** Provides tuition assistance for short-term workforce training, developed in partnership with employers, that can lead to in-demand industry credentials and certifications, including manufacturing.⁵
- **Get a Skill, Get a Job, Get Ahead (G3):** Provides “last-dollar” funding to help improve access to workforce training and “stackable” credentials in five in-demand industries, including manufacturing skilled trades.⁶

According to VCCS Director of Career Education Programs and Workforce Partnerships Dr. Angela Lawhorne, the goal of these two programs is to “close the tuition gap while providing students with clear career pathways, stackable credentials, credit for prior learning leading to faster completion, and connections to employers and meaningful job opportunities.”

The college system has the benefit of seeing opportunities across the colleges for innovative collaboration. VCCS Chancellor Dr. Glenn DuBois, for example, saw a need for a coordinated higher education—manufacturing approach that would use the expertise and resources of three community colleges in the Norfolk region. The Community College Workforce Cooperative was formed—comprising Paul D. Camp, Thomas Nelson, and Tidewater community colleges—to design innovative training and education programs for employers in the Hampton Roads region.

By working together, the colleges engage in large-scale job training projects, meeting the sizable workforce training needs of the shipbuilding industry in manufacturing, welding, and electrical maintenance. The CCWC serves as a liaison between the employer/industry and the community college to direct and coordinate resources and to utilize facilities and labs, providing faster and more cost-effective talent development programs.

The partnership supports many industrial employers, including Virginia’s largest, Newport News Shipbuilding (NNS), which regularly hires thousands of skilled workers. In addition to NNS, the CCWC supports more than 250 shipbuilding companies and suppliers in the area as well as the tens of thousands

⁵ <https://www.fastforwardva.org/>

⁶ <https://viriniag3.com/>

of new jobs in new infrastructure projects and the emerging offshore wind industry.

While some companies hire apprentices to participate in long-term work and training programs, many companies cannot afford to wait to develop new talent. Through a partnership with the Virginia Ship Repair Association (VSRA), CCWC designed six short-term “[pre-hire” training programs](#) to prepare Virginians for entry-level jobs as machinists, welders, pipefitters, sheet metal workers, painters, and electricians. The VSRA worked with the shipbuilding companies, repair yards, and vendors to help design and approve the training program content. Through these Marine Trades Training programs, NNS pre-screens and hires candidates for jobs, and requires those workers to complete the training to begin work. To meet large-scale demand by the employers, courses are available at the three CCWC colleges.

The training program is designed like a boot camp, with pre-hires attending eight hours per day for two to three weeks. The training is delivered in a simulated work environment to help pre-hires become familiar with the workings of a ship and to gain hands-on experience completing ship installations, maintenance, and repairs as part of a team. “The work is intentionally hands-on and practical. The goal is to give pre-hires enough of an introduction and mastery of core skills that they can build on once they are on the job in the shipyard,” shared CCWC Executive Director Michael “Todd” Estes.

Mathematics is a core component of the short-term Marine Trades Training courses, and mathematical literacy and mathematical reasoning are embedded throughout the program. By mimicking an actual work shift, the pre-hires learn their specific tasks, use the appropriate tools, and complete the work to a quality standard. The mathematics skills and competencies needed in each occupation is contextualized. For example, as students learn to assemble and install parts of a ship or make a repair, they review how to do basic calculations steps, measure angles, convert fractions to decimals, read blueprints, and other key mathematics skills necessary for on-the-job use.

With technology having an impact in some job areas, pre-hires might also learn other skills or technology. For example, pipefitters might not only rely on paper blueprints to analyze pipe details, but also use 3D modeling to visualize angles and components of pipe flow. VRSA and CCWC regularly review the content to ensure that it adapts to any shifts in industry demands.

Addressing Manufacturing Skill Gaps in Central Virginia

With 250 manufacturing companies in the Shenandoah Valley, Blue Ridge Community College expanded its credit and non-credit manufacturing programs to respond to a diverse range of employer needs.

Non-Credit, Stackable Credentials. BRCC’s Workforce and Continuing Education program offers stackable credentials, including Manufacturing Specialist (MS) and Manufacturing Technician Level 1 (MT1) certifications from the [Manufacturer’s Skills Institute](#) (MSI). MSI was cofounded by the [Virginia Manufacturers Association](#) in 2012 to offer advanced technology industry training and credentials. Manufacturing employers across the Commonwealth collaborated to establish skill standards to ensure that learning was linked to employment and career advancement opportunities.

BRCC offers the MT1 course over two semesters, covering critical technical skills used in all manufacturing settings: algebra, measurement, math for quality, statistical process controls, spatial reasoning, mechanics, fluid power and thermodynamics, electricity, chemistry, manufacturing processes and controls, quality and lean manufacturing, financial literacy, and business acumen.

After completing the training modules, students must take the MT1 assessment and receive passing scores in three core competency areas: 1) math and measurement, 2) business acumen and quality, and 3) spatial reasoning and manufacturing technology sections. The MT1 certification is a portable, stackable industry credential that demonstrates to employers anywhere in the world that the certificate holder understands modern manufacturing.

Credit-Bearing Program. BRCC offers a credit-bearing Advanced Manufacturing Technology (AMT) program that leads to an Associate of Applied Science (AAS) degree. Matt Goss, an instructor and program director for BRCC’s Manufacturing Engineering Technology and Mechatronics department, created this relatively new program. Previously, the college offered only manufacturing certificates to help upskill workers. Goss saw an opportunity to integrate the content covered in the non-credit, stackable credentials program and created an AAS degree program to prepare technicians and operators for a wide range of careers in high-tech manufacturing industries.

The [AMT degree](#) requires students to take a combination of 61–67 credit hours of general education and technical courses. The AMT degree offers four specialization options:

1. Manufacturing Bio-Technology
2. Manufacturing Engineering Technology
3. Manufacturing Operational Excellence
4. Mechatronics

Mechatronics, which combines mechanics, electronics, robotics, and information technology, is the most popular specialization. Students with MT1 certifications can apply for advanced standing, as the certification counts as seven college credits towards the mechatronics associate degree.

Both the MT1 certificate and the AMT degree offerings at BRCC place a heavy emphasis on the mathematics needed to perform successfully on the job.

Mathematics in the MT1 Certificate Program. Jim Leech is the MT1 instructor who was instrumental in launching BRCC’s Manufacturing Engineering Technology department. Leech had a distinguished career as an industrial engineer working for major manufacturers, including Hershey. Based on his industry connections and regular conversations with manufacturers in the area, Leech added some curricular elements to the MT1 program to ensure that students mastered what he viewed as core skills, particularly mathematics skills. For example, he wants students to learn how to calculate current resistance, voltage, and power so they are prepared

to work with three-phase electrical panels. In addition, he explains the Cartesian coordinate system so students understand how coordinates could be converted into machine-readable code for programming computer numerical control (CNC) machines.

Because mathematics is a core element of many MT1 lessons, Leech reviews basic mathematics essentials such as fractions, decimals, conversions, weights and measures, metrics, and linear equations at the beginning of the course to ensure students have the prerequisite mathematics skills to be successful. He also uses word problems and more complex tasks rather than multiple choice assessments: “Students need to be able to deduce solutions based on the information they are given. I need them to be able to find the important information and use logic to solve a problem.” In the lesson on business acumen, students must create a business plan for a new skateboard company. They are given the price of materials and some basic assumptions about labor costs and other expenses, and must consider the entire production process.

Mathematics in the AMT Degree Program. All students pursuing the AMT degree take a common set of courses during the first semester, which includes a mathematics course in either Basic Technical Mathematics (Math 111) or Precalculus I. Goss and his colleagues revised the Math 111 class to cover the mathematics concepts that were most needed by manufacturing employers in the area. Math 111 is designed as a foundational course emphasizing arithmetic, unit conversion, basic algebra, and geometry.

In addition to the initial required mathematics course, mathematics skills and competencies are uniquely embedded in the technical specialization core courses.

- Manufacturing Bio-Technology students take Electrical Applications (ELE 123), which covers the fundamental principles of electricity with an emphasis on measurements and resistance in currents.
- Manufacturing Engineering students take Electronics Technology (ETR 113) where they study D.C. and A.C. currents and learn how to predict, analyze, and measure electrical quantities.

- Manufacturing Operations Excellence students take Basic Fluid Mechanics—Hydraulics/Pneumatics (MEC 161) to learn the theory, operation, and maintenance of hydraulic/pneumatics devices and systems, which require modeling and application of mathematics principles.
- Mechatronics students take Mechanisms I (MAC 156) where they engage in hands-on activities to learn how to assemble, inspect, and align industry machinery, which require knowledge of angles, measurements, and degrees of deflection.

Goss meets twice a year with the Manufacturing Industry Steering Committee to ensure that the AMT program curriculum and instructional methods meet their needs. In addition, he regularly visits manufacturing facilities to walk the plant floors, examine the equipment, and talk to supervisors about the skill needs of entry-level workers so that future curricular and pedagogical refinements can be considered.

Impact

Like many community colleges across the country, the VCCS has seen overall declines in student enrollment due to the COVID-19 pandemic. However, the system reports increased enrollment in career and technical programs for Virginia’s highest demand fields, which include skilled trades such as manufacturing. From fall 2020 to fall 2021, the number of community college students in G3 eligible programs increased by 9 percent.⁷ The Commonwealth anticipates workforce training programs like FastForward and G3 to continue to grow in the coming years.

CCWC’s short-term pre-hire training options have proven to be effective. Over the last five years, 2,100 students have completed the training programs, with an estimated 90 percent moving immediately into paid employment opportunities. Shipbuilding employers benefit from this training model as they acquire workers who are prepared and committed

⁷ [https://www.vccs.edu/news/virginias-community-colleges-see-enrollment-in-career-and-technical-training/](https://www.vccs.edu/news/virginias-community-colleges-see-enrollment-increases-in-career-and-technical-training/)

to stay after completing the training. As an added benefit, this option reduces employer training costs and improves retention.

Based on employer feedback, CCWC is now developing an eight-week course in two pre-hire training programs (welding and structural fitting). To be piloted in 2022, the extended programs will strengthen workers’ skills and increase job readiness. Because students will need to spend more time in upfront, unpaid training before gainful employment, CCWC is using Workforce Innovation and Opportunity Act (WIOA) funding to organize a more significant set of wraparound supports to help students manage the costs and logistics of attending training, such as transportation vouchers, childcare supports, and housing assistance.

BRCC reports that local manufacturers regularly hire their graduates from both the MT1 and AMT programs, knowing these individuals have the foundational skills to succeed on the job. Jim Leech believes that as the industry increases its automation and technology, BRCC will need to adjust its education and training options while also helping students see the value of investing in continuous learning. He noted that employers are going to demand “not only basic technical skills but also newer skills like programming, critical thinking, and problem-solving skills because that is what they will need to stay competitive and produce high-quality products efficiently.”

Resources

- BRCC MT1 certificate program: see Math for Manufacturing 1-30 (<https://utexas.box.com/s/dx81z9rjj19zvnqlojm6rv3lh8sxc9>)
- BRCC AMT A.A.S. degree: see Math 111 syllabus (<https://utexas.box.com/s/6mm3e6tpwzto5tyn59g9whln3hznegvq>)



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