7 Amazing 3D STEM Projects To Do with Your Class

Seven ideas that will help your students gain experience in design and problem-solving through 3D printing while building their science, technology, engineering and math skills

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THE JOURNAL

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Introduction

Teaching students engineering principles isn't common in American high schools, even though it is the "E" in STEM. Benilde-St. Margaret's School in Minneapolis is an exception. Instructor Tim Jump runs an advanced competitive science program at the school specifically to teach students problem-solving skills. His approach: to have students take on engineering challenges, break them into component-sized steps, create solutions with their 3D printers, test the solutions, and then head back to the drawing board to revamp or refine their designs.

An early project done by Jump's students is to build a Lego object to hang off a surface and act as a hook for holding something. The process is intended to teach them something about mechanical engineering. Along the way they learn how to use design and modeling software. Then Jump has them redesign their inventions without the Legos. Formerly, Jump would take the designs and spend "hours" after school machining the prototypes so the students could see how well their designs worked in real life — even the prototypes he knew wouldn't work.

By adding a Stratasys Dimension 3D printer to the classroom, students could take responsibility for the production aspects of their learning by sending their STL files to the machine and watching their designs be created out of ABS plastic.

"I could talk to a student all day long about the importance of engineering design principles, but until they actually attempt to produce something on their own and encounter challenges and make mistakes, they won't really be learning," said Jump. "With the Dimension 3D printer, students are better able to experiment with their design concepts and test their engineering visions, truly understanding why a part worked or why it didn't. The printer has really changed the whole learning dynamic for my students."

As Jump has found, 3D printing is a strong draw to encourage students in the development of their science, technology, engineering and math skills — right alongside communication, collaboration and problem solving. Programs that allow students to develop, design and produce solutions give them experience with the activities that will serve them well in college and career.

Here we provide seven ideas for 3D printing-based STEM projects for helping your students reach their full learning potential.

Idea #1. Design a New Game Controller

The magic of 3D printing is that it allows young people to experience their designs in a way that plain CAD programs don't allow — especially when the design is for a product intended to be seen and held.

Students in John Keyzer's technology education classes at Lake Zurich High School in Illinois were given a research project to find out what 14- to 18-year-olds wanted in a game controller. They used the data they collected to design and build prototypes

How To Manage 3D Print Projects for Optimal Learning

Teach beyond the physical object. A high school teacher in Ohio has her geometry students create 3D shapes. As part of that exercise, she also has them capture a screenshot of the 3D shape from the software, label dimensions and compute the volume. Later, she has them post the image and their calculations into their online notebooks for review.

Perform "out of town" first. Before you introduce a 3D printer into the classroom for official school work, get comfortable with the technology by running a school club. The students who participate in that will naturally be enthusiastic test pilots and help you work out the curriculum kinks.

Fail early, fail often. Teach students that failure is part of the STEM process. A California middle school science teacher doesn't grade results because she believes a complete failure in a project can make the learning even more powerful.

Promote solutions. A California teacher helps his students learn product development by encouraging them to enter their designs and prototypes into new product competitions, A number of colleges and professional associations host high school events, such as the Rube Goldberg Machine Contest, which encourages students to work in small teams to create highly complex solutions to very simple tasks, such as this year's theme: shining shoes.

Personalize the learning. If one student decides her iPad stand needs a cupholder and another wants to add a Reese's Pieces dispenser to a smartphone outlet plate, who are you to say no to certain genius?

using a Dimension 3D printer to figure out how well they met their objectives. That encompassed figuring out how parts could fit together to form the controller, how it would fit in a gamer's hands, how it would look while a gamer was using it and how well it worked compared to other controllers for helping gamers score points.

Keyzer used that activity as a springboard to help those same students take on more ambitious projects, such as building robot parts for his FIRST Robotics team, sponsored by the school's technology club. "The 3D printer has improved many aspects of our students' learning experience," Keyzer said.

Idea #2. Study the Science of Aerodynamics

The forces of aerodynamics that act on an airplane in flight — lift, gravity, thrust and drag — can be difficult concepts for students to follow through plain lecture or text and images. But if they design and build gliders for themselves, they'll begin to see how opposing forces balance and act on each other.

Stratasys has made an online lesson guide available for teachers that will help them walk students through designing gliders and building them with a 3D printer. The curriculum includes leading questions to help students explore the most effective wing designs, determine the correct balance between strength for launching (and crashing the plane) and weight for gaining optimal flight time, and how to design the glider to minimize material waste.

The lesson also includes design tips for printing glider parts. For example, the minimal wall thickness that can be reliably printed is 0.6mm. For load bearing parts, such as the connectors to which the wings are attached, the thickness should be over 2mm.

A four-minute video shows how the basic design of the glider works and walks the student through the use of wing covering material and adhesives to finish off the project. A downloadable zip file contains STL files that can be used as templates to help students kick off their computer-aided design efforts.

Idea #3. Make Manipulatives for Math and Science

Before young students are able to understand math concepts, math manipulatives help them learn about math by touching it. For decades teachers printed, cut out and taped together paper versions of triangles, squares, and trapezoids, until a healthy cottage industry took off in the school supply business for selling the same objects in a more durable form.

One new approach to meet this material demand would be for students to interview teachers in their own math or science classes or lower grades — acting as a supplier for a school client — to understand what specific needs they might have for manipulatives. Students can then design and print the objects for them. Once the final design and prototype have been approved by the client, he or she may request multiple versions of the product in order to allow students in a given class to put the manipulative together from its flat origins and better understand the shape.

How FDM-based 3D Printing Works

Fused Deposition Modeling (FDM) technology is an additive manufacturing process that builds plastic parts layer by layer, using data from CAD files. Once the user has imported a design file and specified options, special software slices the object into ultra-thin layers and generates the instructions for building it. The printer heats up a ribbon of plastic to make it malleable and runs it through an extrusion head to produce the object. When the part is complete, the student can remove it from the printer, strip away the support material that held the pieces in place and perform assembly.

Idea #4. Engineer with a Purpose

Schools with 1-to-1 programs may appreciate the opportunity to supply their students with stands for tablets, smart phones or other devices. Instead of the district buying those gear holders, students can make them with a 3D printer. This is a project where you could encourage your students to talk with potential users to generate ideas for their "products," then design and build prototypes. You could even run a competition and have students in those 1-to-1 classes test and vote on their favorites.

It isn't a giant step from performing work for "in-house" clients to fulfilling projects from outside organizations. That's what's going on at Chico High School in northern California. Teachers Mike Bruggeman and Tom Phelan reach out to local businesses to invite them to share their design challenges with Chico's industrial technology students.

The first project — for a company that produces eco-friendly stainless steel water bottles — was to design new canteen lids. The students came up with a mix of options that they produced on the classroom Dimension printer. The winning prototypes headed to China to help the manufacturer there understand what the client wanted produced.

Since then, Bruggeman's students have worked on cargo and rack products, full-scale models of new structures and designs for sunglasses made from recycled wood. This process gives participants get first-hand experience and a deeper understanding about how engineering with a purpose works — from the initial contact with the client, through design, prototype and redesign, all the way through to production of the final product.

Idea #5. Take Flight with a NASA Project

For 11 years NASA has run High Schools United with NASA to Create Hardware (HUNCH), a program that works with students in middle and high schools to make "flight certified" products needed for space missions. As the organization explains on its website, "While students are building hardware, etc. for NASA, they are also building their interest as researchers, as well as their self-esteem."

NASA provides the materials, equipment, mentoring and quality inspection that's required for the students to fabricate items, and the school is expected to provide technical direction and a safe working environment.

One school that has participated in this program is Cypress Woods High School, a Texas school where students were invited to design and build a remotely operated vehicle — an ROV — that could carry a camera and maneuver through the International Space Station to give earth-bound controllers a view of experiments, displays, gauges and switches without the human intervention of the flight crew.

NASA engineers provided the specifications for the project, and under the guidance of Industrial Tech Club Sponsor and Teacher Mike Bennett (formerly with NASA himself), the students broke into teams to work on different systems — propulsion, cameras,

Put Your Printer on Display

There are few things more enticing to people than watching the amazing process of a design being turned into a physical object. The smart schools put their 3D printers on display as often as possible while building recognizable objects with students standing nearby to explain how they've taken a software design and turned it into what the 3D printer is now producing. As instructor Tim Jump from Benilde-St. Margaret's School explains, "Students are fascinated by the printer. I could sell popcorn and soda and make a fortune… They're just mesmerized that this technology is even possible - that we can design a part, hit print and produce it in real life. It's magic!" That in turn, creates another kind of magic: students interested in pursuing the classes and clubs that will allow them to learn how to use the 3D printer themselves.

control, and power. Students drew out initial designs then later developed detailed designs in a CAD system. As they developed their plans, they used Stratasys 3D printers, which all of the high school drafting classes had, in order to build functional prototypes and parts.

An edition of the ROV submitted to NASA for testing included six printer-created components, including shells and motor covers. The ROV is powered by six ducted fans providing two different directions of pitch, roll and yaw motion. The camera transmits audio and video on the 900 MHz spectrum. And control is provided via a radio control system taken from a model helicopter.

The use of the Dimension 3D printer allows students to continually refine their designs and improve functionality. As an example, one prototype had the motor fitting only one way into the housing; the students updated the design to allow for the motor to go in from either direction and printed out new components.

The students actually had the chance to test out the ROV in a special Boeing 727 operated by Zero G Corp., which flies parabolic arcs to produce periods of weightlessness that last between 20 to 25 seconds. They were able to check out the maneuverability and controllability of their vehicle and its ability to take and transmit images. Based on those tests, the students revised their design for the next generation of ROV.

More recently Tech Club students built a "Microgravity Science Glovebox" trainer. With built-in gloves, these boxes allow space crews to perform experiments.

"The ability of Dimension 3D printer to quickly and inexpensively produce parts that are strong enough for use in real applications opens up a world of opportunities for schools such as ours," said Bennett.

Idea #6. Create a Source of Hydro Power

The Pelton Wheel was an ingenious marvel of the 19th century that's still in use today. Although waterwheels existed aplenty before Lester Pelton came up with his unique design, none was more efficient than his off-center, curved-bucket approach, which allowed for the flow or jet of water to turn kinetic energy into rotational energy. A shaft connected to the Pelton Wheel can be used to produce mechanical power or run a generator to produce electricity.

Allowing students to create their own water wheel, either modeled after the original with its 24 spoon-shaped buckets, or experimenting with their own designs, is possible with the use of 3D printing. Students could also experiment with fewer buckets, make variations in placement of the buckets on the wheel's perimeter and introduce other variables to test out for themselves.

STL files for this kind of project are findable online, or students can go directly to the original images from the Pelton Wheel patent to jumpstart their designs.

Stratasys FDM Printers

Stratasys offers several 3D printer brands that use FDM technology: Mojo, uPrint and Dimension. All of these lines use ABSplus thermoplastic available in multiple colors to deliver professional grade 3D printing that's fast, accurate and high-quality.

Build sizes

Mojo: 5 x 5 x 5 inches.
uPrint SE and uPrint SE Plus: 8 x 8 x 6 inches.
Dimension Elite: 8 x 8 x 12 inches.
Dimension 1200es: 10 x 10 x 12 inches.

The company's Fortus line of 3D printers can work with multiple materials and colors and has the capacity to do low-volume manufacturing.

Fortus 250mc: 10 x 10 x 12 inches.
Fortus 360mc: up to 16 x 14 x 16 inches
Fortus 400mc: up to 16 x 14 x 16 inches
Fortus 900mc: 36 x 24 x 36 inches.

Idea #7. Study Historic Technology

If you were doing battle in the Middle Ages, which would have been a more effective long-range weapon — the catapult, which uses tension to fire the projectile, or a trebuchet, which used a counterweight? This STEM lesson uses new technology — 3D printing — to understand historic technology. "Building a Catapult" is an online guide from Stratasys that provides leading questions, tips and lessons to help your students design and build their own catapults and use those as a starting-off point to explore related topics, such as tension, flexure and torsion.

The models featured in this lesson are made completely from printed material. There are no springs, rubber bands or bolts used in the designs. A collection of STL files provides templates for experimenting with spring arm designs that have different thicknesses and that can be made with different materials.

A three-minute video introduces the topic and shares some of the different designs students may choose to experiment with in this lesson.

Idea, Design, Build, Test, Repeat

Whether you choose one of the projects profiled here or guide your students to take on more ambitious projects such as the design and building of prosthetics, robotics parts, automotive components, movable tools, archaeological specimens or something else, the use of 3D printing in your classroom can help your learners develop hardcore STEM skills and practice their soft skills such as persistence, communication and teamwork. Those are lessons that will last each one of them a lifetime.

About Stratasys

Stratasys® manufactures 3D printing equipment and materials that create physical objects directly from digital data. Its systems range from affordable desktop 3D printers to large, advanced 3D production systems. Its specially engineered 3D printing materials include hundreds of photopolymers and thermoplastics.

Manufacturers use Stratasys 3D Printers to create models and prototypes for new product design and testing, and for low-volume finished goods. Educators use the technology to elevate research and learning in science, engineering, design and art. Hobbyists and entrepreneurs use Stratasys 3D Printing to expand manufacturing into the home — creating novelties, customized devices and inventions.

To learn more, visit www.stratasys.com

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