Defusing bombs by color

May 22 2015, by Hannah Hailan Pang

Explosive ordnance technicians work with 3-D printed models to learn how different unexploded shells and land mines work. Credit: Golden West Humanitarian Foundation.

This March, Cambodia held its first national-level science festival at the Royal University of Phnom Penh, attracting over 10,000 young students to the science booths over the course of three days. At one table, Allen

Tan, the country director for Cambodia of the Golden West Humanitarian Foundation, held 3-D printed land mine models, decked in bright red, white, and yellow colors to demonstrate the safe and dangerous parts. Nearby, J. Kim Vandiver, mechanical engineering professor and director of the MIT Edgerton Center, helped his wife, Kathy Vandiver, community outreach education and engagement director at the Center for Environmental Health Sciences, run a large booth of "Atoms and Molecules" kits. Tan and Vandiver had a lot to be excited about: This science festival was an unpredicted benefit of an association that had begun with a brainstorming session in Phnom Penh on ways to improve the training of people who work with unexploded mines and other remnants of conflict in Cambodia and around the world.

The demining process, called explosive ordnance disposal (EOD), is dangerous but necessary work. It is estimated that there are still 4 to 6 million unexploded pieces of ordnance in Cambodia, which was heavily bombed during the Vietnam War. The repercussions have been severe: Between 1979 and 2013, there were over 40,000 reported injuries and nearly 20,000 fatalities due to unexploded land mines. The U.S. State Department helps countries such as Cambodia train and deploy EOD teams, but, inherently, the training and deployment are difficult. Trying to alleviate this problem, Tan and Vandiver came up with the idea to use 3-D-printed training models.

There are several advantages of 3-D-printed devices over 40-year-old real devices that have been rendered inert. First, there is danger in disarming the real devices, as well as some difficulty in obtaining them in sufficient quantities to use in training. Training with 3-D-printed versions is also more effective because students can assemble and disassemble such objects and clearly understand how the various brightly colored components interact. An additional major advantage is the ability to bring these models on commercial airplanes, whereas real parts of bombs are never allowed.

Vandiver made the organization's first 3-D printed land mine example from an existing computer-aided design (CAD) model of a Russian anti-personnel landmine. The U.S. State Department was so impressed with the prototype and proposal from the Golden West Humanitarian Foundation that they soon provided funding to design and create a training set consisting of 10 explosive devices commonly encountered by workers in Cambodia. The closest 3-D printers, however, were at the Singapore University of Technology and Design (SUTD).

Fortuitously, Vandiver was participating at the time in a collaboration between MIT and SUTD. He realized the project would be a great opportunity for SUTD and MIT students to improve their CAD skills and learn to perfect 3-D printing. Ten months ago, the Golden West Foundation completed its first complete set of 3-D-printed models, ready for use in training.

Vandiver's contribution to the final training set was introducing modern pedagogical approaches to the training of EOD staff, who were not fluent in English and had little education in engineering and science. True to his Edgerton Center roots, he helped Tan and others adopt the use of active learning in EOD training. Instead of the traditional, default lecture style, students were expected to disassemble and work with the 3-D printed models to learn by discovery how different bombs and mines worked. In these 3-D models, a simple mapping of colors showed the crucial pieces: yellow is explosive material, red is the firing pin, and blue is inert structural material.

"It was important that they take them apart and put them together," commented Vandiver, "because then they would really remember it."

Allen Tan (left) of the Golden West Humanitarian Foundation and MIT Professor J. Kim Vandiver hold 3-D-printed advanced ordnance training materials. Credit: Camilla Brinkman

Vandiver, who collaborated closely with Institute Professor Harold "Doc" Edgerton in the 1970s, founded the Edgerton Center in 1992 as a legacy to Edgerton's belief in the power of "learning by doing." He is a professor of mechanical and ocean engineering and also served as a lieutenant in the U.S. Army Corps of Engineers in Vietnam in 1970-1971. Vandiver was drawn to the Golden West Foundation EOD project because of his interest in engineering technology for developing countries. While working at SUTD in Singapore in 2012, Vandiver visited one of his graduate students working on an EOD project in Cambodia. It was on this visit that he met with Tan and engaged with

him in a conversation about how to involve SUTD and MIT students in meaningful, real projects. This brainstorming session produced the idea to engage student interns in the computer-aided design of training objects.

The completed set of 10 3-D models of mortar, artillery, and bomb fuses have been well received in the humanitarian EOD community. Golden West is receiving orders from around the world for models made on 3-D printers set up by Golden West in Phnom Penh. SUTD and MIT student interns travel to Cambodia to help with design and production in coordination with John Wright, the project engineer at Golden West's headquarters in Cambodia. The training set costs approximately $7,000 and may be shipped as ordinary luggage on commercial flights. The United Nations has also ordered sets for EOD training in sub-Saharan Africa. Because of the high demand for these effective, portable training sets, the U.S. Department of State has funded an extension of the project to produce training sets for cluster bombs and land mines.

A 3-D-printed device (left) next to an actual explosive device. Credit: Golden West Humanitarian Foundation.

There have also been unexpected side effects, such as Cambodia's first national science festival. Modeled on the Cambridge Science Festival and the U.S. Science and Engineering Festival in Washington, this fair introduced middle school-aged kids to many facets of engineering. Tan hopes the festival will help Cambodian students see that science and engineering education can make it possible for them to make important contributions to their home and country.

Today, the Golden West Humanitarian Foundation continues to make EOD training sets, and is looking at more ways to improve EOD education using technology. Vandiver, on top of other MIT and Edgerton

Center-related work, stays in contact and continues to be involved in projects that make an impact in developing countries.

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Provided by Massachusetts Institute of Technology