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MAGAZINE

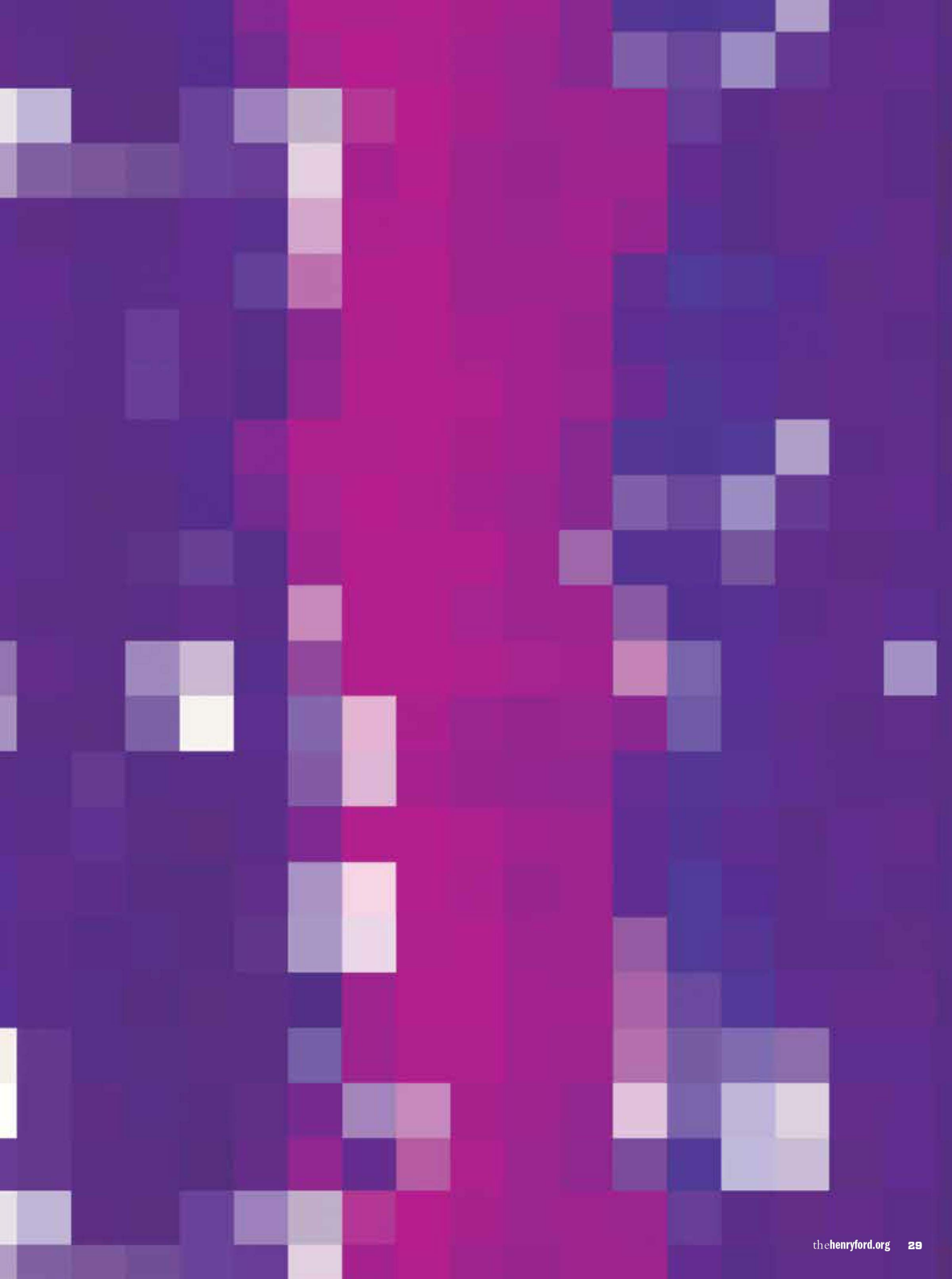MARCH-MAY 2017

THE MATH ISSUE

PAGE 48

What if a museum of history added a mathematical exhibit to the experience equation?

+

WRITING CODE THAT
CREATES MUSIC
HOW MATH SLIPS INTO
THE MAINSTREAM
MODERN-DAY MAKEOVER
OF A MATH BOOK

MATH, MUSIC+ *The Matrix*

LIVE CODERS ARE IN TUNE WITH THE MATHEMATICAL MAKEUP OF SONG

By Sarah Jones

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ou're in a nightclub. The cavernous space is packed with bodies moving in time to the pulsing, morphing rhythms of electronic music. On a small stage, a shadowy figure hunches over a laptop, typing furiously. Projected computer code scrolls down a wall, *The Matrix*-style, a digital flurry of numbers, words and brackets as synth sounds build and music loops modulate.

This scene could almost be a slick DJ club set, but there are no knobs, decks or instruments in sight. Yet the code is real, and it's all live.

This is the world of live-coding music, an art form in which performers create music by programming computers on the fly, in front of an audience, writing and revising instructions that trigger and manipulate sounds, rhythms and effects in real time.

THE MATH OF MUSIC

When it comes to expressing musical ideas, computer programming might seem an unlikely outlet. But computer science is grounded in math, and music, with all of its messy, imprecise human expression, is largely built on mathematical relationships — harmonic structure, rhythmic patterns, and at its most fundamental, the unique combinations of sine waves that make up the sounds all around you, from birdsong to the roar of a jet engine.

We've been exploring parallels between music and math since the days of Pythagoras. Today, musicians and composers are able to use computers as tools to interpret and express these values and relationships.

"It's clearer through coding that music can be expressed as essentially patterns of numbers that are processed and transformed in various ways — and that we can add expressivity by changing the sounds we are using and shaping the structure of our sounds," said Shelly Knotts, a composer, experimental artist and live coder in the United Kingdom.

As a live coder learns to anticipate these mathematical relationships, his or her ears learn to "hear" the relationships, much like in traditional music theory training. Live coders often write code that they can hear in their heads — which, at a fundamental level, relates to Beethoven's ability to continue composing even after he had completely lost his hearing. ▶

SYNTH, SOFTWARE & SCHOOLING
Live coder Sam Aaron performs at Moogfest 2016 using Sonic Pi, a software program he created to help teach people how to manipulate sound. Aaron is of the mindset that music wraps "math concepts and computer science concepts into something that has direct meaning to kids."

DID YOU KNOW? /
Moogfest — an annual, multiday music, art and technology festival — will take place May 18-21, 2017, in Durham, North Carolina.

BREAKING DOWN BARRIERS

Live-coding languages and styles vary. Most performers create music entirely on the fly, constructing ideas from scratch; a few mix in precoded elements, DJ-style. But they all embrace the movement's overarching philosophy that live coding should be inclusive and accessible to everyone.

For most live coders, exposing their code is part of the performance and serves to demystify their process, forging a connection with the artist through his or her "instrument," explained Sam Aaron, a British researcher, software architect, educator and live coder. "Why is it important for a guitarist to let you see his or her guitar? People have all held guitars; most of us are not very good at it, so when you see someone who's good at it, you can appreciate the virtuosity."
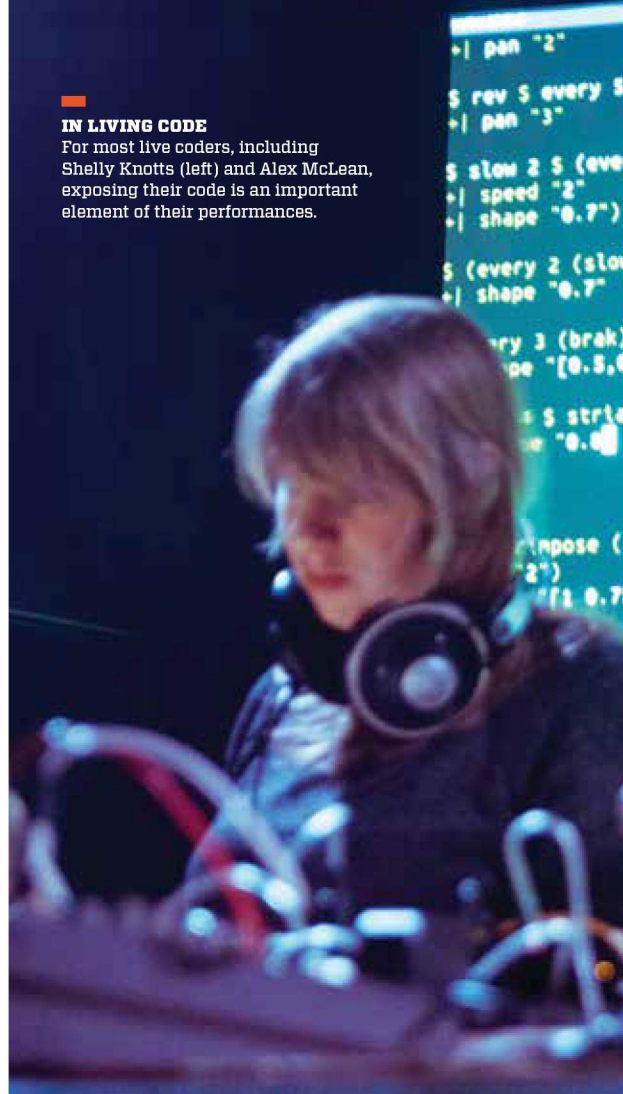
There's no denying that projecting computer code adds a compelling visual element to a performance, but if you're not paying attention to the language itself, you're missing the point. "It's like saying Jimi Hendrix made amazing music, but he had a fabulous wooden necklace," added Aaron.

Live coding challenges preconceived ideas about the programmer's experience by bringing a traditionally solitary process into a participatory realm. "It's like writing, really; you don't generally write in a social way," said British musician and researcher Alex McLean, member of the live-coding band Slub and cofounder of TOPLAP, an organization formed in 2004 to bring live-coding communities together. "I think live coding is not necessarily showing programmers as something different, but rather a different way of interacting with the computer; it's very different, working alone on a piece of text and having people in front of you, listening intently," added McLean, who is also credited with co-inventing the algorave, a rave-like club event based around live coding.

Since its inception about 15 years ago, live-coding culture has been rooted largely in Europe and the U.K., but the movement is slowly building international interest through festivals and other live events, long-distance collaborations over video and social media, and creative partnerships with more mainstream artists. But the most powerful force for longevity is education, and right now, it's Aaron holding the key. ▶
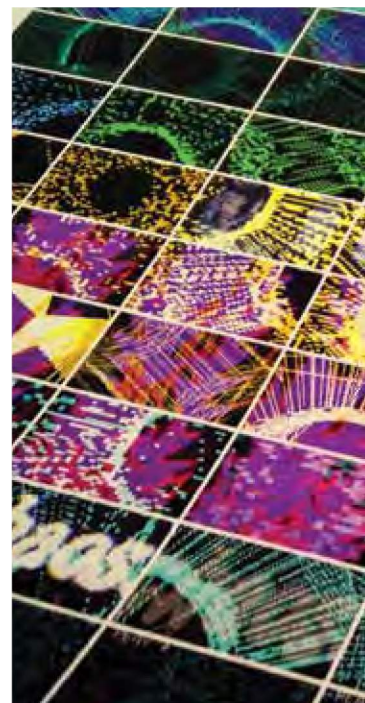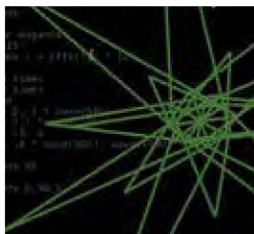
PHOTO COURTESY OF ALEX MCLEAN

PHOTOS BY DAN HETT

DID YOU KNOW? /
During live improvised performances, particularly algoraves, live coder Dan Hett captures a stream of his performance footage as image sequences. He then takes this visual data set and creates a series of print responses to it — each print representing precisely five minutes of a live improvised performance that's unique. "Once a set has finished, the code no longer exists," he said. "I wanted to really try and capture that in some way."
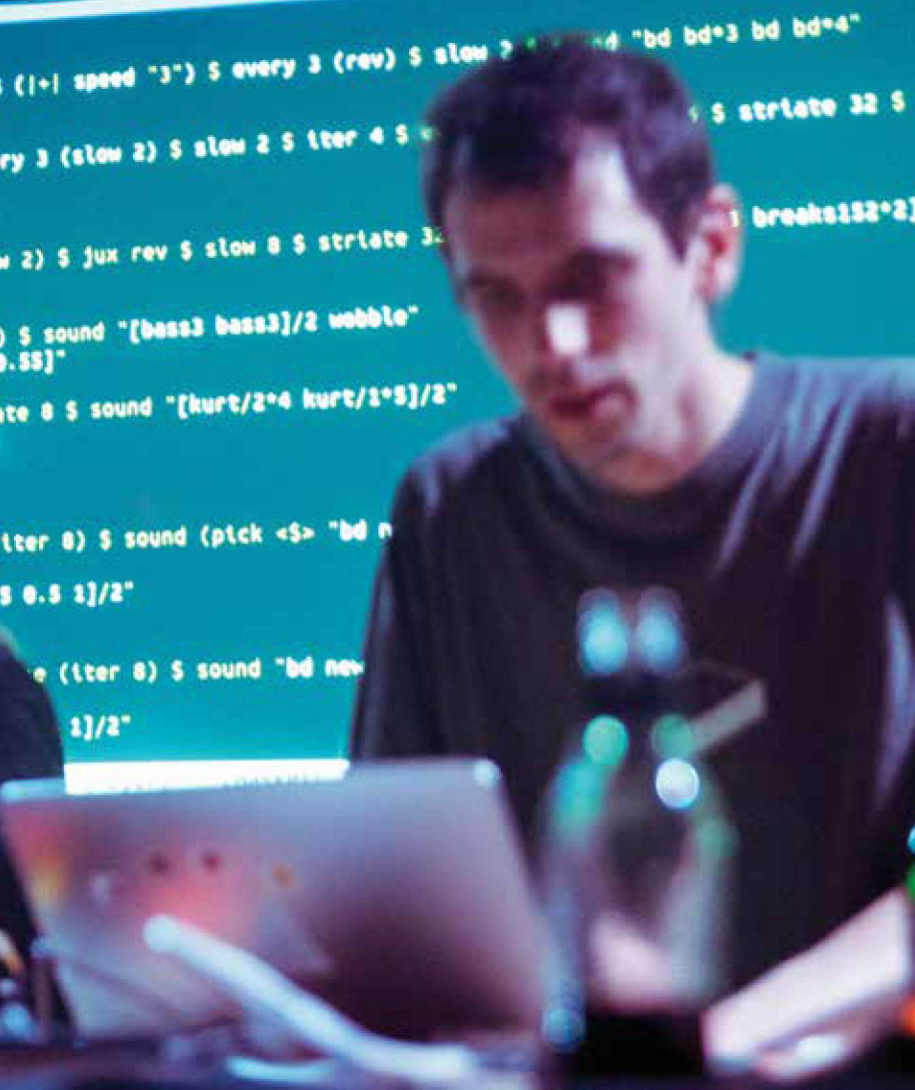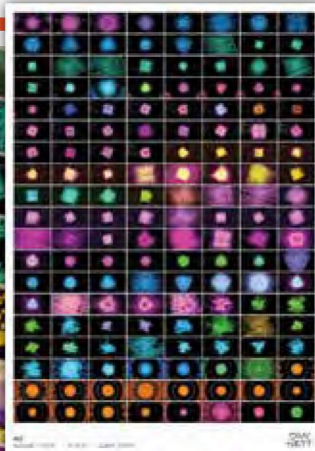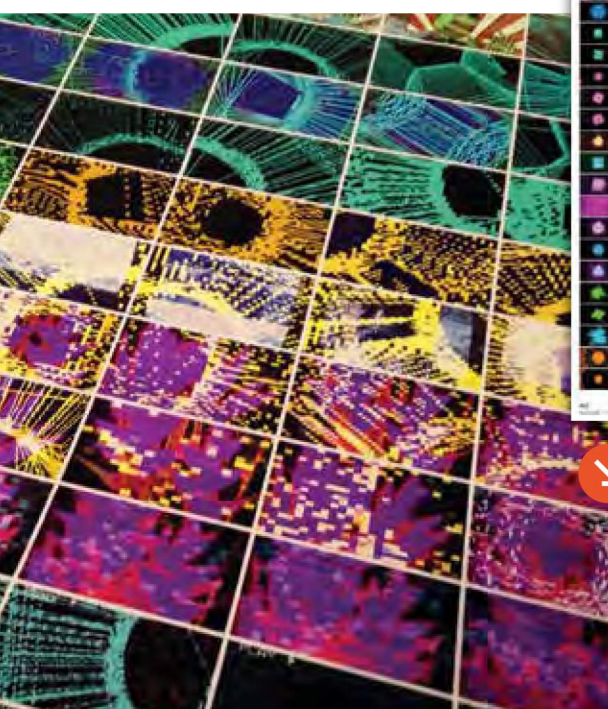
THE MOZART EFFECT

CAN LISTENING TO MUSIC MAKE YOU SMARTER?

Given the parallels between music and math, it's a natural progression to explore the relationship between musical exposure, experience and ability, and enhanced cognitive abilities. And while some research suggests a connection, studies don't take enough variables into consideration, explained Dr. Robert Slevc, assistant professor in the Department of Psychology and the Program in Neuroscience and Cognitive Science and director of the Language and Music Cognition Lab at the University of Maryland.

"For example, imagine I find some relationship between children's musical and mathematical abilities — say, that the more musical kids learn algebra faster than the less musical kids. That might result from some shared processes underlying both music and math," he explained. "But it might actually reflect some third factor — for example, perhaps the kids who are smarter overall do better at both music and math. Or the more motivated kids pay more attention in music and in math class, so end up being better at both."

For this reason, said Slevc, the Mozart effect — the idea that listening to Mozart makes people better at cognitive tasks — has been largely debunked in the science community. "Specifically, there's good reason to think that listening to Mozart does make people do better at some kinds of cognitive tasks, but it doesn't seem to be because Mozart makes you smart.

"Instead, listening to Mozart makes people a bit more calm and happy, and calm and happy people tend to do better at a bunch of different things," he added. "It's a bit like why you might listen to music when you exercise: Music can have pretty strong effects on mood, emotion and motivation, which might then lead you to have a better run. But it'd be misleading to say that there's a, say, Daft Punk effect where listening to Daft Punk makes you faster."

"May not music be described as the mathematics of the sense, mathematics as music of the reason? The musician feels mathematics, the mathematician thinks music: music the dream, mathematics the working life."

— mathematician James Joseph Sylvester, 1864

CRACKING THE CODE

"I want to make sure the leap from code to music is as small as possible and as clear and simple to as many people as possible," said Aaron, a passionate advocate for unearthing the creative potential of programming languages. He spends his days as a researcher at the University of Cambridge in England and his nights performing live coding.

In 2012, Aaron created Sonic Pi, a simple yet powerful open-source programming environment designed to enable users at any level to learn programming by creating music and vice versa. Sonic Pi is used all over the world; it runs on any computer platform including Raspberry Pi, the $40 credit card-sized computer designed for DIY projects and for promoting computer science in schools and developing countries.

"Music really helps by wrapping the math concepts and computer science concepts into something that has direct meaning to kids, which is making

music," Aaron said. "And making the kind of music, hopefully, that they listen to on the radio or stream."

The case for building these new learning paths to computer science is strong. Understanding basic programming improves logical thinking and provides a fundamental understanding of technology we use every day.

"Teaching people what coding is — how precise a language has to be for a computer to understand it — gives people an appreciation of an execution of semantics in a program, affordances of a system, interaction with a system," said Aaron. "People are telling kids to learn how to program because they can become professional programmers. It's like saying we should all do sports in school so we can become professional athletes. You don't teach math because you're training the future mathematicians. There's a level of math that's useful to all of our lives." •

WATCH Sam Aaron live code a DJ set with Sonic Pi
youtube.com/watch?v=KJPdbp1An2s ▶

ONLINE Overtone is an open-source audio environment designed to explore new musical ideas, from synthesis and sampling to instrument building, live-coding and collaborative jamming
overtone.github.io ▶

RESEARCH Smule, a mobile app developer, specializes in developing social music-making applications
smule.com ▶

READ Curator Kristen Gallerneaux's blog post about her experience at Moogfest 2016
thehenryford.org/explore/blog/tag/moog ▶

DID YOU KNOW? /
The Stanford Laptop Orchestra is a unique computer-mediated ensemble of 20 laptops, human performers, controllers and custom multichannel speakers performing boundary-free music together.

DID YOU KNOW? /
The International Conference on New Interfaces for Musical Expression gathers researchers and musicians from all over the world to share their knowledge and late-breaking work on new musical interface design.

PHOTO BY IAN CLONTZ

◄ Sam Aaron is looking to educate the masses about programming by creating music and vice versa.

WIKIMEDIA CREATIVE COMMONS/ EVAN-AMOS

LIVE-CODING TOOLS

If mixing math, music and computer programming is your personal thing, or you're an educator, parent or mentor looking for ways to leverage music to make math more digestible for young minds, there are a number of free educational resources that can help.

PICADEMY: Offers a range of free Raspberry Pi teacher-training tools from the Raspberry Pi Foundation, from two-hour classes to a two-day course. **raspberrypi.org/picademy**

TOPLAP: The official community organization for the live-coding movement, TOPLAP hosts videos, blogs, event listings, software links, discussion forums and other resources for live coders and fans. **toplap.org**

PHOTO BY CLARE HAIGH

SCRATCHJR: A free app for iPads and Android tablets that lets young children (ages 5-7) program their own games. A Spanish version is available. **scratchjr.org**

LIVECODING.TV: Broadcasts live and archived screen-share streams in focus areas ranging from music to video games to website design, searchable by programming language and ability level. **liveedu.tv**

THE SONIC PI LIVE & CODING PROJECT: Are you an educator? This research and development project offers a free toolkit that includes software, lesson plans and a collection of inspirational works. **sonic-pi.net sonicpiliveandcoding.com**
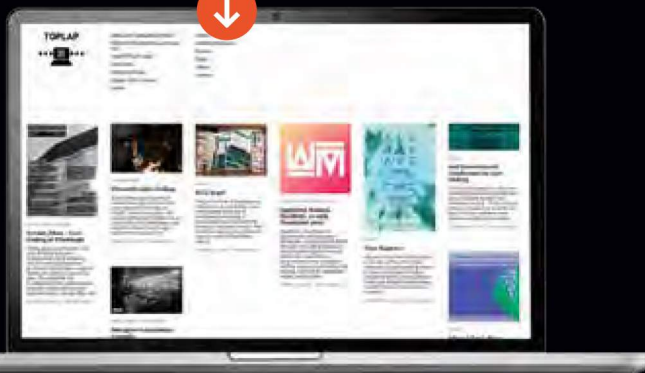
The Raspberry Pi (top) is a credit card-sized computer designed for simple DIY school projects that promote computer science and programming. Students at the Sonic Pi: Live & Coding Summer School (above right) explore their potential and the potential of the Sonic Pi software. ▲