PROPELLING LEARNING WITH FDM

Class Exposes Students to Real World Engineering Processes

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— Brad Christensen, Professor, Technology and Industrial Arts, Berea College

This is a finished propeller made with a Dimension 3D printer.

"Backwards instructional design" is what Brad Christensen calls his method of teaching his Technology I class. A professor in the Technology and Industrial Arts Department of Berea College in Berea, Ky., Christensen gives his students the final project on the first day of class. He then presents his instruction based on what is needed. A recent project involved making radio-controlled boats using Fused Deposition Modeling (FDM) technology from Stratasys.

"Most students in this class have never designed anything," he said. "Many have never measured or cut on a line before. This is their first exposure to the engineering process, their first try at making something work." Berea College is a private liberal arts college providing education primarily to students from Appalachia who show great promise but have limited economic resources.

Christensen may jokingly call his instructional design "backwards," but his understanding of technology is definitely forward-thinking. He has used a Dimension BST 3D Printer for four years in this class and in others. An engineering drafting class printed and assembled tabletop steam engines with spinning fly wheels and moveable pistons. In another class, students made model rockets with printed nose cones. Both projects were great successes, according to Christensen. "Students encounter 3D printers in industry and throughout their education," he said. "I want to expose them to rapid prototyping while they are at Berea."

His goal is to teach his students the entire engineering design process, including the identification of a problem, the brainstorming process, the quantitative component and optimization. For the boat propeller project, each team calculated the diameter of the propeller, drawing the part through computer-aided design and sending the concept to the 3D printer.

"The technology enabled students to draw the propeller on the screen in 20 minutes," he said. "It is not as difficult as it may look. Students could shape the propeller in different ways and see how it looked on the screen. They could make sure it was facing the right direction, and all of the dimensions were correct before they printed it out."
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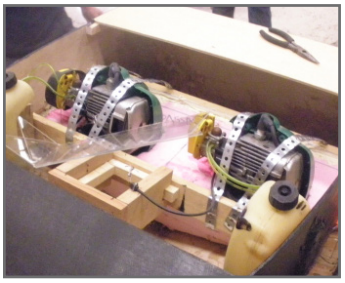
The Dimension 3D printer uses FDM technology in which a plastic filament is fed into an extrusion head and heated to a semi-liquid state. Following a toolpath defined by a CAD file, the head deposits the material accurately in layers as fine as 0.005-inch thick. The model is built from the bottom up, one layer at a time.

Because the printer was purchased with one-time grant money, finding a printer with a low cost of operation was key, according to Christensen. The Dimension printer churned out these parts for about $7 a cubic inch. “Once students had a propeller in their hands, they could test it and go back to make changes if they wanted,” said Christensen. “It never failed that someone would draw a prop counter-clockwise instead of clockwise. That is an easy mistake to make. Because of the low cost of materials, we could make the change and reprint the part immediately. A model boat propeller from a hobby shop could cost $35 or more. The part from a Dimension printer was about $10 or less. The 3D printer was really the only option we had.”



Students modeled propellers for radio-controlled boats made in an introduction to engineering class.

Originally, the idea was to use the printed propellers to make a mold through a traditional plaster of Paris casting process, as Christensen did not think the propellers would be strong enough coming off a printer. The blades were only 1/8 of an inch thick by 1 inch wide with an overall diameter of 2.5 to 3 inches. “We thought a blade from a printer would break right off,” he said, “but it didn’t.” In fact, students took their radio-controlled boats for a test run in an ice-filled pond near the college. “We didn’t anticipate ice on the pond,” said Christensen. “It was a real test for the propellers. They got a little chewed up, but none of them failed.”

Propellers were put to a real test on a pond near the college.

“One team created a surface-piercing propeller that was five inches in diameter with six curved blades,” Christensen said. “It was a nasty looking propeller; almost scary. It worked well, however, providing reasonable thrust and entertaining the crowd with a great “rooster-tail.” There was no other reasonable way to make this prop than with the Dimension 3D printer.”

Without the printer, students would have fabricated a metal hub and welded blades onto it. “We never would have gotten the angles or the curvature correct,” said Christensen. “We could have carved the propellers out of Styrofoam and cast them, but we would not have gotten that exactly right either. It would have been by guess and by golly. Forming something out of wax and casting it would not have given us nearly the precision, accuracy or fun. Carving would have taken a lot of time to get it right, and carving is not part of the course content.” Another benefit of the 3D printer was that the propellers could be made overnight. The process did not consume any class time. “If we had to cast them or form them in some other way, it could have taken at least five hours of class time,” said Christensen. Casting would have been a less expensive route for producing the propellers, but that didn’t bother Christensen. “The printer enabled us to do so many things that would have been impossible any other way,” he said. “It just made sense.”

Because this course is an introductory course, many students are just beginning to explore engineering as a major. FDM technology, however, may have made a difference for some. “Of the 44 students in my class, more than 20 of them said this project influenced their decision to pursue a major involving engineering technology,” said Christensen.

“When students print a part, they are instantly confronted with their lack of attention to detail early in the process,” said Christensen. “They learn that 1/16 of an inch really matters. The 3D printer adds a new level to what we teach. It is a new avenue for learning. It’s not just the professor saying something. The students are actually seeing if something works or doesn’t. Quality becomes more intrinsic. The printer has added a lot to my class.”

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