# The CCAC Makerspace: helping students' innovative ideas become reality

Approaches to entrepreneurial product design and development are changing rapidly, as new technologies like 3D printing and sophisticated computer modelling push the frontiers of what's possible. In Pittsburgh in the US, **Professor Justin Starr** and **Assistant Professor Francis Cartieri** have established the **Community College of Allegheny County (CCAC) Makerspace** to help young minds understand and embrace this developing field. This stimulating teaching and learning space is providing the tools and facilities for students to imagine, create and perfect innovative products that solve real-world issues.


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Principal Investigator of the CCAC Makerspace grant, Endowed Professor of Advanced Technologies

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Talk like an ...

## entrepreneurial designer

**Computer aided design (CAD) —** the use of computer-based software to simulate real-world objects, to help the design process

**Computer numerical control (CNC) machine —** a machine controlled by pre-programmed computer software

**Fabrication laboratory (fab-lab) —** small-scale workshops used to create objects, normally for prototyping and testing

**Makerspace —** a collaborative, communal workshop where makers can create and design products

**Prototype —** an early, preliminary model of a product, used to test if it works as intended and to help inform future changes to the design before it is rolled out at scale

The never-ending development of new products and technologies drives societal trends. Everything from smartphones to electric cars, to even the most obscure but crucial components of industrial machines begins life as the brainchild of an innovator. "Entrepreneurial design is the process of identifying opportunities to create innovative products or solutions with strong commercial

**Field of research**
Entrepreneurial design and manufacturing

**Research project**
Creating the CCAC Makerspace, a unique facility that allows students to learn how to create innovative products through practical teachings

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potential," says Professor Justin Starr. "It combines traditional design methodologies, like user-centred design thinking, with core business principles such as market research, cost analysis and strategic planning."

Entrepreneurial design brings together product concepts that could solve real-world problems with paths towards market viability, helping pave the way to making these products a useful reality. Led by Justin and Assistant Professor Francis Cartieri, the Community College of Allegheny County (CACC) Makerspace is designed with this approach in mind, introducing students to the whole pathway of product design and rollout, from thinking up ideas and testing different materials and production techniques to optimising and marketing their products.

## The CCAC Makerspace

The CCAC's entrepreneurial makerspace has several components. One is the fabrication laboratory, or 'fab-lab' for short, a small workshop where students learn to make prototypes of their digital designs. The CCAC Makerspace also has teaching classrooms, to enable students to learn how to use the facilities, as well as an industrial-grade workshop for the creation of high-quality products and materials testing. "The fab-lab is equipped with entry-level equipment for teaching groups of students. Young students are going to break things, there's no way around it, and that's all part of the educational process!" says Francis. "More advanced students and professionals use our industrial-grade space, where we have state-of-the-art manufacturing and product optimisation equipment."

This equipment includes materials testing equipment suitable for testing products for applications (such as medical prosthetics, robotics and aerospace), a range of 3D printers that can create high-precision metal and carbon polymer products, and reverse engineering technologies that allow students to learn from and be inspired by existing designs.

"By providing young people with access to cutting-edge equipment and fostering a culture of hands-on experimentation, the makerspace naturally sparks curiosity," explains Justin. "The environment is low-risk but high-engagement: students are free to fail, try new things and pivot rapidly, and pivot rapidly, which cultivates resilience and fosters true creative thinking." Alongside the high-tech equipment, the makerspace includes offices and open labs for project planning, team meetings and collaborative learning. "We also host pitch events, regular workshops, and collaborative challenges to encourage students to learn by doing," says Francis.

## Process learning

Taking a product from an idea to reality is an involved but rewarding process. "The first step is an in-depth consultation with a professor, makerspace technician and, sometimes, a subject matter expert," explains Justin. "This helps students learn that there are several possible methods for producing their product; choosing the best route requires an exploration of potential markets, competitor pricing, materials costs, and so on." After having these conversations and conducting market research, students develop digital models of their product using CAD software, before producing prototypes using 3D printers or laser cutters. "Once they have their prototypes, advanced equipment like 3D scanners and CNC machines allow precise adjustments and optimisation," explains Francis. "Once students have validated a design, they can undertake small-batch production or collaborate with industry partners for larger-scale manufacturing."

This process teaches students a plethora of technical skills, from designing and programming parts for manufacturing, to harnessing the power of 3D printing technologies and computer-operated machines, through to the processes behind prototyping, testing and iterative design of products themselves. "As well as technical skills, we also teach a range of critical soft skills," says Justin. "Just like in the real world, students' projects often involve interdisciplinary collaboration, identifying opportunities and being resilient to setbacks, and communicating their ideas effectively to industry mentors and peers."

## The learning experience

The CCAC Makerspace aims to set students up with the skills, knowledge and confidence needed for an entrepreneurial career. "It places students at the intersection of innovation and hands-on skill development, giving them tangible experience of product creation," says Francis. "That's invaluable for starting their own ventures or standing out in the job market." The experience that students gain does not stop with product development. The CCAC team has links with the Innovation Accelerators network across much of Pennsylvania, which provides opportunities for collaborating with like-minded people and even pitching to investors.

One notable and unusual success of the makerspace involved the reverse-engineering of a sculpture for the International Sculptors' Association, creating a 1:1 full-colour reproduction for the organisation's lifetime achievement award. "We used our medical printing technology to create the sculpture," says Francis. "We love having artists in the space, as they tend to think outside the box." The result of this process will be an artist-in-residence programme that highlights the similarities between rapid prototyping and the creation of innovative artwork.

The CCAC Makerspace is still developing and growing its suite of offerings. "We envision the makerspace as a central innovation hub where students, faculty and community members continually collaborate," says Justin. "As the region's entrepreneurial ecosystem grows, we'll expand our equipment offerings and deepen partnerships with industry." The team is on the cusp of introducing several new certificate courses around entrepreneurial design and manufacturing, which will attract further young minds. "I can't wait to start teaching our inaugural cohort of students soon!" says Francis.

# **About** *entrepreneurial design and manufacturing*

Entrepreneurial design and manufacturing involves every stage of a product's life from thinking of an innovate creation, to manufacturing and testing a useable design, through to getting your product to market. "Entrepreneurial design empowers individuals to be both creators and problem solvers, while manufacturing turns that creativity into impactful products," says Francis. "The sense of ownership, creativity and tangible contribution to the community is deeply satisfying."

Until recently, it was a lot trickier for an individual to manage every stage of this design and manufacturing process, but technological progress is making it possible. "Rapid advancements in robotics, artificial intelligence (AI) and advanced materials are creating unprecedented opportunities in individualised manufacturing at small scales," says Justin. "The next generation of designers will be able to leverage automation, sustainable materials and digital platforms to innovate faster and more cost-effectively." This progress may also pave the way for smaller operations to profit and thrive, despite competition from large manufacturers. "Custom manufacturing can support small production runs that help small businesses," explains Francis. "This opens doors for small-scale, niche entrepreneurship to grow past the cost and training barriers that may otherwise prevent them from maturing."

While products are becoming increasingly sophisticated and specialised, small-scale production is becoming cheaper and easier, especially for entrepreneurs with design and manufacturing skills. The CCAC Makerspace aims to upskill the existing workforce, so already-qualified workers meet the needs of rapidly evolving sectors like automation and robotics. The CCAC team is excited about the potential of this new, accessible approach to product design and manufacturing to enthuse the next generation of entrepreneurs. "It's the thrill of taking an idea from a concept to physical reality and seeing its potential to solve real-world problems," says Justin. "And of course, making a profit from your ideas doesn't hurt either!"

## **Pathway from school to** *entrepreneurial design and manufacturing*

Justin and Francis say that, for entering courses such as those offered by the Community College of Allegheny County, academic qualifications are less important than your disposition and willingness to learn. "Being curious, pragmatic and industrious is more important than experience in STEM or coding," says Francis. "You can learn the technical skills needed as you go. Successful entrepreneurial designers make what they are passionate about, and that can range wildly."

The CCAC Makerspace is deeply committed to community engagement. The team's outreach efforts include tours, workshops and hands-on activities for local high schools. If you are local to the CCAC visit its website to find out more about events that you could take part in: **ccac.edu**

Justin and Francis also partner with local schools to mentor FIRST robotic (**firstinspires.org/robotics/frc**) and BotsIQ teams (**botsiqpa.org**), as well as hosting summer camps and after-school programmes focused on sparking interest in STEM.

## **Explore careers in** *entrepreneurial design and manufacturing*

Careers in entrepreneurial design and manufacturing can vary widely, depending on your interests and what exactly you want to design and manufacture. The Indeed career guide has some useful tips for turning your idea for a product into a reality: **indeed.com/career-advice/career-development/how-to-manufacture-product-idea**

The CCAC website provides useful information about many different career paths related to design and manufacturing, such as mechatronics: **ccac.edu/academics/programs/industrial-technology-trades-and-transportation/mechatronics-technology/**

There are many career paths related to design and manufacturing. Prospects outlines several of them, including:
CAD technician:
**prospects.ac.uk/job-profiles/cad-technician**
Product designer:
**prospects.ac.uk/job-profiles/product-designer**

## Meet *Michael*

**My official title is Entrepreneurial Instructor and Technician.** In a nutshell, I instruct any CCAC Makerspace workshops we run, supervise the space and perform maintenance on all the equipment. I also help students gain clearance to use the equipment, as they need to show they understand how to use the equipment safely.

**Students gain so much from using the makerspace!** They become more familiar with using a range of technology and develop their critical thinking skills. For example, students learn about the need for prototyping. As a designer and manufacturer, you need to make a small prototype to judge if you want to invest more time, resources and money on a larger scale of your design. You might want to change the internal structure of a product – for example, you might want to make it hollow or completely dense – so students learn how certain features, such as structure, impact the properties of the product, manufacturing runtime and resource management.

**The makerspace helps students to think through problems.** For example, if there's an error on your 3D print, what went wrong? Is it bumpy when it should be smooth? Has scaling up to a larger size gone wrong? What clarity did you choose when you were making your reverse engineering scanner? Did you use the correct software? How can you solve a problem when you thought you had the best path forward, and it didn't work? All these questions translate to critical thinking experience in the field, and this critical thinking leads to problem-solving.

**When I see a student go through the design process – having never done it before – and succeed, I see a change in that student.** I see them gain confidence and useful skills that will stay with them. As an educator, it's such a rewarding feeling to know they are learning and gaining insight into the design and manufacturing process.

**The great thing about technology now is that it's so ubiquitous.** If you don't have access to expensive equipment, there's free software available for you to try, such as Tinkercad (**tinkercad.com**), which is a free web app for 3D design. If you don't have a computer, you can use drafting books which go through the process of scale.

## Meet *Ellie*

**I am the project manager for the Makerspace Innovation Accelerator (IA)** network (**connectmakelaunch.org/about**) – my role involves helping to build connections. The IA network is a group of seven makerspaces located throughout the Pittsburgh region which collaborate together to share curriculum, expertise, equipment and resources to help students, entrepreneurs and small businesses grow. As part of the network, the CCAC Makerspace provides equipment and expertise to the local business community. For example, with its injection moulding and stress testing equipment, the CCAC Makerspace has capability for advanced prototyping and materials testing. When an entrepreneur from another location needs that expertise, we send them to CCAC!

**The original six IAs were funded by the US Build Back Better grant,** but we are actively adding more locations – typically, existing makerspaces that have not been connected to a network before. Individually, each makerspace may not have enough resources to support all their businesses, but together, as a network, we are able to more effectively serve the entrepreneurial community.

**The most rewarding aspect of the work is connecting entrepreneurs** to resources and new partner. The Pittsburgh region was once an industrial powerhouse, the centre of steel production and innovation. Over the past 30 years, it has undergone a period of deindustrialisation and economic distress. Initiatives like the Build Back Better Grant and Makerspace Innovation Accelerator Network are working to bring back entrepreneurship and connect resources across our region. I am grateful to be a part of that work.

**Ultimately, the Makerspace Innovation Accelerator network will increase jobs** and innovation in the region. A network means that there is no wrong front door; any individual interested in starting or growing a business can go to any makerspace in the network and get connected to equipment, expertise and resources. Our network means that organisations that used to be isolated and working alone are now connected and thriving.