EDUCAUSE LEARNING INITIATIVE

7 THINGS YOU SHOULD KNOW ABOUT...™

3D PRINTING

Scenario

David is a research fellow at the anthropology museum at a university in British Columbia. His mentor, Dr. Blaine, has suggested David familiarize himself with the scanners and 3D printers in the learning center. The printers create 3D items using specifications sent from modeling software. With the specs, they can build an object a layer at a time from superheated plastic or polycarbonate, up to a cubic foot in size. David can generate a 3D scan of many smaller objects in the museum collection, and anyone with a 3D printer can use those specs to create a duplicate at their own location.

Over the past month, the museum has received several requests for artifact copies or scans of rare objects that the requestors could print at their own sites. Currently, he is scanning several examples of otter teeth dated over the past half century for Dr. Meriwether, a professor of oceanography at a university in California who is researching the change in mussel populations along the Pacific coast. She will use a 3D printer at the Oceanography Center to make copies of the otter teeth from the specs. Because otters can chew through the shell of small mussels, Meriwether and her graduate seminar will analyze the teeth to try to discover how mussel consumption may have changed over the past 50 years.

David is also working on a local request from Dr. Franklyn, who wants copies of two sets of pre-Columbian rabbit bones. David is delivering four sets of white plastic "rabbit bones," which he created by scanning the originals from two pygmy rabbits. Franklyn asks the students if all of the bones are from a single rabbit. The students begin sorting and grouping the small bones and fragments, working to identify them and any distinguishing characteristics. The students at table four are the first to insist that some of the bones are from a male and some from a female rabbit. David quietly closes the door as students at all four tables try to determine the respective ages of the rabbits.

He hurries back to the museum. Sitting in the printer is a completed 3D model of a partial human foot. The specifications for the foot came from bones scanned in Spain, identified as Neanderthal. A faculty member from the medical school will arrive soon to collect the model so he can say whether he agrees with a colleague who thinks the malformed ankle bones are due to a condition other than arthritis.

1 What is it?

For most of us, the notion of printing calls to mind the process of putting ink on paper. By contrast, **3D printing is the process of creating an object using a machine that puts down material layer by layer in three dimensions until the desired object is formed.** A 3D printer extrudes melted plastic filament or other material, building objects based on specifications that come from modeling software or from a scan of an existing object. The process is widely used in industry to create prototypes more quickly than traditional methods, and in some situations it has begun to replace conventional manufacturing processes, such as injection molding. The technology has caught the attention of educators as prices for 3D scanners and extrusion printers have dropped, making it feasible to use them for design, production, or preservation in a wide range of educational venues.

2 How does it work?

To create something with a 3D printer, **a user begins either by scanning an existing object with a 3D scanner to obtain the needed specifications or by generating the specs in a 3D modeling application.** The specifications are then sent to an extrusion printer, where plastic filament or other material is used to create the three-dimensional model one layer at a time. As the material is extruded from the nozzle of the printer, the software controlling the machine moves either the platform or the nozzle itself such that the material is deposited in a succession of layers to create the object. Often, the completed object is a single color, but printers are now available with two nozzles for dual-color prints. Printing can take a few minutes for a small object the size of a keychain or several hours for larger, more complicated objects.

3 Who's doing it?

Several institutions and organizations are investigating ways 3D printing can enrich their learning environments. In fall 2012, faculty at the University of Mary Washington will offer a freshman seminar course in which students will use 3D printers to build objects they scan or design themselves, providing a tactile understanding of various objects and the ability to easily experiment with modifications to those objects. Future plans include building a "Makerspace," a laboratory where students can collaborate and experiment with a broad range of 3D hardware and software. Digimorph.org, part of the NSF Digital Libraries Initiative, provides 2D and 3D models of the structure of animals and other organisms—vertebrates and invertebrates, living and extinct. Curators create many of their anthropological models by scanning fossils and printing replicas on 3D printers. Some universities use 3D printing to facilitate hands-on creativity. At Full Sail University, for example, students have used the technology to create plastic models of the 3D comic characters

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they build in 3D software. At Virginia Tech's College of Engineering, students can print projects on a "vending machine" that is four 3D printers enclosed in a glass case—students insert an SD card with a CAD design file, the design prints, and the finished 3D object is dispensed into a bin for retrieval.

4 Why is it significant?

3D printing puts significant capability into the hands of students, allowing them to answer complex and open-ended questions and demonstrate those answers in three dimensions. A student in culinary arts might manufacture decorative molds for ices, gelatin, or butter, while a mechanical engineering student might produce several models of a prototype part, refining the design until the piece fits perfectly into a larger device. Faculty and students can create 3D models of concepts in physics, engineering, and mathematics that are usually described only through formulas, facilitating a new means of understanding those concepts. 3D printing enables a culture of innovation by allowing users to quickly generate physical models of objects and ideas. Students in certain fields, such as industrial design, architecture, engineering, or medical technology, might use 3D printing regularly in their chosen careers. For students in any discipline, this technology opens a new avenue for active learning by enabling the rapid move from imagination to instantiation of a physical model.

5 What are the downsides?

To move from an imagined item to a completed 3D model using this technology might require working knowledge of modeling software, which could present an obstacle for some users. **The technology might also raise new questions about intellectual property.** The ability to duplicate and distribute electronic specifications for commercial products could create a market for pirated specs, not unlike the changes seen in the music market that resulted from the move from CDs to digital music. Just as digital content creates broad opportunities for copyright violations, 3D printing could open the door to patent infringement.

6 Where is it going?

Newer devices print at higher resolutions and have become progressively cheaper. At the same time, 3D media has moved beyond plastic into polycarbonate, rubber, resins, and even chocolate. As the technology improves, specifications for commercial products might be sold via the web to consumers who print them. Local 3D print shops might one day let customers e-mail their specifications and pick up the finished product the same afternoon. Much of the work already done in 3D printing is focused on creating robotics, and this field will no doubt profit enormously from 3D printing because inventors can refine parts over several iterations in inexpensive media. In the health field, 3D printing could create an exact model of a scanned tumor or an injured joint so doctors could more easily consider how to address such problems before surgery. In dentistry, a replacement tooth of high-impact resin might be made to order on site. Finally, because a 3D printer enables the immediate creation of specified items, it could have a place on space stations and other exploratory venues.

7 What are the implications for teaching and learning?

For basic classroom use, 3D printers offer promise anywhere people might use models or 3D visualization in their instruction: architecture, cinematic arts, history, geology, geometry, building and construction management, or other disciplines. Museums could employ scanners and software to send specs to colleges and universities that request artifact models. Moreover, although anyone might learn more from holding an unusual object than from peering at it through glass or examining a photo, students who have a significant visual impairment could—with 3D printing technology—hold and touch examples of objects otherwise represented only as pictures. The 3D printer opens new creative opportunities in fields that benefit from use of a physical model, such as industrial sciences, aerodynamics, engineering, or design, offering shorter cycles between prototypes as students physically manifest what they imagine. It also enables a wide variety of self-directed learning across the educational spectrum, making it possible for students in any discipline to solve real-world problems by constructing solutions.

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