

Women in Electronic Musical Instrument Design

A balance shift

When Paul Lehrman, senior lecturer and director of the Tufts University Music Engineering program, shared with the *IEEE Women in Engineering Magazine* team that female students outnumbered male in both his Electronic Musical Instrument Design (EMID) and Computer Tools for Musicians courses in the Fall 2022 semester, we thought this shift in gender balance might make an interesting story. But when I spoke to a couple of Lehrman's female students and his female teaching assistant (TA), they had not even noticed. And in many ways, that's the best story of all.

Tufts is known for supporting women in science, technology, engineering, and mathematics, so much so that current senior Annika Schaad remembers the statistic announced on her matriculation day that the engineering class that year was 51% female. And although she is of course aware of the issues women face in the industry at large, Tufts has created an environment where the encouragement from professors on down to classmates—across genders—has enabled her to not focus on gender dynamics much. “For my senior project my professor, a woman, asked me if I was comfortable being in a group of all men, and

I hadn't even thought about it,” she recalls. “I said I would be but would prefer there be another woman. It's cool that that is an option we have in terms of numbers, and great to even be given a choice.”

Schaad goes on to say that she did not realize until our conversation that EMID was a predominantly female class when she took it. “I think the impact of the gender balance is something that can be hard to directly identify until you compare it against a similar situation where that gender balance isn't there. I looked around my robotics class the other day and there were five women and 15 guys, and that was honestly kind of weird,” she shares.

Echoes fellow senior and EMID student Anna Quiros, “The community that Tufts builds where the women are as supported as the men are, the differences in gender ratio are not that noticeable, which I really appreciate. What's important is that there be representation across the board.”

Lehrman agrees, noting that he does not see any difference in the class dynamics based on the ratio of gender identification. Music engineering courses attract students with such a wide array of backgrounds and inter-

ests that it is not gender that has any impact on the courses at all. “Every year, the background level of the students gets better in terms of their experience in computer programming, in electronics, in using tools like 3D printers and laser cutters,” he says. “The students come up with their own project ideas, which I have to approve, but I haven't noticed any shift in the project choices based on gender.”

Musicians Teaching Engineering

It has been more than two decades since the Music Engineering program first launched, spurred by a grant from Steinway & Sons to start a course at Tufts in musical instrument engineering. Musical Instrument Design and Manufacture, taught by Prof. Chris Rogers, was the first course offered and it deals with acoustical musical instruments, such as guitars, flutes, trumpets, and bagpipes. In



Paul Lehrman

2001, Rogers asked Lehrman if he would teach an electronic version of the course and EMID was born. Given every year in the fall semester, EMID consists of four main parts: sensors such as switches, light sensors, distance sensors, resistors, strain gauges, and humidity sensors; translating those sensors to serial data via a microprocessor board called an *Arduino*; converting the data to a musical instrument digital interface (MIDI) using a computer language called *Max*; and finally, converting the data to sound via a computer program called *Reason*.

The first half of the semester is primarily lectures and demonstrations while the second half is devoted to students building electronic versions of instruments. Throughout the semester,

a number of guest speakers come in, including those who have developed their own instruments and become virtuosi. Students do not have to be engineers although they do need some music experience to take EMID, and the guest speakers in particular help demonstrate how those with varied backgrounds can apply the skills of the course in the real world.

It's a combination of teaching and learning methods that Lehrman describes as extremely gratifying. "I see the lightbulbs go on all the time as the students learn and teach each other," he says. "Halfway through the semester, I set up the teams so that they have complementary skill sets within each project group, then sit back and let them work together. We end up with electrical engineers teaching musicians about soldering and musicians teaching engineering

students about musical counterpoint, and computer scientists learning about synthesizer parameters from musicians. They teach each other and it's an incredible thing to watch, and it's very effective."

Another course, Computer Tools for Musicians, is more specifically geared toward musicians, teaching the tools available for composing and arranging music on computers. The syllabus starts with the language of MIDI and MIDI sequenc-

ing to compose and arrange music using a digital audio workstation that controls MIDI synthesizers. From there, it goes into sampling, digital audio recording, synthesizer design and music notation programs, specifically the program Sibelius, and rounds out with lessons on composing music for visuals, such as film and video, and

composing for live performance with computers.

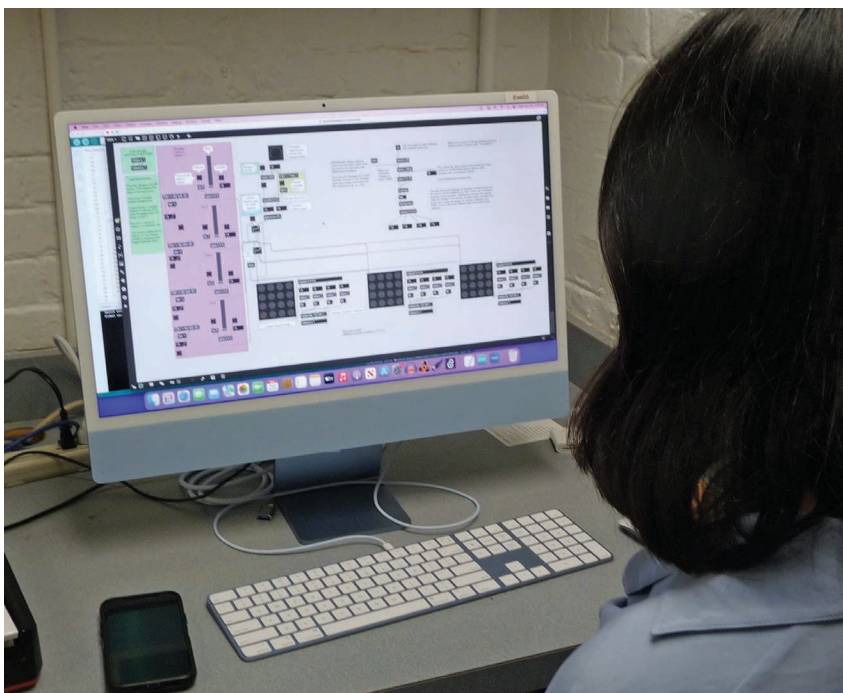
Other classes by Lehrman include the Origins of Electronic Music and Music Recording and Production, which he supervises, while the full Music Engineering program includes many more options taught by varied faculty.

Lehrman says he has given a lot of thought to why the electronic music courses have attracted a high proportion of female students. "I'm not sure if I'm correct here, but I think that, in the past, female engineering students have felt that they need to take very serious courses and can't leave room for creative exploration," he suggests. "I think what has happened now is that that has relaxed, and female and nonbinary students feel they can stretch a little more to courses that interest them, even if those courses may not be for their careers." Although the electronic music courses are fully accredited in the engineering program as electives, this freedom to explore that, Lehrman explains, means that students are signing up even if they do not plan for a career related to music.

That seems to be a part of it, although the reality is that Lehrman has a reputation as an exceptional professor and the courses are known to be a unique yet practical way to enhance engineering studies. Although EMID is offered only once per year to no more than 12 students, Lehrman and the course are singled out each year by graduates when they provide feedback on their favorite or most effective course.

That was the motivation for Rachel Brennan, a mechanical engineering major and architectural studies minor who took EMID in the fall of 2021 and was a TA for the class in the fall of 2022. "I was looking for a mechanical engineering elective, and my advisor suggested I take the class because it is a practical use of what we learn in the junior year of the mech (mechanical) engineering program," she recalls. "It is a program that's special at Tufts and Paul is a great professor so my advisor said that if I could get in, I should do it."

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Quiros works on a Max program for the Marble Sequencer.

Schaad signed up for the course because it combines her major, mechanical engineering, and her passion: live music. A member of the musical events technical staff for the Granoff Music Center, Schaad has been working in live music in some capacity since her sophomore year of high school and knew she planned to continue doing so as a student at Tufts. Although EMID does not teach to the live audio sphere, she finds she can apply a lot of what she learns in the course to the live audio space and to her personal interests. “I listen to a lot of electronic music, and I may have known vaguely how it is assembled, but when I hear something and have absolutely no idea how they did it, what sounds came from the same instrument, it baffles me and that’s a lot of fun,” says Schaad. “I was excited to learn through EMID how different sounds are made and what kinds of considerations go into making different types of electronic music.”

Opportunities Arise

In addition to his work at Tufts, Lehrman is a writer, technologist, consultant, and musician who composes and arranges for live performances and scores for television, film, and multimedia. A pioneer in the field of computer music, he is world renowned for bringing to technical life the *Ballet mécanique*, composed by George Antheil for the original score to the 1920s film of the same name.

The original piece as written by Antheil was meant for a percussion orchestra and 16 player pianos, but it was impossible to synchronize the pianos to have them play together at the same speed back then. Instead, after acquiring the rights to all of Antheil’s works, publisher G. Schirmer contacted Lehrman, who recognized the ability to combine multiple technologies—thanks to MIDI—and convert the original *Ballet mécanique* score into a file that would make it possible to play with the intended 16 player pianos.

The first performance of the revised piece took place in 1999 at the University of Massachusetts Lowell, where Lehrman

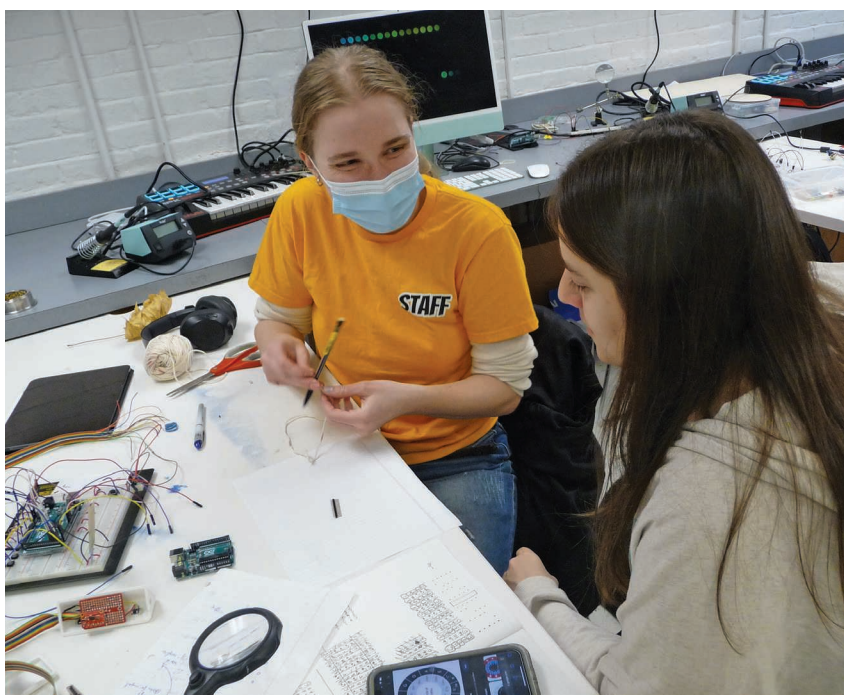
was teaching at the time. Since then, the composition has been played around the world by other orchestras, edited (by Lehrman) into a score for a silent film and featured in an exhibit of Dadaist art at The National Gallery

of Art in Washington, D.C., among other accolades.

The *Ballet mécanique* project continues in the present day. “We’ve come up with a new version of the piece for a solo pianist and eight loudspeakers,



Quiros (left), Schaad, and Brennan in the EMID course.



Schaad (left) and Good work together.

commissioned by a festival in Germany,” shares Lehrman. In partnership with pianist Guy Livingston, he has edited the score into a concerto for piano and electronics that has been performed four times already: in Germany, Montréal, Boston, and Providence, Rhode Island. “We are hoping to perform in Switzerland in 2024,” he adds.

Concurrently, Lehrman has been serving as an expert witness in a patent infringement case involving electronic drums (the plaintiff, whom he has been helping, won the case), and working on a project around the sonification of data streams. For the sonification project, he and other Tufts professors joined an outside corporation to look at ways of turning data, such as weather and stock market data, into music so that people listening to it can discern patterns that they might not be able to distinguish through other senses. “The sense of

hearing and the sense of distinguishing pitches, timing, and timbre can be much more acute in anybody than even the sense of sight,” explains Lehrman. “We can discern patterns that otherwise would not be discernible.”

All of this work presents opportunities of which Lehrman advises students to remain aware. Although it is hard to earn a living in the music business solely as an artist, he says there are tremendous opportunities on the legal side, in manufacturing, design, software, and more. “Regarding the sonification project, students who studied cognitive behavioral science or audio engineering would find opportunities there, while in the patent infringement case, students who studied mechanical engineering and electronic music could be a part of it,” describes Lehrman, adding that an electrical engineering student who graduated two years ago

(and was a TA for EMID) is working with the sonification team.

A background in and understanding of electrical, mechanical, or human factors engineering and design would all be helpful for careers in music. Says Lehrman, “The hardest part is to bridge the gap between the engineers who design the equipment and the musicians who use it, and getting that feedback loop established is tough. Working between designers and users is a very important place to be.”

Student Quiros is targeting a career between the two, combining her skills as both a mechanical engineer and a musician who sings and plays piano and flute. After taking Computer Tools for Musicians and Architectural Acoustics, she realized she wanted to work in acoustics, and building musical instruments in later courses helped her figure out how to create the sounds she wants to make via technology.

Factoring into where she may pursue jobs, however, is the reality that the representation she finds at Tufts is not reflected in the career field yet. “As I’m researching this field more, I’m realizing how heavily cisgender, white-male dominated it is,” she says. “I’ve come across acoustic consulting firms in the northeast where every single person featured on the website was a man, but I’ve also found a really cool women-owned firm that I had no idea about until I started researching. It’s definitely out there, but in the acoustics world it could be a lot more prominent.”

She is grateful for the experience of her classes at Tufts, which offer not only a network of her peers but also the guest speakers who were able to share their own stories entering and growing careers across music and technology. With continued entry of young professionals who were able to study in this dynamic field, it’s only a matter of time until the gender balance shifts in the industry and, like at Tufts, hopefully becomes so normalized that we do not even notice.

—Leslie Zucker

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