PENN CHARTER + SMITHSONIAN

A 3D PARTNERSHIP

by Rebecca Luzi

WHEN SCIENCE TEACHER Corey Kilbane read last spring that the Smithsonian Institution was in the early stages of creating 3-dimensional scans of its artifacts, he wanted in. He was advising Penn Charter's Innovation Club, which he had established along with parent David Robertson for the purpose of increasing invention and innovation in the curriculum. Robertson had a 3D printer himself, which piqued the students' interest. And Kilbane's.

He cast around for an email address of someone on the Smithsonian project, and when he sent his question – *Would the museum publish any of its 3D models for others to print?* – he got a quick response. The Smithsonian was actually looking for educators to partner with its National Museum of American History to create curricula surrounding these 3D objects. With state-of-the-art 3D scanning and image-based modeling technology, the museum will be able to make its collections accessible around the world.

Especially in light of a PC partnership with the Smithsonian, Kilbane saw great potential for a 3D printer at Penn Charter for use in both the curriculum and the Innovation Club. With a technology grant, the school purchased a $3,000 MakerBot 3D printer that arrived in September.

Kilbane wasted no time printing 3D plastic models of Smithsonian artifacts, including a sixth century statue, Vairochana, the Cosmic Buddha, featuring detailed illustrations on its surface. "With a high-definition printer,"

STRATEGIC VISION

GOAL 2: CONTENT

Collaborate locally, nationally and internationally to enhance learning and leadership opportunities for Penn Charter students.

STRATEGY

Multiple platforms for content delivery, including new technologies, will maximize student engagement and success.

Excellence • Innovation • Collaboration

LEFT PHOTO: **MEREDITH HEUER**.

Kilbane explained, "you can touch the relief, which you could never do to the actual artifact." Kilbane offered feedback to the Smithsonian: make it easier to print smaller-scale models with the same level of detail.

Its ability to engage students makes the 3D printer a powerful tool, and Kilbane found practical applications for it across disciplines. "What can we do that would be good curriculum?" he remembers thinking. "Not just nifty. ... at Penn Charter we want to be more substance than flash."

Kilbane found a website on which researchers had published 3D models of proteins and hemoglobin, which carries oxygen in red blood cells. After downloading the models, and converting them into a printable format with another piece of software, Chimera, he was able to show that the addition of two atoms of oxygen to a protein can change its entire shape, affecting how it works. "Kids could actually be hands-on with biology in a way never before possible," he said. A limited number of 3D models are available for purchase but cost hundreds of dollars. "Now we can print as many as we want for just a few dollars." Plastic filament for the 3D printer costs about $15 a pound, and most prints weigh about an ounce.

Kilbane also printed a model of the P53 protein, a mutation in which is a likely cause of glioblastoma. Science teacher Timothy Lynch is a survivor of this cancer and is currently on sabbatical conducting research at the University of Pennsylvania on how the immune system interacts with glioblastoma. Lynch used the model, Kilbane said, "to explain cancer in a very hands-on way to his students."

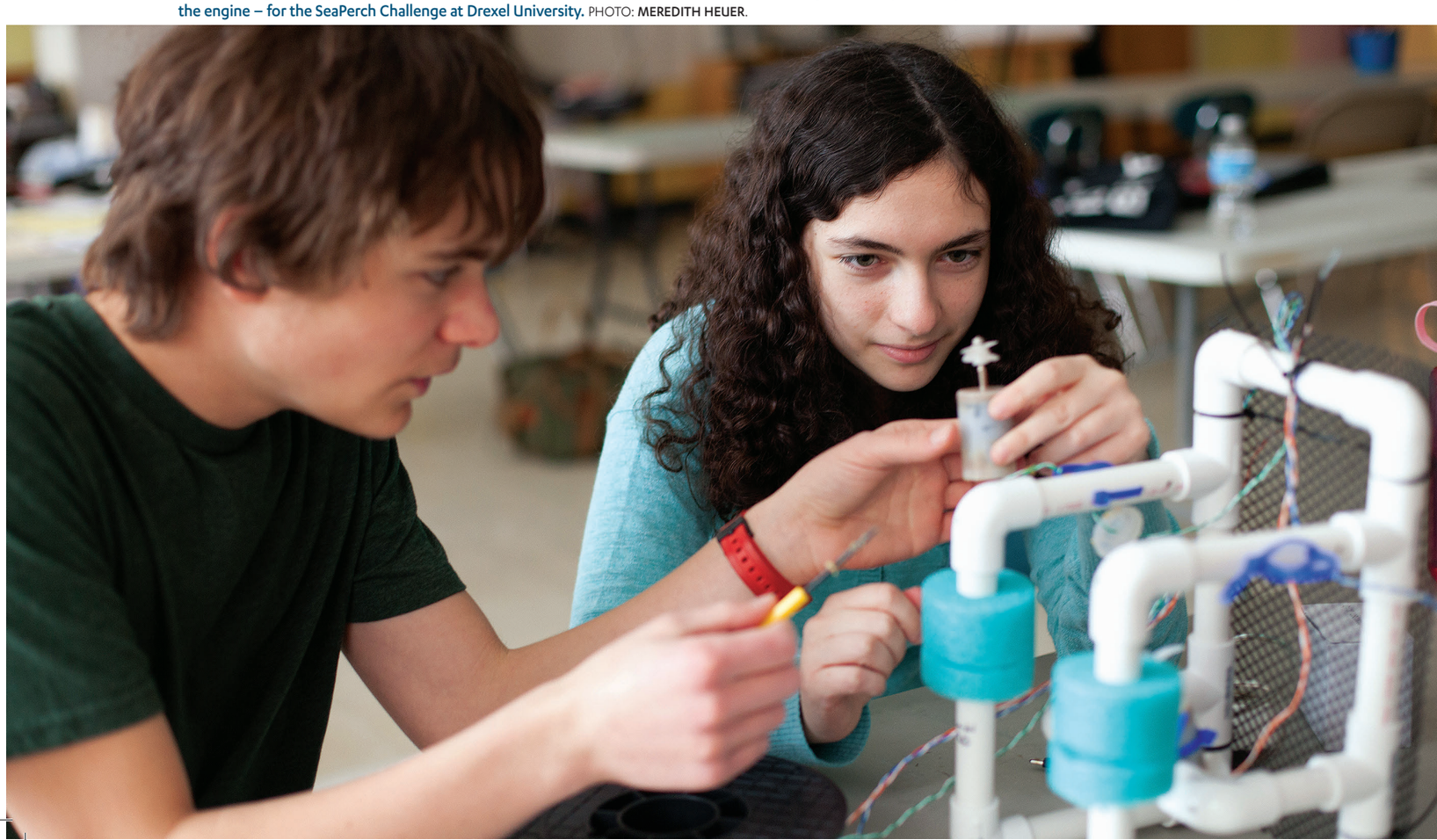
When the Innovation Club students decided to build hovercrafts, they custom designed a propeller and an engine-mount for them. Using Google's SketchUp, a 3D CAD (computer-aided design) program, they uploaded the dimensions, then printed the models to scale. After some trial and error, they got the size they needed.

They also used the printer to prepare for April's Greater Philadelphia SeaPerch Challenge, an underwater robot competition at Drexel University in which remotely operated robots navigate a course and pick up objects underwater. Competitors begin with a $25 robot kit and can make improvements – within a $20 limit for materials. Using SketchUp, PC's young innovators fashioned parts for their robots. They also printed miniature prototypes of their robots. "When we think we've got an idea," sophomore Gordon Robertson said, "we can look at the whole idea from a 3D perspective, not just on paper. We can look at the merits of the model."

"The great thing about the Innovation Club," junior Blake Hastings said, "is that we're allowed to use these [tools]." What Blake was not allowed to do was print parts for his PHAT Physics vehicle. In the Penn

"...at Penn Charter we want to be more substance than flash."

After creating prototypes of their robot on a 3D printer, Innovation Club members Blake Hastings and Emily Ominsky built their underwater robot – and waterproofed the engine – for the SeaPerch Challenge at Drexel University. PHOTO: MEREDITH HEUER.



Charter physics competition, students build and race self-propelled cars made with very specific materials like coffee cans and mousetraps. Blake was able, though, to create a prototype of the car so that his teammates "could see what was happening inside my head."

"It's fun just to mess around and have Mr. Kilbane give us goals and keep us on track," junior Henry McIlvaine said of the Innovation Club.

"I think the Innovation Club could almost make their own 3D printer at this point," Kilbane said, and paused. "That might be next year."

HIGH TECH, HANDS ON

Penn Charter teachers and students are playing a significant role in one of the Smithsonian's first 3D projects: an Apple iBook of Abraham Lincoln's life mask. Currently in production, *Abraham Lincoln: The Mind Behind the Mask* is a free educational resource for grades 8-12. The iBook includes 3D models of two life masks, one made in 1860, months before Lincoln was elected president, and the other in 1865, two months before his assassination. 3D images of the life masks, molded and cast by two different sculptors, Leonard W. Volk and Clark Mills, respectively, illustrate in minute detail the man, his life and the toll that the presidency took. The iBook also contains a timeline of his life, early images of Lincoln, and primary documents that he wrote, such as the "House Divided" speech he delivered at the Republican Convention in 1858.

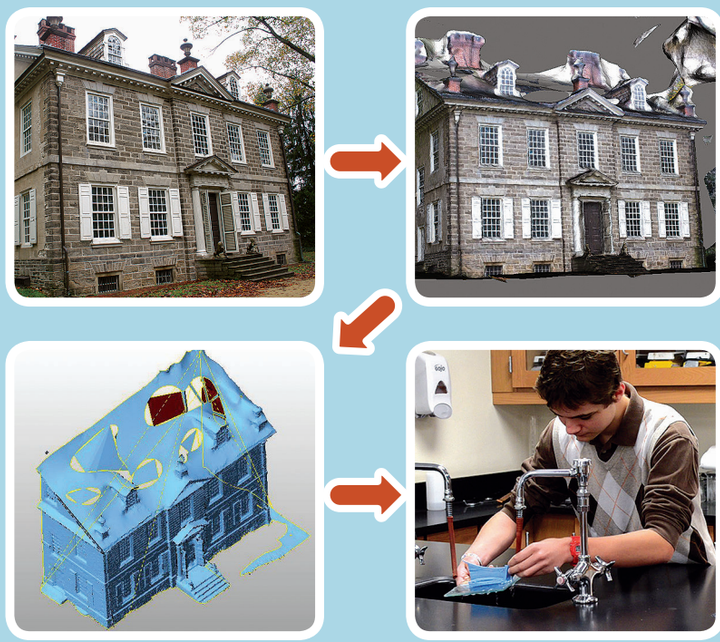
Social studies teacher Sarah Sharp, like Kilbane, got an early peek at the iBook. "In some ways," Sharp said, "it's sort of the ultimate getting inside Lincoln's head, pretty literally. It explores different approaches of understanding who Lincoln was."

Earlier this year when Kilbane told her and other teachers about the 3D printer and his involvement with the Smithsonian, Sharp realized it was the idea she needed for her AP U.S. History students in May, after AP exams. "I wasn't interested in it just because it was

Students used photogrammetry, the science of making measurements from photographs (shown on p. 22), to create a 3D model of Alexander Calder's famous City Hall statue of William Penn, a replica of which stands outside Gummere Library. PHOTOS: MEREDITH HEUER.

More Classroom Applications

FOR A RECENT ARCHITECTURE CLASS TRIP TO CLIVEDEN, a National Historic Landmark, science teacher Corey Kilbane gave a student a short tutorial on **photogrammetry**, the science of making measurements from photographs. The student photographed the building from many different positions and angles, uploaded the photos to Autodesk software to produce a 3D file, and was able to print a model of the building, shown below. In this way, after a field trip, a teacher can go back and expand on the features of a historic site. Earlier in the year, Kilbane accompanied PC's third grade class to Pennsbury Manor, the 17th century country estate of William Penn, and followed the same process to create a 3D mini version of Penn's home. And during spring break when Innovation Club member Andy Nguyen traveled to China on a PC study trip, he used photogrammetry to document and create 3D models of Chinese monuments to share with the PC community.



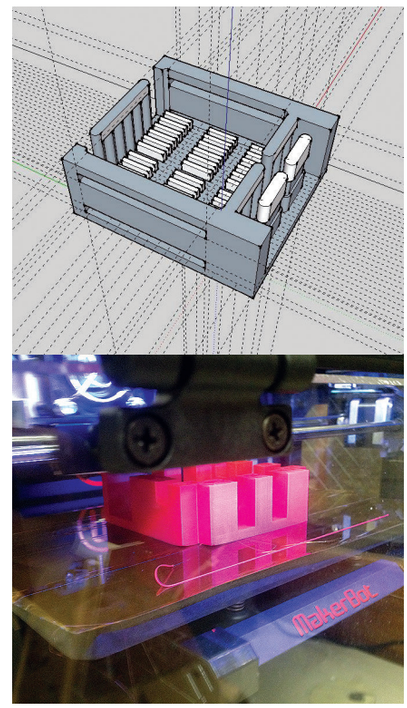
In Middle School, technology coordinator Bob Rowan has been experimenting with a second, smaller 3D printer given to Penn Charter by the Smithsonian. "One of my sample prints," he said, "was a replica of the **bones in a human knee joint**, which tied in with work that Jeff Humble was doing in science class, and we also printed a replica of a human heart to show his students. I'm expecting there will be many more uses for the printer with our work in science classes."

A musical use for the Middle School printer came about during a lunchtime discussion between Rowan and music teachers Hayley Varhol and Bob Wilson about the difficulty of playing a brass instrument in cold weather. Rowan found a 3D model of **mouthpieces for the trumpet and trombone** and was able to print plastic mouthpieces, rather than the metal (cold!) ones that musicians normally use.

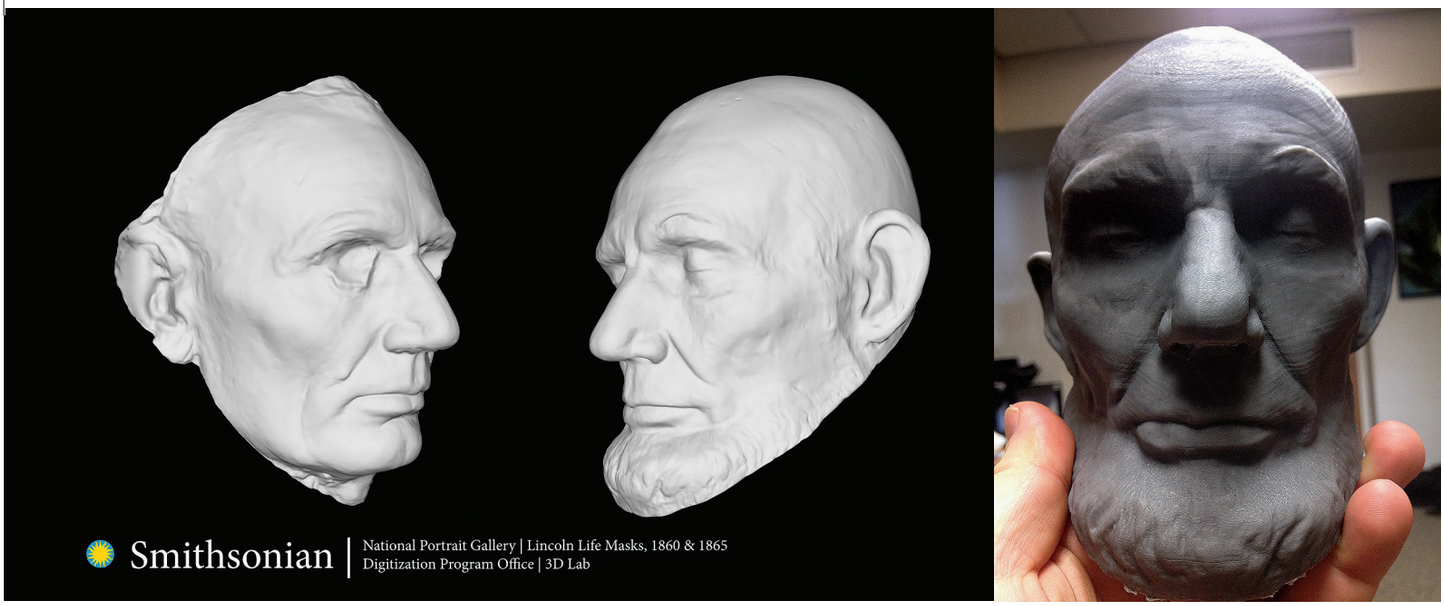
different," Sharp said. "I was interested in it because I'm always looking for ways to help kids think, and thinking historically isn't easy. After the AP exam, kids need to be working on something that's different and refreshing. Still working, but turning something sideways – out-of-the-box thinking."

Testing a student activity in the iBook, Sharp will have students simulate the presidential campaign of 1860. Each member of the class will be assigned a role: Lincoln, a supporter, or a delegate who is a potential supporter, for example. The activity will "enable students to see who Lincoln was." Students will assess the activity. Does it work? Is it worthy of class time? "They're put in the position of being evaluators" for the project, Sharp said.

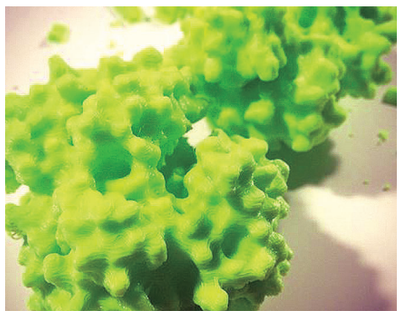
Educators from the Smithsonian will visit Penn Charter at the end of May for a chance to ask the experts – students – about the iBook. In addition to Sharp's students,



Supporting the school's 1:1 laptop program, Kilbane and head librarian Doug Uhlmann used the 3D printer to create fixed charging stations for Mac laptops. Modeling and printing a plastic insert to fit inside a standard electrical box, they nested a charger inside and securely mounted each box in the wall or under a table.



The Smithsonian provides on its website 3-dimensional views – as well as downloadable 3D models – of its two Lincoln life masks. The 1865 Clark Mills life mask (right) was printed by PC students. Visit https://3d.si.edu/browser to explore these and other models.



A 3D model of oxygenated hemoglobin protein allowed freshman biology students to see how red blood cells use proteins to carry oxygen.

members of both the Innovation and Science clubs will weigh in on the iBook. Some have already begun using and evaluating a student papercraft activity. Designed for schools that don't have a 3D printer, this project involves printing and cutting out pieces of paper and connecting them to make a 3D, paper life mask of Lincoln. PC students already have a suggestion: When piecing together the life mask, instead of matching tab A with slot A, match an event in Lincoln's life with the date it took place – match up the Lincoln-Douglas Debates with the year 1858, constructing a timeline of Lincoln's life as a way of building students' knowledge while they piece together the life mask.

Another section of Sharp's AP U.S. History class will work with 3D models found on 3D Warehouse, a crowd-sourcing site that allows users to create 3D scans of buildings and structures and upload them to Google Earth. Students will choose and research three landmarks – perhaps the Tacony-Palmyra Bridge, Baltimore's Oriole Park or Coney Island's Cyclone roller coaster. They will download and print the models, and record their insights into the process of creating the 3D images.

Sharp hasn't told her students about the 3D projects she has in mind. She'll wait until they need a boost, "when they're making a final push for studying for the AP exam" in early May.

LIFE-ALTERING APPLICATIONS

Tenth grade Quakerism students and 10th and 11th graders at Widener Memorial School, a Philadelphia public school for students with physical disabilities, are working on an exciting, real-world application for 3D printing. Many Widener students have difficulty resting their arms on a walker because they lack the strength to manipulate it with just their hands. So, teams of two PC students and two Widener students are designing and producing on the 3D printer a "trough" that can be attached to the walker to make it easier for Widener students to move around both the school and community. "Our hope is that we can not only make a series of braces for Widener students to use, but that we can also personalize the troughs for individual students," said Jim Ballengee, founder of the Center for Public Purpose.

Outside of Penn Charter, doctors and scientists are using 3-dimensional technology to make life-altering – even life-saving – devices. In Michigan, doctors treated a toddler born with a defective windpipe by making a CT scan of his windpipe, then 3D printing a replica of it to wrap around and support his own trachea like a splint, keeping it from collapsing. Biomedical researchers at Alfred I. DuPont Hospital for Children created a custom exoskeleton for a child whose arthrogryposis meant that she couldn't move her arms on her own.

Science teacher Corey Kilbane, shown here with Innovation Club member Gordon Robertson, presented in November at Smithsonian X 3D, a sold-out conference on how 3D technologies will transform museums and research institutions worldwide. Kilbane spoke about multidisciplinary applications for 3D printing in the classroom.
PHOTO: **MEREDITH HEUER**.

The applications for 3D printing at Penn Charter, as well as throughout the world, are seemingly endless. "While it may not be the solution to everything," Kilbane said, "it's definitely adding a whole new set of tools to our toolbox." **PC**