Inspired by a music box, Stanford bioengineer creates $5 chemistry set (w/ video)

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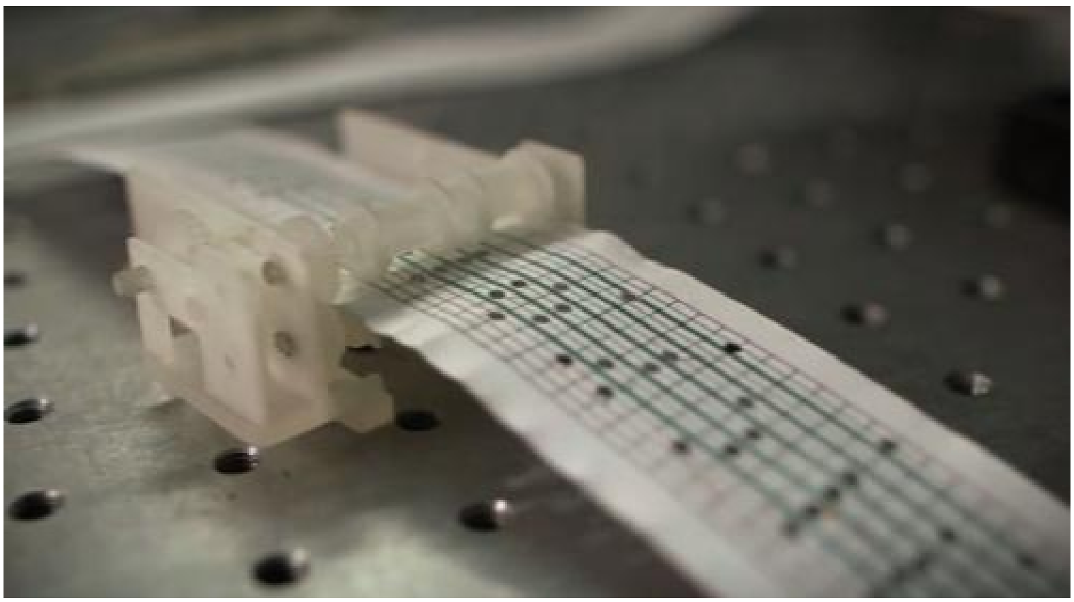

(Phys.org) —Manu Prakash won a contest to develop the 21st-century chemistry set. His version, based on a toy music box, is small, robust, programmable and costs $5. It can inspire young scientists and also address developing-world problems such as water quality and health.

When Manu Prakash was young he had a thing about flames. He's not encouraging all kids to follow his fiery lead – he did burn one hand pretty badly – but he thinks kids should explore more when it comes to learning about science. That's the idea behind his programmable, toy-like device that won a competition to "reimagine the chemistry set for the 21st century."

The Science Play and Research Kit Competition (SPARK) was jointly sponsored by the Gordon and Betty Moore Foundation and the Society for Science & the Public. Prakash, an assistant professor of bioengineering at Stanford, will receive a $50,000 award toward further developing his prototype into a low-cost product, which he thinks can have widespread use both in the developing world and as a creative toy for kids.

"In one part of our lab we've been focusing on frugal science and democratizing scientific tools to get them out to people around the world who will use them," Prakash said. "I'd started thinking about this connection between science education and global health. The things that you make for kids to explore science are also exactly the kind of things that you need in the field because they need to be robust and they need to be highly versatile."

From music to chemistry

The idea for this device started not with flames or even chemistry, but with a music box that Prakash's wife brought home from a gift exchange at work one Christmas. It used a tiny hand crank to pull a paper ribbon through a set of pins on concentric disks. When one of the pins hit a hole in the paper, the disk and pin rotated, causing another pin to pluck a metal strip to make a sound. One of the tapes in his lab has holes set up to play the song Happy Birthday.

In his toy-filled office, Prakash played with this music box and got the idea that the rotating pins could also be used to pump fluids through tiny channels or to control valves and droplet generators in a programmable fashion. "Punch-card paper tapes like this have been used to program computers and fabric looms, so why not chemistry?" he said.

After talking with graduate student George Korir, Prakash started working with him on a way of pairing the hand-cranked toy with a small silicon chip containing tiny channels for manipulating fluids. These chips, called microfluidics chips, are increasingly common in research labs, but require expensive equipment and electricity to run. The expense and equipment required is a bottleneck in adapting the technology for science education and global health, Prakash said.

What Prakash and Korir invented is inexpensive, hand-powered, self-contained and programmable. "It's important to bring open-ended tools for discovery to a broad spectrum of users without dumbing down the tools," Prakash said.

Programmable and portable

Like the music box, the prototype includes a hand-cranked wheel and paper tape with periodic holes punched by the user. When a pin encounters a hole in the tape it flips and activates a pump that releases a single drop from a channel. In the simplest design, 15 independent pumps, valves and droplet generators can all be controlled simultaneously.

Prakash and Korir didn't set out to make a kit for kids. Their idea was that a portable, programmable chemistry kit could be used around the world to test water quality, provide affordable medical diagnostic tests, assess soil chemistry for agriculture or serve as a snake bite venom test kit. It could even be used in modern labs to carry out experiments on a very small scale.

Although the original prototype was made from music box parts, Prakash and Korir have many versions in which the crank and pins (they call this part the actuator) were printed on a 3-D printer. They say the actuator, the paper tape and the silicon chip can all be modified to meet different uses, and can be made from inexpensive, durable materials costing less than $5.

For example, if someone wants to test water quality he might create a chip with channels that combine the water with chemicals that detect contaminants, pH, or the presence of microorganisms. Another kit might force droplets through a twisting pattern to mix chemicals within the drops. Holes in the paper tape can be punched to release drops from different channels in a set sequence or to open and close valves that combine chemicals or keep them separate. Prakash said each chip can be rinsed out and reused with a new batch of chemicals.

A kit for kids might come with several chips containing different types of channels and with a few pre-punched tapes. The chemicals never leave the chip and thus are never exposed. Prakash said he envisions youngsters eventually punching their own holes to program new experiments.

Sparking inspiration

This kind of open-ended creativity is what the competition sponsors intended. They cite a concern about classic chemistry sets that inspired a generation of scientists being reduced to rote toys that don't spark the same excitement and wonder.

Prakash said inspiring kids to be interested in science is directly tied to solving developing-world problems. "Science education in developing countries doesn't exist and that's probably one of the reasons why we don't have enough doctors and scientists," he said. "It's not just about resources. It's about people not realizing that this is something they want to invest their life in."

Korir was born and raised in Kenya. "If we were curious and wanted to explore, for example to find out what was out there in the muddy water, or to find out why some water tastes different than other water, we had no way to do that," he said. "Having something that you could use to ask these questions would open up the space to kids but also to other people all over the world. It really democratizes chemistry."

Prakash is affiliated with both Stanford Bio-X, which encourages interdisciplinary research between biological sciences and engineering, and the Stanford Woods Institute for the Environment. This project and other "frugal science" from his lab marry those two affiliations by creating low-cost engineering tools that can be used for health care or environmental applications. He recently announced development of a 50-cent microscope called Foldscope that can be folded like origami out of paper.

With the prize money, Prakash and Korir hope to continue working toward a product that other groups, including researchers and citizen scientists, can then modify and program for a wide range of uses, both educational and scientific. "When you go out in the field you feel like, 'If I'm not making a product, then I'm not getting out to people in even the smallest possible way,'" Prakash said.

Provided by Stanford University