AFINIA 3D

Afinia 3D Printer-Enhanced Educators

STORIES OF SUCCESS

Volume II

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FORWARD

“Develop a passion for learning. If you do, you will never cease to grow.” - Anthony J. D’Angelo

At Afinia, we love to learn. We love learning about technology and how things work, and we love learning about how our customers are using our products. We are thrilled that we are seeing more and more educators with our Afinia 3D Printer in their classrooms, inspiring students to get involved in STEAM (science, technology, engineering, arts, and mathematics).

In this volume of our eBook, we have collected stories from 10 educators (or in some cases, educational company leaders) about how they are incorporating 3D printing into their students’ learning. It is amazing to see what educators who have a passion for learning are doing for their students, and we are excited to see how these innovative individuals will continue to educate and inspire.

Afinia is proud to work closely with educators and we believe that 3D printing will make a genuine impact on education and the future.

To our Afiniac educators: Thank you for your continued support and for showing us how impactful technology can be in education.

Mitch Ackmann
President
Afinia 3D

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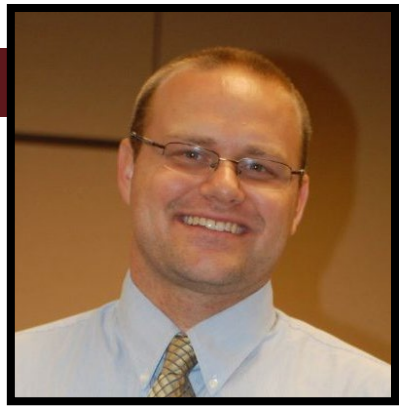
CLARK BARNETT



Facility: Conejo Valley Unified School District & Pepperdine University

Title: Educator and Technology Consultant & Adjunct Professor

In education circles, Dr. Barnett is known for his Ecosystem and build-a-bug Entomology labs.

3D PRINTED BUGS

Read or Experience?

"I was trying to figure out how to really engage my students because Ecosystems and Entomology are subjects that are far more interesting to experience than to read about. Fortunately, I got my hands on an Afinia Desktop 3D Printer last summer and the teaching ideas just began to flow. I decided to tell the kids that the classroom was an environment in which an insect lived. They would get to design their own bug, describe how it interacted with its environment and 3D print it.

"We started talking about living and non-living things in environments, decomposers, and other insect types. I found that I could also teach other curricula standards by working a writing assignment into the lab."

Thorax?

"Entomology requires students to know a lot about insects and their parts. Instead of having them memorize this I used experiential education. When they are designing an insect the kids want to know what the parts are called. In my opinion, this is a much better way for them to learn, as opposed to rote memorization. I also included in the curriculum links to kid-friendly entomology web sites so that they could study on their own. One student got so excited about that extra knowledge she brought a giant, live, bug into class, which we studied. That's what's great about being an educator."

Student-designed, 3D-printed bugs.

Couldn't Settle on a Major

"I became an educator for a couple of reasons. When I was growing up, I had lots of younger cousins and enjoyed spending time teaching them about what I knew. As a young adult, I had a lot of interests and couldn't settle on a major so I thought education would be a great course of study, where I could continue to learn about many different subjects.

"As a teacher, I always thought that I taught like everyone else, which I have found is not the case. I've learned that at the core of teaching is planning how to present information. I've moved to a more student-centered teaching pedagogy, which puts more of the learning in the kids' hands. It's definitely different than what my colleagues do. We all plan together; I just use technology that they are not familiar with, yet. I'm teaching them, though."

"Different" Teachers, Like Me

"I serve on our District Technology Committee. Our District Superintendent believes that there are a wide variety of teaching styles and "different" people like me should be encouraged to develop their craft so that they can teach their colleagues. I feel like I'm supported.

"The feedback that I get from my students' parents is that

they are really happy with what their children are learning. They have also told me that, in many cases, their children surpass their own technical knowledge. Few of my parents understand 3D printing. In fact, some initially thought that 3D printing was printing an isometric drawing on paper. They quickly learn what 3D printing is when their child brings home a model that they have created in class."

3D Printed Squirrel

"One of my students brought in a squirrel that was made on the 3D printer at their parent's office, so there's a wide variety of parental knowledge. Speaking of parents, as you know, educators are always looking for funding. Fortunately, I have one parent who is a grant writer. She is helping me get funding for more 3D printers. I can tell that this technology has really engaged our parents.

"Other parents are willing to put in their own money to help expand 3D printing in our school. They understand that it is big, and getting bigger. This might sound surprising until I tell you that the major employers in our area are Amgen & the Jet Propulsion Laboratory. Many of my parents are part of our large, local scientific community. Even though we were studying insects, there is a lot of engineering involved. For example, the legs have to be designed to support the weight of the bug's body. 3D printing makes it easy to bring in engineering techniques and see how things work. It's kind of like sped-up evolution."

Hacking A Magic Marker

"A few years ago we were working on an electronics unit and happened to get interactive whiteboards installed in our classrooms. We also received some really expensive projectors that used an infrared sensor to run the smartboard software. In trying to find a more cost-effective solution, we found a Wii remote hack that did the same thing. One of my colleagues, Dr. Carl Friedlander rigged up a magic marker with an infrared sensor and it worked pretty well, except in my classroom because there was too much sun. Five years later I happened to show the prototype to the kids, they got excited, so I gave them the pen to see what they would do with it.

3D-printed interactive whiteboard marker.

"The very next day they said, "Let's take the thing apart and reverse engineer it." They figured out how to improve the pen's performance, figured out a bill of materials and put together a proposal for student counsel. They asked for $500 because they wanted to make one for every teacher in the school, and got the money. We'll be 3D printing the cases. What a great Real World exercise that was!"

My Wish For Students

"What do I wish for my students? I hope to see them in an engineering field. I want them to use technology and make and fix things in their own homes. I've been trying to build inquisitive minds and give them the confidence and skill to figure things out. 3D printing accelerates learning those types of skills. For example, for science projects they will print out a replica of the molecules that they are working on, or the different phases of a plant's life cycle. I want to expose them to the tools and give them the skill to know when and how to use technology."

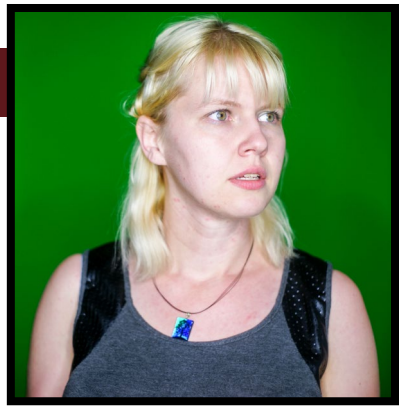
A Bug In His Pocket

"I've seen quite a few transformations in my classroom. One student, in particular, was having problems finishing projects. I decided to train him on the 3D printer. He had the first bug done and he just glowed when it finished printing. He now takes it with him wherever he goes. His parents and I discovered that when we invested time talking to him about where he could improve, as opposed to talking about behavior issues, he was able to move forward.

"I have another student that used to get into trouble because he has lots of energy and has difficulty focusing. He got excited about 3D printing and his energy has been channeled. Now, he feels he can do anything and his parents say he is more confident and is enjoying school. Everyone is thrilled to death.

"Now, I'm not suggesting that 3D printing is the answer to all of my students' issues. It has gotten a few of the more challenging ones to focus on something productive and, from that, they have learned some important life skills. Curricula, Standards and technology are important – it's what you do with them and how it positively impacts the kids that counts."

LIS BOKT



Company: The Geek Group Science Center

Title: Executive Director

Lis Bokt, is the Executive Director of a 43,000 square foot makerspace, in Grand Rapids, Michigan.

TRANSFORMATION, FAILURE, AND ART: THE BEAUTY OF THE GEEK GROUP

The Geek Group

"The Geek Group Science Center is where individuals can work on projects, regardless of scope. We have everyone from engineers doing product prototyping on our Haas CNC machine or our 6 Afinia 3D printers, to folks playing with our KUKA Robotics prototype KR-350/1, to kids doing their homework. We have 25,542 members that span the globe. For this reason, video is important to our outreach. We also hold tours every week and that helps us increase our membership."

Transformational Tour

"One of my favorite moments came during one of those tours. A high school girl was gearing-up for college and was told that she should go into administration. She loved watching TV shows where people were making stuff like motorcycles and custom cars. She saw our equipment, and was really interested. We told her, "You can make anything here. At first, she didn't believe it, and when we walked her through the steps, she realized there was nothing keeping her from making things. She changed majors and went to vocational school."

Failure!

"I think that story illustrates our motto: Confidence, Freedom to Explore and Permission to Fail. In fact, we have a case in our lobby containing our spectacular failures, such as broken parts, fixtures and other things."

Born of Surplus Computer Parts

The idea for the Geek Group came about in 1994 at Grand Valley State University in Allendale, Michigan. There, a group of friends began experimenting with surplus computer parts and surplus electronics. They attracted more like-minded people and grew over a few years into a small company, which they named The Geek Group. They started hanging out on a regular basis and realized that they could accomplish much more, together.

From Garage to Acre-Sized Makerspace

"Our first makerspace was a collection of equipment in someone's garage, and it was not enough space. So we rented a small warehouse and realized that 5 – 10,000 square feet was still not enough space. When we got to 15,000 square feet we added a robot that needed 1,000 square feet. We had difficulty making that space work and decided to take the plunge and become a large-scale operation.

"When we obtained our current 43,000 square foot space in 2010, we knew we were taking a risk and, because of that, weren't getting a lot of sleep. Immediately, though, we got a lot of attention from the community and the space began to fill. As we add workstations, people come and fill them up. Each day we have as many as 60 people. On rainy days, we're packed.

"We discovered early-on that we attracted science teachers who wanted to share our space with their students. They found that they could make science much more interesting by giving their students a hands-on learning experience not available in school."

Putting the "A" in STEAM

Lis' background is quite varied and explains why The Geek

Group isn't your average makerspace. Lis is an artist who works in multiple disciplines (floral design, woodworking, plastic, glass blowing, painting, drawing, clay sculpture, metal work, and calligraphy). She is also a programmer (PHP, SQL, JavaScript, ActionScript) and speaks English, German, French, Swedish, Sámi (the language of nomadic Lapps in northern Scandinavia). She has all of the makings of a STEAM (Science, Technology, Engineering, Art, and Math) proponent.

GeekArtist or ArtistGeek?

"As Executive Director, my background allows me to approach things from both worlds: Geek and Artist. Most traditional geeks don't approach things from the artistic side. Having said that, I have also discovered that our more artistic members quickly pick up on how they can use our equipment as new tools to create their art.

"Accessibility to non-geeks in our community is a priority of mine. I've noticed that there are parallels between spoken and programming languages. This allowed me to pick up on G-code pretty quickly and it helps me to teach it to people.

"I consider myself to be pretty good at explaining things to others. That's because, early in my life, teachers let me approach learning in my own way, I would discover things on my own. As a young child I wanted to learn about everything and they let me explore. My mom was also a big influence. She was a music teacher and let me learn in my own way. I guess that's why I'm a big proponent and practitioner of experiential learning."

Don't Worry, It's Only an Industrial-Strength CNC Machine

"For example, here's how I teach people to use our industrial-strength CNC machine: I put them in front of it, tell them which way is up, show them a bit about the software and say, 'This may look intimidating. You're smart, and can figure it out.' They go to work, ask for a bit of help and leave with something they've made. They tell their friends, 'Look what I made. You can do it, too.'"

What does the future hold for The Geek Group?

"We would like to expand in the future and are considering a Campus Model versus a single building, like we have now. One thing is certain: the people in our area have the interest to support us."

OWEN COLLINS

Company: Washington and Lee University

Title: Professor

Owen Collins is a Professor and Head of the Department of Theatre at Washington and Lee University in Lexington, VA, who enjoys the technical side of theatre.

SETTING THE SCENE WITH THE AFINIA 3D PRINTER

Prologue

"My dad is an architect, and through him, I developed an interest in drafting. During the late 80's I was employed at his firm and learned how to use computer drafting tools.

"During graduate school, I became interested in how computers were used to control the "technical side" of the production: lighting, sound, and video effects. I worked in New York City for a year and then got a job teaching theater."

Kits vs. Out-of-the-Box 3D Printing

"Four years ago, I bought a 3D printer kit. It looked easy to assemble, but it was a lot harder than it appeared. All told, it was really a great experience, the soldering and playing with electronics. After a good couple of years, however, I found that I was spending too much time tinkering and not enough time printing.

"I happened to see the Afinia 3D printer in MAKE Magazine's "Ultimate Guide to 3D Printing" and immediately bought one. Based upon their review, I knew that I'd be printing, right out-of-the- box."

From 2 to 3 (Dimension, that is)

"At Washington and Lee, the Afinia fits really well into our creative process. Before I had a 3D printer, I would draft models and stage layouts in 2D and review the drawings with the Director. I still design my models and sets in 2D and, more importantly, have figured out how to export and print STLs. Directors really like to see and feel the physical objects. They find it extremely helpful."

Alexander the Great

"Our Afinia 3D printer has also found a home in prop design... When we produced a play called "The Nerd," which is set in an architect's home, we needed stuff on the walls and to decorate the room. It was easy to print custom posters on a large format printer. The art objects I needed were just as easy. I downloaded a scanned sculpture of Alexander the Great. I 3D printed it on the Afinia and painted it bronze. To the actors and the audience, it looks like the real thing.

"It has been used in all of our other productions as well. For "Arsenic & Old Lace," we created World War I period toy battleships and soldiers."

Even for Dummies

"We use 3D printing to produce plays that would normally have been too expensive. One of our Senior students wants to stage a Twilight Zone episode, in which a Ventriloquist gets turned into a dummy. I love the story, and initially, it seemed cost-prohibitive because the student needed two or three dummies, which cost around $1,000 each. Now, I am scanning the actor's faces, 3D printing them, and will be able to create the dummies at a fraction of the cost.

"Because of this [the ability to 3D print "dummies" and models], 3D printing is now integrated into our curriculum. We teach a Directing class, where originally, the students would be on the stage, moving furniture around so that they could visualize where the characters should be and how the set should look. Now, we have 3D printed scale models that the students move during the "blocking"

process. It takes a whole lot less effort."

Little-known Design Software

"To accomplish these things, I use Vector Works as my design software. It's not very well known. It has integrated tools for lighting design. It's a no-brainer. I can create the set design and add in the lighting. I had never took advantage of Vector Works' 3D file exporting capabilities until I had the Afinia 3D Printer."

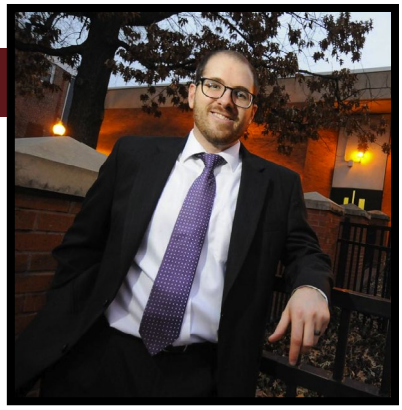
3D Printer on the Podium

"Due to my 3D printing experience, I was asked to be a panelist at the most recent US Institute for Theater Technology Conference and Stage Expo. During the discussion, the other panelists were talking about their printers. I brought mine and was able to show the attendees how it worked and what it produced. Its pretty amazing to see things created right in front of you."

Epilogue

"The beauty of imagination is that you can buy into and embrace a story. When done correctly, it can transport and transform you. The fun of these shows is that we create experiences that cause the audience to talk about the human condition and gain empathy for others. The Afinia 3D printer makes it easy. It's also really reliable; I printed more than 30 lbs. of material before it had its first very minor hiccup."

ANDREW COY, SHAWN GRIMES, & STEPH GRIMES



Company: The Digital Harbor Foundation

Title (respectively): Executive Director, Director of Technology, & Director of Curriculum

The Digital Harbor Foundation (DHF) fosters innovation, tech advancement, and entrepreneurship by helping youth develop digital age skills through maker activities and tech workforce readiness.

FROM REC CENTER TO TECH CENTER

In the Beginning

"Our story begins when a few educators in Baltimore learned that the city was closing the nearby Rec Center. The closings were due to the financial constraints of the Baltimore school district budget. Two blocks from one of the most recent Rec Center closures, however, a technology teacher in Baltimore City Public Schools had a vision of revitalization. His vision found a way to re-imagine the role this underutilized space could fill by converting it from a Rec Center into a Tech Center, where youth could learn a wide variety of high-growth, tech-sector skills such as digital fabrication, web or app development, and electronics. To turn this dream into reality, it would take a team of passionate, dedicated individuals countless hours and a number of miraculous convergences.

"Six of the more than twenty Rec Centers that were slated to close happened to be physically attached to elementary schools. School administrators were able to make arrangements for these spaces to be transferred to the control of City Schools and remain open, being utilized for a variety of purposes from simply expanding classroom space for the school to maintaining them as an operating Rec Center."

Save The Rec Center!

Andrew Coy, who was at that time a City School technology teacher, ran around sharing his vision of how this space could be transformed from a Rec Center into a Tech Center. Soon, a small team had gathered around this shared vision and with the support of local industry leaders, philanthropic organizations, and the City Schools, this dream became a reality as the Digital Harbor Foundation Tech Center was born.

People gather around during the Grand Opening.

The news of these efforts spread quickly. Numerous educators wanted to learn more about Digital Harbor's success and how they could do something similar in their classrooms, schools, and communities. In the 18 months since the DHF Tech Center opened, more than 1,200 individuals from around the country, including program officers for national organizations, teachers or administrators from individual schools, district superintendents, state and federal government officials, entrepreneurs, and technologists all came to tour the space and learn from the Digital Harbor Foundation's team.

FabSlam-ing

The Digital Harbor Foundation has created a wide variety of programs serving youth from first through twelfth grade. One program, FabSlam, provides an introductory experience in the form of a competition, designed to provide more youth with opportunities to learn about 3D printing. This challenge-based experienced involves a 6-8 week process that allows a team of students from any middle or high school to form a team, get paired up with a local "Tech Coach" for support, and then compete in a challenge centered on a given innovation theme. Topics for past FabSlams have included "Wearable Technology", "Play", and "Travel".

"These competitions do far more than provide an opportunity for youth to explore a topic," says Andrew Coy, Executive Director of the Digital Harbor Foundation. "They provide a context in which learning has real-world application. Each youth team has to answer the question for themselves: What do you want to build and how do you want it to work? They have to learn to explore, experiment, innovate, and iterate — all of which builds true learning confidence."

"A confident student is a confident employee," adds Shawn Grimes, DHF's Director of Technology. "This experience is part of our youth development process. Fundamentally, we are building a pipeline into tech-powered careers. They may not become a software engineer, but they will have valuable tools to help them in the workplace, whatever their career. Interestingly enough, the original Rec Centers were used by to help youth get physically fit. We are doing the same thing, but for mental fitness."

Theme Dreaming

"How do we come up with themes? There is no magic; we just find something that's real world and interesting, then we make it vague enough to allow for imagination. We never know what the youth will come up with exactly — which is part of the magic. Some were printing pieces of their projects and iterating on initial designs right up until the end," explains Steph Grimes, Director of Curriculum. "Documentation of the design progress is key to this whole process. Sharing their team's successes and failures through the innovation and prototyping process is a major part of the presentations made during the competition's final event."

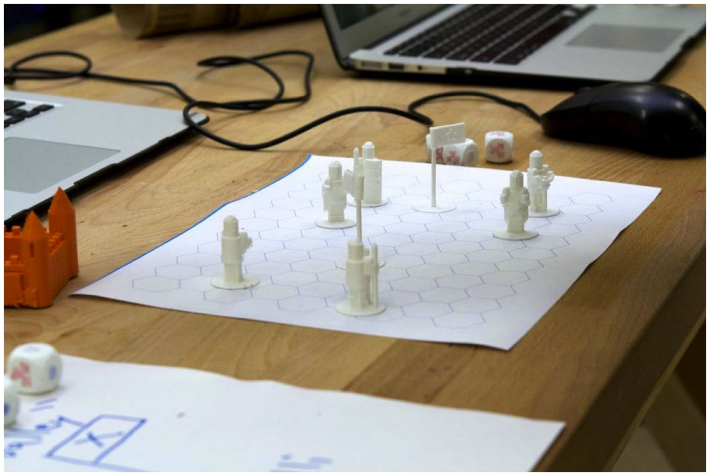
Here Comes The Judge(s)

"Surprisingly, judges are fairly easy to find," explains Shawn Grimes. "There is a great tech community in Baltimore and the panel is made up of about one-half engineers or technologists and one-half educators or community members. The feedback we receive from the tech community is really positive! They are envious of the opportunities our youth have at such young ages."

Transformative Tech

"3D printing plays a large role in the FabSlam process. Teams have access to a variety of 3D printers at different locations through mentor relationships. At the Digital Harbor Foundation Tech Center, we used extensively a

Hard work and brainstorming take place during the FabSlam.



3D prints from the Afinia 3D Printer hold down the fort (or paper) at DHF.

half-dozen or more different 3D printers," says Coy. "The Afinia Desktop 3D Printer is a fantastic and very reliable printer — far more than [other brands] have been for us. We are really excited to continue to see this industry grow!"

Community Support

"We have only been able to accomplish all of this due to the tremendous support we have received from the larger community. Our supporters buy into our vision because they visit our space and see what we are doing. They see that this is an amazing experience for young people who otherwise wouldn't have these opportunities. They see that we are addressing a glaring gap in the current education system — bridging education and the workplace. Our work wouldn't be possible without all of this!" says Coy. "Because of this support we are able to make all of our programs simply Pay-What-You-Can — which has successfully removed any financial barriers that would otherwise exist for these type of opportunities. Thanks to folks like Afinia and many others that have given in-kind as well! Our community space exists because of such organizations and individuals!"

To learn more about the Digital Harbor Foundation, please visit their website at http://www.digitalharbor.org/.

KAYE EBELT

Company: National Science Foundation

Title: Directorate for Engineering

Kaye Ebelt is an Einstein fellow, inspired educator and life-long learner who has a BA in Elementary Education, ME in Computer Technology, and MS in Science Education.

3D PRINTING THE IMAGINATION: EDUCATING FOR THE FUTURE

The Power of Passion

It is clear from Kaye Ebelt's background that she has a passion for learning. During her interview, we learned how she is passing that passion on to other teachers and students. As the Directorate for Engineering at the National Science Foundation, Ebelt provides her expertise forming STEM education programs. When we asked how Ebelt was awarded the Directorate position, she admitted, "It started with me wanting to know what a 3D printer was. A fellow teacher connected me with John Westrum from Afinia, and he set me up with a printer. When I got it, it was the only thing my students and I focused on for two months. They would skip lunch and recess to print!"

Ebelt recognizes the impact that teaching has on students. "When you have a teacher who is so passionate about what they are dong, you get excited about it. A teacher is supposed to share their experiences. When a teacher shares their passion for STEM, their students are more likely to go into a STEM career."

When we spoke with Ebelt, she had just returned from a trip to Houston and Wyoming where she shared her STEM knowledge with 20 cadets, their parents, and sponsors, showing them how to use 3D printers. "People loved the Afinia 3D printer. I was up until 3am every day, printing in my room, which was filled with people!"

3D Printing the Imagination

The Afinia 3D printer affected the students more than they could have imagined. "My 5th grade students came up with a way to teach kindergartners how it works by comparing it to a topographical map: they explained that it is built in layers. At first you can't tell what it is, but as the layers are stacked, the full-picture comes into focus." Ebelt explains, "Using the printer not only helped students learn about engineering and how things work, but it also expanded their vocabulary. They learned words like 'extruding,' 'initialize' and 'calibrate.' The projects they were doing (including building a catapult) excited them so much and were so fun, they didn't even realize how much they were learning. They read the entire manual and ended up knowing more about it than I did. They even came up with a motto: 'You can print your imagination.'"

Word traveled fast about her 3D printer and soon students from other classes and grade levels were investigating Ebelt's printer during passing time. "The 5th graders even ended up explaining the printers to the 8th graders.

So many classes were interested in the printer that we decided to have a presentation for everyone at the end of the year."

Teaching Engineering Education

"When I came to Washington D.C., it was decided that teachers needed to be educated in engineering and 3D printing. That became my mission. Educators need to know engineering education and how to use a single printer to teach 27 students.

"Critical thinking is a pivotal aspect of engineering, and it is the hardest skill for teachers to foster. With math, science, and social studies, all of the subjects are taught separately. With engineering, it combines subjects and takes students to the next level of critical thinking while simultaneously letting their creativity run wild. In engineering, the sky is the limit. You don't know what the outcome will be… and that's the fun part."

Ebelt promotes pre-engineering in preschool, since it is where visualization skills are sharpened. "There's been research on incoming freshman engineering students. Girls are coming in with weak 3D visualization skills while boys are coming in with stronger skills. If you think about the toys each gender plays with during their younger years, it makes sense. Girls are encouraged to play with Barbies while boys are given Legos. However, video games are also causing a loss of 3D visualization. Engineering and 3D printing can bring it back and sharpen these skills in both girls and boys."

A Hands-On Approach

Ebelt has always preferred hands-on learning. "It comes from my parents. My mom is an elementary school teacher and my dad has an engineering degree. Throughout my childhood, play and making, designing, and revising was how I grew up. Hands-on learning was part of my life, and that became the way I teach."

This hands-on focus magnifies Ebelt's love of 3D printing. "Traditionally, lots of students get overlooked. You don't see how skilled they are in building and fixing because they lack hands-on activities. Being hands-on can help solidify concepts, too. Because of this, my lowest-achieving math student now loves math. Working with the

Students get hands-on experience with catapult project.

3D printer taught him how to stick with a project until it was finished."

Fighting for Robots

Ebelt is no stranger to sticking with projects. "Ten years ago, I approached the school principal about starting a robotics class. I offered it as an after school program and had 7 students sign up. In its second year, two parents decided to get involved, one being an engineer. That second year, our club won the state tournament and went to nationals. For the first time, students were realizing they could become engineers. After that, the school board unanimously approved to make robotics a school sponsored activity. That was eight years ago. Since then, we have grown from a team of 7 to a team of 75. It has been incredible. Other Missoula schools have taken it up, and even the middle schools have adopted robotics. Kids are realizing engineering is fun!"

Can't Stop

Ebelt's passion for students and science didn't stop at robots. After participating in NASA's MicroGX and Reduced Gravity Flight and attending a space camp, she knew it was something that would fascinate students. "I knew if I'm this excited about it, the students would be ecstatic! [Space camp] was something that Missoula

didn't have, so I designed one. It's offered through the Y and has impacted almost 2,000 students."

Not only has Ebelt participated in Reduced Gravity Flight, she also enjoys spending her weekends gliding.

Ebelt has also designed a mini medical school class. "Kids apply for medical school and take on a variety of specialty roles. Doctors come in from the local hospitals and help teach the children about the medical field. The students end up preparing a presentation and taking their "medical boards." Once they pass, they get a patient card and use their knowledge to diagnose the patient. Incorporating a 3D printer is very exciting - now the students can use it for the biomedical unit and can print mock body parts rather than using props like soda bottles as lungs, as we did before."

When we expressed our awe of her passion and creativity in teaching, Ebelt's modesty appeared. "I like learning things I don't know and sharing that with the kids. I try to be the type of teacher I would want." She added, "The opportunity provided to me with the Afinia 3D printer has changed everything for me… I'm lucky to be involved in education right now. Where this is heading, it is very exciting."

Schools are realizing how important 3D printing and engineering are to education. There is already talk of making Ebelt a STEM Coordinator, emphasizing engineering education in Montana Schools, to coordinate and train teachers in new technologies when she returns in 2015.

BONNIE ROSKES

Company: 3DVinci

Title: Creator

Bonnie Roskes is the creator of 3DVinci, a company that offers training in SketchUp and other application tutorials to beginners and professionals and everyone in between.

SCHOOLING WITH SKETCHUP: MODELING THE FUTURE WITH 3D

In The Beginning

3DVinci was an innovation born out of necessity. "I wrote the first tutorial for SketchUp in 2001, when SketchUp wasn't at all mainstream. There were no other tutorials on the market, and people needed guidance on how to use the software. In 2006, when Google bought SketchUp, there was a free version that teachers were flocking to, but weren't sure how to use, so I wrote tutorials for the education market as well."

SketchUp for 3D Printing

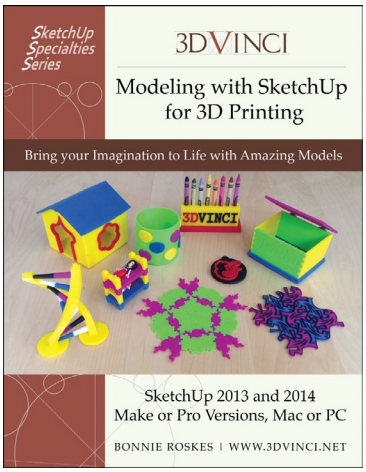
"I started creating tutorials on SketchUp for 3D printing in 2013, while I was writing K-12 projects," explains Roskes. "Having a 3D printer is really fun. I have five kids, and when their friends come over, they stare at my Afinia 3D printer for hours. The whole neighborhood loves it and people ask me to make things that will fix little issues that they have!" Roskes uses her creativity to find solutions to all sorts of problems. "I got the idea to design hooks to install a curtain for privacy on my kids' bunk beds and I created holders for painted wall tiles."

Afinia: Above the Rest

"When it came to choosing a printer, I thought the Afinia 3D printer's ability to switch colors was fantastic. It is a great feature that I use all the time! The Afinia can create some amazing pieces that wouldn't look nearly as good in one color. Other printers have the multi-color option, too, but required G Code programming. If you're a serious maker, you can do it, but teachers cramped for time aren't going to mess with it."

Schooling with SketchUp

Roskes says, "My book, Modeling with SketchUp for 3D Printing, has sold several hundred copies so far. It is a great book for educators and contains step-by-step projects for students. A lot of the ideas I Include in my books actually come from my kids. One of the models that draws the most attention from teachers is the DNA strand," explains Roskes. "It's a really cool design to look at. It's printed out in pieces, so it is very tactile. Math and geometry teachers also really like the Escher tiling projects. These are great because the math concepts that are difficult for students to understand become completely clear when they can create it in 3D. I've found that SketchUp and 3D printing can be used for nearly any subject."



Roskes' SketchUp book for educators.

A key piece that is missing from the desktop 3D printing ecosystem is the ability to convert an idea or product into a 3D model. Desktop 3D scanners are not generally ready for prime time yet, so it's important for printer owners to have some knowledge of SketchUp or another design application.

Roskes explains that when people begin 3D printing,

they should download something small to print, to make sure everything works. “That part isn’t particularly rewarding. But if you can find a model and modify it in SketchUp, actually make physical changes to it, that’s great. That’s the first step.” Roskes’ book takes individuals from the beginning stage to a very highly creative and innovative level.

Student Development

“SketchUp and 3D printing do amazing things for students’ spatial relations development. It’s important to begin this at a young age so later they can apply it to higher-level concepts. If I had SketchUp or a 3D printer growing up, it would have been much less intimidating going into a technical field. With this technology, kids in middle school are doing things we didn’t do until college,” admits Roskes.

“I think after school clubs will be a big area for 3D printing and hopefully more students will get involved with these programs. That is where the real innovation is going to start.”

DR. EVA STRAWBRIDGE & JEFF KOPSICK

Company: James Madison University

Title (respectively): Assistant Professor- Department of Mathematics & Statistics; Junior in Mathematics

Eva Strawbridge and Jeff Kopsick found themselves on an unlikely 3D printing journey after Jeff's independent study course in 3D printing.

3D PRINTING, MATH, BIOLOGY, AND WORM LOCOMOTION

Inspirations from Independent Studies

Their story began when Jeff took an independent study course in 3D printing. He'd never seen a 3D printer in action and knew that his Dad's company used one to design bottle cap prototypes. That was it.

Once familiar with the capabilities of a 3D printer, Jeff was inspired, and wondered if a 3D printer could be used to create micro-environments through which round worms (Caenorhabditis elegans) could navigate and be studied. Talk about connecting dots that are pretty far apart.

He contacted Eva, who directs the WORM (Wiggling Organism Research and Modeling) Lab at JMU. She remarked, "I was so pleased to have Jeff approach me with his novel idea. I had never heard of anything like it. Sure, my colleagues had been studying roundworm locomotion for years, and to my knowledge, no one had thought of this before. My research interests include fluid dynamics, biomechanics, mathematical biology, and applied mathematics, so this was a great fit."

No Project Too Small

Round worms are really small (less than 1mm in length) and were the first organism to have their genes fully sequenced. This is important because there is a link between genetics and movement, which is what Jeff wanted to study.

The first task was to create a very small and precise environment for the research. "Since we needed a microscope for this study, it made sense to print a maze on a microscope slide. I had another 3D printer but it couldn't print at the level of detail that I needed. Our Afinia had just been updated with new software and I was able to print mazes with 1mm wide and 2mm tall obstacles."

Eva said, "Jeff had a hypothesis that round worms change the way they move based upon their environment so he set out to create different mazes. He developed a protocol where he printed one on a microscope slide, introduced a round worm in a saline solution and made a "sandwich" by placing another slide on top. All of the obstacles have to be exactly the same height so that the slides are parallel."

A Closer Look

Eva and Jeff had another item to consider. There wasn't a microscope with the capability to record the worm's movement. In true Maker-fashion, they made one.

Jeff said, "Nothing existed with the ability to do what we needed, so we built a microscope with a motorized cage and video capability that would capture the worm's progress. I learned how to write code to control the equipment so that we could document what happened.

"During the experiments, we could tell by observation that the worm reacted differently based upon where we placed the obstacles. The next step was to quantify the motion so that we could prove that it was different.

"Although round worms are fairly simple creatures, how they move through their environment is very complex. We used the video to overlay the worm's centerline, center of mass, and velocity. This data helped us to extrapolate via formulae how the worms would move in certain circumstances."

Visit http://educ.jmu.edu/~strawbem/ to see Eva's WORM Lab page. The black dots in the videos are the 3D printed obstacles that also keep the microscope slides apart.

All in all, this has been a fruitful partnership for Eva and Jeff, who is now the senior researcher at the WORM lab. "Jeff is really excited about his work and sometimes we have to tell him to go home. I can't wait to see where he will do his post-graduate work and what he will accomplish."

DR. LAURA TAALMAN

Company: James Madison University

Title: Full-Professor of Mathematics and Statistics

Dr. Taalman had an interest in 3D printing and decided to create a lab in her building.

THEORETICAL MATHEMATICS, KNOT THEORY, AND 3D PRINTING

Bringing Learning Out of the Closet

"The only space available [for a "classroom"] was a closet where people used to store their bikes. I turned it into a makerlab and stuck a few 3D printers in there. It really caught on and I thought, "How can I teach more than three students at a time?" I worked with my colleagues and we were able to secure funding for a real classroom and 11 Afinia 3D printers.

"We're also teaching a 3D printing class where we certify students to use the lab, which we call the JMU 3-SPACE. 3-SPACE is the first true 3D-printing college classroom in the country, built for general education courses that are open to all of our students and departments. We have "swipe cards" and there are students running prints 24/7. I've stopped by the lab at all hours of the night and on weekends – students are there all of the time.

"They are 3D printing all manner of things, from viruses with antibodies on them to pencil cups to gears to really cool enclosures for USB drives."

Comprehending Concepts

Typically, 3D printing would be limited to the Engineering Department at James Madison, but the Mathematics Department has found great use for the device.

"One of the 3D printing applications that I enjoy most is its use in teaching the concepts of Knot Theory."

Inspired by familiar knots, which appear in shoelaces and rope, a mathematician's knot differs in that the ends are joined together so that it cannot be undone.

"Initially, all of the knots that we work with were only described by formulae or shown as 2D drawings. We started putting the formulae into Mathmatica and generating STL files that we print on our Afinia 3D printers. It's pretty exciting for the students and really gets their attention. I think that having them look at and handle the knots adds to their comprehension of the concepts."

Mini knots, created using data provided by mathematician Jason Cantarella of the University of Georgia.

The Thrill of 3D Printing

"I'm a theoretical mathematician and many of the concepts are only described, and proven, by formulae, which make things very abstract. Adding the ability to print 3D representations adds impact to the concepts.

"Another thing about 3D printing that I find very gratifying is our 3D printing class has become very popular – it fills in a couple of hours, as does the waiting list. Now my job is to recruit more of my colleagues to teach so that we can add additional class sections."

DR. DAVID THORNBURG

Company: The Thornburg Center

Title: Founder and Director of Global Operations

Dr. Thornburg is an award-winning Futurist, author, and consultant, who recently authored "The Invent to Learn Guide to 3D Printing in the Classroom: Recipes for Success" with Norma Thornburg and Sara Armstrong.

CONSTRUCTING KNOWLEDGE AND CONNECTING CURRICULA WITH DR. THORNBURG AND 3D PRINTING

Learning In Style

Studies have shown that students have different learning styles. Some may learn visually, some aurally, and some kinetically. Dr. Thornburg realizes that students all learn differently, also recognizing that "students learn best when they are constructors of their own knowledge." For this reason, Dr. Thornburg has focused on creating materials that assist educators in encouraging their students to construct knowledge and "become comfortable with learning to become makers."

"I grew up with a dad who tinkered. He enjoyed woodworking, like making clocks from scratch using wooden gears. I grew up in an environment with plenty of resources, and when I went to school, there were plentiful opportunities for students to build. Unfortunately, when computers were introduced into schools, computer labs replaced shops and took away the hands-on opportunities. Now, we are facing a generation of kids who haven't grown up building stuff."

Dr. Thornburg explains, "my focus is on helping educators learn to use technology in good ways in their classroom. Currently, there is increased interest in, and mandate of, engineering in teaching. Teachers don't have a clue on how to include engineering, since many don't have a background in it. They don't know how to approach the topic. I'm seeing that 3D printing is a way to address engineering in a way that these teachers are comfortable with."

Constructing Knowledge

"Professor Seymour Papert, from MIT, was a big advocate of constructivism, a process by which kids create models of learning in their minds. When a student builds artifacts separate from him or herself of what they learn, it has a lasting impact. It doesn't matter if it is a sandcastle or poem; it being external to the learner is the critical element. He calls this creation of artifacts constructionism since it involves actually making something.

"I find in workshops, that as soon as the 3D printer gets started, people go nuts! They watch something they designed be built. To them, it's a real plus: knowing something that started in their mind is now becoming real. One student once told Dr. Papert 'I'm having hard fun.' The concept of hard fun is such a good one. Just because something is hard doesn't mean it is less fun."

Invent to Learn: The Curricular Connections

Thornburg's book provides 18 projects designed to help teachers instruct with 3D design in a way that connects to curriculum and the Next Generation Science Standards (NGSS). "It's extremely important to show teachers the curricular connections. Their day is full and they have tons of requirements, as-is. Their first reaction to 3D printing might be, 'when will I find time for this?!' They agree that meeting objectives with a 3D printer would be great, but they simply don't know how to do this.

"Therefore, without the prerequisite staff development, nothing with happen. Teachers need the opportunity to

learn to design and 3D print, which requires support from outsiders like myself who can come in and take them step-by-step through this process. The design element is essential, and the actual printing is reward.

"In our workshops, we toss attendees into a 'life-or-death' design project and tell them to work together to solve the crisis. Afterward, we ask what subject areas they encounter, and get responses that include engineering, physics, mathematics, life sciences, etc. Just about any subject can benefit from using 3D tools: for language arts, you can build dioramas with 3D prints of things they're reading about, which can involve some critical thinking of how they interpret the readings and leads back to that theory of constructivism. In history, students can design a building according to the architecture of the time and place they study, which can lead to a conversation about why that era was so interested in certain things (materials, shapes, etc.). Many people focus on how 3D printing involves math and science – because it is so clear that it can help bring something theoretical to real life – but 3D printing can be used for much, much more.

"The response to my workshops and book has been positive. At the CUE conference in Palm Springs, people were sitting on the floor and there was a line outside into the hall, all because of topic of 3D printing. People said they were "blown away" by the presentation. Not a single teacher has gone through a workshop without saying 'we need one of these for our kids.' It engages kids who are not otherwise engaged in school."

More Than a Hammer

"I like using multiple design tools in 3D printing, because as Maslow says, 'if all you have is a hammer, you will view everything as a nail.' I really like SketchUp and what Bonnie Roskes has done with it that. I also like MeshMixer and OpenSCAD. Each program allows you to design things in different ways, whether building out of geometric primitives, sculpting out of virtual clay, or computing a shape using mathematics. I find myself going back and forth with tools, thinking to myself 'what tool lets me do what I want with the greatest ease?' I'm currently writing a book on coding language for 3D projects. Coding is now a big topic in American Education. Kids have no idea how computers learn to do the things they do."

The Holodeck

Dr. Thornburg is also the inventor of the educational holodeck. It was inspired by Star Trek: The Next Generation and is an empty classroom that transforms into an interactive learning environment based on what it being taught. It is based on idea of inquiry-driven, project-based learning. Students want to ask more questions, are more engaged, and remember more of what they've learned.

A technological classroom such as the holodeck also helps students learn how to use technology responsibly. "Students are taking control of their informational tools, they are bringing electronic devices to school. They may understand how to use these devices mechanically, but they may not know how to judge the value or accuracy of information they are finding. Google can provide data and information, but that doesn't mean it actually provides knowledge or understanding.

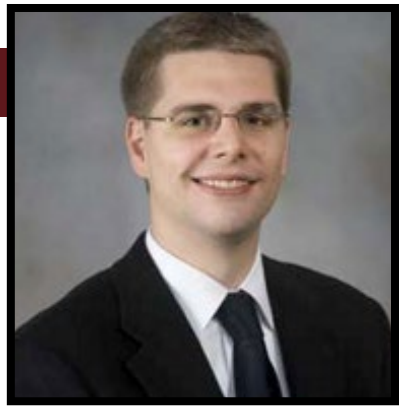
"I love using 3D printing in my holodeck classroom. In our Mission to Mars project, we set up the classroom like a spaceship and I tell my students there is a leak in the ship and they have one hour before we start losing oxygen and we must design something, and design it NOW!"

Dr. Thornburg, the Futurist

"I am a futurist. I look at trends and explain what these trends mean for the future. And I think the future for Afinia can look really, really good. I've been very happy with the Afinia, and the support (especially from John Westrum) has been terrific. Any time I have a hiccup with the machine – which is rare – it has been taken care of promptly. Because I get to work with kids and teachers I get to continue to be a kid myself and play with this stuff. I normally have something cookin' [printing] most of the time downstairs!

"I will be doing a workshop in Aurora, IL for the Illinois Mathematics and Science Academy and for the community, setting the stage to show how we are at a new cusp of industrial revolution with 3D printing. It's all about doing new things. Not doing old things in new ways. The power of technology is to use it to do things we couldn't do before at all, not just to do things differently."

DR. CHRIS WILLIAMS



Company: VirginiaTech's College of Engineering

Title: Assistant Professor - Department of Engineering Education

Dr. Williams was awarded the 2012 International Outstanding Young Researcher in Freeform and Additive Manufacturing by the International Solid Freeform Manufacturing Association.

THE DREAMSLAB AND 3D PRINTING IN HIGH SCHOOLS

Dr. Chris Williams, Ph.D. is an Assistant Professor at VirginiaTech's College of Engineering in the Department of Engineering Education. He received his B.S. in Mechanical Engineering in 2000 from the University of Florida, Gainesville and his M.S. (2003) and Ph.D. (2007) from Georgia Tech.

Chris directs the DREAMSLab (Design, Research and Education for Additive Manufacturing Systems), which contains eight different 3D printers representing five different 3D printing technologies. His DREAMSLab is the go-to source at VirginiaTech for engineers who need sophisticated 3D models to further their research. The DREAMSLab mantra: "If you can design it, we can make it!"

A teacher learns to work with a 3D printer before bringing the technology into her classroom.

A strong proponent of Additive Manufacturing and 3D printing, Dr. Williams was interested in developing a way for K-12 STEM teachers to bring the technology to their schools.

The Engineer of the Future

"What really gets me excited about Additive Manufacturing is that it can fundamentally change the way we design products and get young people excited. For example, we have a group of Mechanical Engineering students who are redesigning an Autonomous QuadCopter. Their intricate honeycomb superstructure is very lightweight, very strong, and could only be made with 3D printing. No longer are we constrained by traditional manufacturing and their rule sets."

Chris has a Renaissance-Man view of what engineers will need to know in the future. The traditional ping-pong approach of a Design Engineer and a Manufacturing Engineer, sending models back-and-forth is outdated. The Engineer of the Future will be educated in not only design, but Additive Manufacturing, Material Science, and Ergonomics. "The Designer will be the Manufacturer and vice versa" is one of Chris' favorite statements.

Here's an example of why this process is needed. Chris had a group of engineering students that asked, "Why am I carrying around this mass of keys? What if we could design a swiss-army-like device that we could use instead?"

Chris said, "They came up with a beautiful design that won a Best In Show. As a reward, we printed it in our

DREAMSLab. The model came out wonderfully, except that it was about 4-1/2" long. Now, when they saw it on a CAD screen it looked great. When they put it in their pocket it just didn't work. Designs need to be created in an environment where they are more closely coupled to manufacturing capability and the end-user's application."

Teaching Teachers, Improving Learning

As part of its Outreach Program, the DREAMS Lab holds 3D printing workshops for K-12 STEM teachers at the National Science Foundation (NSF) Center for E-Design's Research Experience for Teachers (RET).

STEM teachers work on their Afinia 3D printers during a week-long 3D printing workshop through DREAMSLab at the NSF center.

According to the NSF, "The Directorate for Engineering (ENG) and the Research Experiences for Teachers (RET) program supports the active involvement of K-12 STEM teachers and college faculty in order to bring knowledge of engineering, and technological innovation into their classrooms.

"The goal is to help build long-term collaborative partnerships between K-12 STEM teachers, college faculty, and the NSF university research community by involving the teachers and college faculty in engineering research and helping them translate their research experiences and new knowledge into classroom activities."

On October 1, 2012, Chris received $450,000 in NSF funding for an Innovation-based Manufacturing program with the Virginia Polytechnic Institute and State University. These funds were put to use by developing and hosting several dozen high school STEM teachers for a week of intense in-service training on how to introduce 3D printing into their classrooms.

During the week-long session, the teachers are given an Afinia Desktop 3D Printer to use and take with them for their students.