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Sound, Electronics, and Music: A Radical and Hopeful  
Experiment in Early Music Education

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Computer Music Journal, Volume 41, Number 3, Fall 2017, pp. 36-49 (Article)

Published by The MIT Press



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# Sound, Electronics, and Music: A Radical and Hopeful Experiment in Early Music Education

**Abstract:** Discussions of pedagogical approaches to computer music are often rooted within the realm of higher education alone. This article describes *Sound, Electronics, and Music*, a large-scale project in which tutelage was provided on various topics related to sound and music technology to around 900 schoolchildren in Scotland in 2014 and 2015. Sixteen schools were involved, including two schools for additional support needs. The project engaged several expert musicians and researchers to deliver the different areas of the course. Topics included collective electroacoustic composition, hardware hacking, field recording, and improvisation. A particular emphasis was placed on providing a form of music education that would engender creative practice that was available to all, regardless of musical ability and background. The findings and outcomes of the project suggest that we should not be restricting to the university level the discussion of how to continue to educate future generations in the practices surrounding computer music. We may be failing to engage an age group that is growing readily familiar with the skills and vocabulary surrounding new technologies.

*Sound, Electronics, and Music* was conceived as a ten-week program. The aim of the project was to harness a latent potential for accessible music education, which could engage pupils regardless of their musical and socioeconomic backgrounds. The project was funded for two consecutive years by Creative Scotland's Youth Music Initiative, which is aimed at providing high-quality musical activities for young people in Scotland. The program was offered to around 900 eight-to-twelve-year-old children in 16 schools in West Lothian, Scotland. This county lies to the west of Edinburgh, Scotland's capital, and its residents have an average gross annual salary that falls below both the Scottish and the British averages (WLC 2016). Sixteen one-hour weekly workshops were given in eight schools each week (two classes per school, eight schools per year). In the first year, the course was offered to Primary 5–7 classes (covering children aged 8 to 12 years), and in the second year it was expanded to include two after-school secondary (each group with pupils of mixed ages, ranging from 11 to 17 or even 18 years old). Two additional support needs (ASN) schools were involved in the project and received all of the same course material as the other schools. Children may attend these schools for a variety of

reasons, including “learning environment, family circumstances, disability or health need, and social and emotional factors” (Scotland 2009).

The curriculum was designed by the author, who was joined each week by a different musical practitioner. Each of these guests was given the freedom to contribute their unique perspective and set of skills. Of the seven additional musicians involved, five have completed doctoral studies in sound and music-related topics, and all are highly active practitioners in fields ranging from game audio design to contemporary classical composition, digital musical instrument design, and improvisation. In addition to the large number of workshops given, the project produced four new software applications designed in Max, which were distributed and remain on laptops within the schools. In the following pages I describe and assess the project through both reflexive ethnography and analysis of the quantitative feedback collected from the class teachers. I come at this research not as a social scientist but as a practitioner-researcher. I approach the research as an active musician and sound artist using a phenomenological approach to investigate how my experience of building and performing with hybrid analog/digital instruments might translate into a pedagogical context where I would give 160 workshops—involving material as unfamiliar to the children as it was to the music teachers—over the course of ten weeks.

Computer Music Journal, 41:3, pp. 36–49, Fall 2017  
doi:10.1162/COMJ.a.00428  
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## Background

There is a growing body of literature describing different ways of progressing within higher education (HE) music pedagogy, as many courses in music technology (MT) and electronic music begin to mature. There has been a rapid increase in the numbers of such programs in the UK over the last 15 years (Born and Devine 2015). Moreover, undergraduate courses offering instruction in the history and practice of computer and electroacoustic music can be found in universities worldwide. Some of the most recent developments in pedagogy in this area include incorporating research-led teaching perspectives (Ferguson 2016), advocating for extracurricular interdisciplinary collaboration (Dobson 2015), and stressing the importance of reflective writing in addition to musical practice (Moore 2014). These augment the numerous accounts of existing courses from HE institutions within Europe and the United States (see, for example, Boehm 2001; Timmermans et al. 2010). Although the topic is beyond the scope of this article, it is important to note that such academic fecundity is not universal. In Latin America, for example, the situation varies between regions. Whereas there have been many positive developments throughout Mexico (Rocha Iturbide 2010), at the same time “computer music and related areas have yet to find a place in the Peruvian academic world” (Ramírez-Gastón 2013, p. 295). As José Ignacio López Ramírez-Gastón’s (2013) research illustrates, this is related to social, technological, and economic factors, rather than to a lack of musical activity.

## Transitioning to Higher Education

Aimed at dispelling previous research that suggested a more pessimistic state of affairs, a recent large-scale study of children in England has reported high levels of informal musical activities taking place outside of school, which include active participation in music-making in addition to listening to and sharing music (Lamont et al. 2003). Further UK-based studies suggest significant disparity between the musical

social lives of pupils enrolled in secondary schools and the musical education that they receive in class, which is usually based around a prioritization of the classical canon (Sloboda 2001; Field 2007; Finney 2007). John Sloboda discusses several cultural trends that have led to this phenomenon. In the case of how music is both produced and consumed via increasingly miniaturized technology, he suggests that “young people can easily and cheaply create their own musical ‘worlds.’ Institutions such as schools no longer comprise a privileged route to access” (Sloboda 2001, p. 250). Ambrose Field argues that rather than attempting to simply duplicate the methods and information that children may have access to outside of school, curricula should be designed to foster creativity and build upon the existing practices of pupils (Field 2007). Yet such an approach demands not only experience and cultural awareness from the teacher but also a willingness to move beyond established paradigms and explore the relationships between musical meaning and social context. Sloboda warns that “no classroom teacher could hope to adequately address issues relating to techno with their students without specific understanding of, and exposure to, that sub-genre and its role for its habitual users. The same point can be made for almost any other sub-genre” (Sloboda 2001, p. 249).

My own observations of teaching undergraduate MT courses in the UK and the United States seem to corroborate these findings. By the time students undertake introductory modules in MT within universities, many of them are already familiar with, if not highly practiced in working with, digital audio workstations (DAWs) and electronic music production techniques. For example, within the undergraduate student cohort of the bachelor of arts degree in Digital Culture offered by the School of Arts, Media, and Engineering at Arizona State University, many first-year students commence my Introduction to Digital Sound course already in possession of such skills—this has been evident in the three years that I have taught this course. At the point of transition into higher education, these students are already producing their own electronic music by working with DAWs such as FL Studio, Reaper, and Ableton Live. Furthermore, a handful

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of these students have also already established performance practices, most commonly working as DJs, and later sharing their mixes via online music streaming Web sites such as Mixcloud. As Daniel Walzer writes, millennials equipped with open-access, affordable software and an Internet connection “delve into an individualized creative process with their preferred tools at arm’s reach” (Walzer 2015, p. 34). Walzer goes on to note that this active participation and interest in electronic music must, of course, be celebrated, and it signals the potential for new forms of collective music making to emerge, particularly through networked and online models. Aside from questions about the types of aesthetic determinism that commercial software can foster, it nevertheless seems important to consider what effects early education in music that acknowledges and builds on the exposure to new media and technology that young people experience might have on their artistic and social development.

The advice put forward in the aforementioned study (Lamont et al. 2003) concerning the musical habits of primary schoolchildren in England certainly translates to secondary and higher education, namely, that it is crucial to “help all those who show an additional interest in music beyond the classroom to develop that, recognizing the value of their own contributions, developing their individual skills through valuable social, cultural, and primarily musical experiences and activities, and providing the confidence to partake in musical activities in whatever personal or social context they choose” (Lamont et al. 2003, p. 240). Although this seems reasonable, studies such as Georgina Born and Kyle Devine’s recent analysis of the demographics of music and MT students in the UK suggests that there are other factors that need to be addressed for better diversity in HE, beyond simply encouraging students who already have an interest or aptitude for MT. They look to feminist theory, among others, to explain why, for example, “gender is the most alarmingly imbalanced” in their results (Born and Devine 2015, p. 146). One such explanation is the “gendering of music classrooms as technological spaces” (Born and Devine 2015, p. 150); another noted issue is the “indirect discrimination” (Born and Devine

2015, p. 150) that may be present within teachers’ interactions with children. In relation to gender diversity specifically, they suggest that large-scale cultural transformation is required to make progress (Born and Devine 2016). By introducing MT at the level of primary schools with careful attention, there is a possibility to build on what Kathy Lane has also speculated, namely, that “many women working within sound art and electroacoustic composition seem to have had a significant positive experience with technology and access to role models from a relatively young age” (Lane 2016, p. 35).

### **Harnessing the Presence of Technology**

Computer science and engineering are being marketed to younger children through low-cost computer hardware such as the Raspberry Pi, and electronic inventor kits including, for example, Ayah Bdeir’s littleBits. With the advent of touch-screen technology within mobile phones and tablets, many children are becoming technically engaged at a very young age: Viral videos circulate on social media sites of one-year-olds using hand gestures observed from parents to interact with touch screens. The littleBits Web site claims that “Our kids spend more than eleven hours with electronic devices every day, but most of them don’t know how they work, or how to make their own. At littleBits, we believe we have to empower kids to be creators and inventors with technology, and not just consumers of it” (<http://littlebits.cc/about>).

Even technology within schools has become ubiquitous, and standardized to some extent. All of the schools that were involved in this project are government-funded, and use the same laptops and interactive whiteboard (IWB) projectors on a daily basis in every classroom for curricular teaching. Computers are not only used by staff, but are often distributed among pupils who would solve educational puzzles or play games designed to develop mathematical skills or teach vocabulary. Schools continue to foster traditional music education, which encompasses theory, aural skills, musical notation literacy, and instrumental training, yet there is clearly a “technocultural” space in which

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to develop a pedagogical approach to MT. Acknowledging this potential curricular opportunity—along with current leanings towards science, technology, engineering, and mathematics (STEM) education (Tinkle 2015)—was key to the development of this project. If technology is already in these spaces and children are becoming increasingly “technoliterate,” then at least some of the initial conditions appear to be in place for incorporating electronic and computer music in these schools.

### **Goals and Objectives**

This section describes the main research objectives of the project, namely, to explore whether the techniques surrounding electronic music can offer music pedagogy an approach that is inclusive, inspiring, and enduring.

### **Inclusive Classrooms**

The course was devised to inspire creative exploration from all pupils, particularly those who had no formal training in playing a musical instrument or reading traditional musical notation. Working with sound as a material—and using materials to make sounds—provides a nonpreferential platform from which to create music. The experience of sound itself—how it is perceived, understood, and talked about—can be considered without necessarily having to engage with the solfège system, concepts of beat division, and so on. Pupils who were receiving music lessons were encouraged, however, to bring their instruments to the classes so that they could use and expand these skills. Working from an experimental perspective, they were introduced to extended techniques, improvisation, and electronic augmentation.

Owing to the emphasis we placed on encouraging inquisitive curiosity during the workshops, there was very little modification needed to include pupils at the ASN schools. These sessions covered the same material but were flexible in their delivery, allowing more time for playful exploration. The use of narrative was also a helpful device here, as it could be

used to thematize the weekly sessions. This model evokes William Gaver’s idea of ludic design, which “means allowing room for people to appropriate technologies. Playing involves pursuing one’s inner narratives in safe situations, through perceptual projection or, ideally, action. If computational devices channel people’s activities and perceptions too closely, then people have to live out somebody else’s story, not their own” (Gaver 2002, p. 5). At the end of some sessions, a performance would emerge, but the workshops were aimed at engaging the pupils’ imaginations throughout. This included allowing pupils to partake in the actual process of building an instrument, discovering new affordances of technologies, or even diverging from the structure provided by workshop leaders to forge new artistic ideas. Allowing for ambiguity of technology (Gaver, Beaver, and Benford 2003) within a musical context, a loudspeaker was simultaneously a converter of voltage into sound, a magnet, an instrument, and a device used to evoke wonder by creating bursts of air on a cheek.

### **Accessibility and Legacy**

The project acknowledged that, although young people’s affinity with technology is often purported to be fact, this is not a universal phenomenon within the UK, and it can be directly related to socioeconomic status (Baguley, Pullen, and Short 2009). Lack of formal musical training or musical literacy among children can often be linked to low family income (Tinkle 2015). As such, the course was designed to work with technology that would always be available in class—school laptops and an IWB projector—as well as to utilize low-cost hardware and found materials. It was important to ensure that what was demonstrated could be developed further both inside and outside the classroom. We attempted to ensure that the majority of instruments or pieces of equipment that were introduced were either available to purchase online at a low cost, or could be found in local hardware stores. This turned out to be crucial to the legacy of the project, because children would often ask where they could acquire materials after

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each session. The most expensive item used was the Korg littleBits Synth Kit, which cost US\$ 159 at the time of writing. Despite the young ages involved, pupils would often inquire about audio programming languages, particularly after they had used software that had been designed specifically for the course. They were directed to open-source software (OSS) such as Pure Data and ChucK. The course itself did not teach coding but demonstrated the creative implications of developing one's own software.

Each school was provided with a box of sound equipment. This contained a variety of items that were showcased during the weekly workshops. The kit included a two-channel sound card; headphones; a Korg littleBits Synth Kit; two Makey Makey invention kits; a Minirig loudspeaker; a Zoom H1 portable sound recorder; a condenser microphone, a dynamic microphone, and stands; various cables; do-it-yourself synthesizer kits, electrical components, batteries, crocodile clips, and speaker cones; and various craft materials, such as tin foil, garden wire, and paint. A manual was left in each class, outlining ideas for lesson plans, as well as providing (1) detailed descriptions of how to connect and operate all hardware, and (2) instructions for running the provided software. In this way, students could continue to work with the equipment between the weekly workshops, and teachers could incorporate it into other curricular activities.

### Supporting Teachers

The teacher is slower than me. He's doing something and he doesn't know how to do it and I just want to shout out what to click on. To me it just seems like common sense.

—Finney 2007

Recent analysis of studies examining the role of technology within education stresses the importance of getting teachers involved in the learning process: "Educators have to be willing to learn about and engage with new technologies so that, as with any discipline area, they are aware of new

developments and how these can be used to inform the learning environment" (Baguley, Pullen, and Short 2009, p. 12). Many of the concepts involved in the course were new, both to the class teachers and to the music teachers that were present. Out of the 16 schools visited, two provided a music teacher—rather than a class teacher—to supervise the class. Out of the 32 classes involved, only one teacher had previously worked with any of the technology that was being used: the Makey Makey invention kit. Another teacher was in the process of developing a new MT course for his secondary school pupils.

Theano Koutsoupidou conducted a study on the use of improvisation within primary school music classrooms in England, and warned that

although a great deal of research has been conducted on children's music making, little emphasis has been given to music teaching and learning, the place of creativity within these processes—improvisation in particular—and the teacher's role in ensuring an environment that will foster creativity in the classroom (Koutsoupidou 2005, p. 364).

The research showed that although teachers saw the value of improvisation within music pedagogy, whether they used it or not was largely dependent on their own musical histories. Those with experience as performers were more inclined to build improvisation into their lesson plans, whether in accordance with established curriculum or of their own accord. Another factor determining if improvisation was embraced in the classroom was whether the teachers themselves had been using improvisation during their own education. This link between what is adopted by teachers and their own educational experience conveys the potential difficulties of leaving a lasting legacy of MT in a preuniversity classroom, particularly when the presence of computers has only become standardized within the recent past.

To ensure that lesson content could be repeated and expanded upon, it was important to involve teachers from the outset. Continuing professional development (CPD) training was provided outside of the scheduled class time. Teachers were offered two CPD sessions, one at the start and one at the end of the course. These were an opportunity for teachers to

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spend more time familiarizing themselves with the software and hardware that would remain in their schools after the workshops had been completed. It also allowed them to discuss ways in which they could continue to foster the various skills developed during the workshops or use the technology in other curricular areas.

### **Course Design**

The broad range of relevant topics involving MT that could be taught at the school level has been documented elsewhere (Brown 2007). Rather than prescribe a particular set of lesson plans, this section expounds upon some of the key themes that were prevalent throughout the conception and execution of this project. The course consisted of ten workshops. Learning was scaffolded by building on skills and vocabularies learned in the previous weeks. In this way, a sense of continuity was established from week to week. Furthermore, at the start of each class pupils were encouraged to present examples of sounds they had heard outside of the class using descriptions or recordings. These sounds were used both as material for listening exercises and as samples for sound organization and manipulation. Pupils were able to directly contribute their own material to the course.

### **Embodied Learning**

The majority of the workshops were designed to facilitate embodied learning where possible. This draws on current research into embodied and enactive cognition, which is rooted within the philosophy of Maurice Merleau-Ponty. Merleau-Ponty (1962) suggests that it is through perception that we engage with the world, but that perception is linked to action itself, being something that we do. Research into skill-acquisition (Dreyfus and Dreyfus 1999) and, more recently, theories of practice-based learning also stresses the importance of the role of the body: “To the extent that learning/knowing is a matter of doing, doing can only be performed through the efforts of the human body”

(Yakhlef 2010, p. 423). This is not to suggest that embodied music education should be conflated with the aural or physical facets of learning styles (Keefe 1987), a controversial pedagogical approach (Pashler et al. 2008) that attempts to categorize the ways in which children learn through a labeling system based around single-sensory modalities, such as visual or verbal stimuli. The enactive position (Varela, Thompson, and Rosch 1991), on the other hand, offers a framework for a hopeful account of music cognition that diverges from the cognitivist stance that views behavior as a function of mental representations of the world and eventually leads to the notion that “the very acquisition of knowledge (in the sense of formal musical training) is both necessary and sufficient for musical understanding” (Matyja and Schiavio 2013, p. 354). Rather, we might understand all musical experience—including listening—as an exploratory activity, based on our ongoing sensorimotor engagement with the world.

### **The Practice of Listening**

In his work on enactive music cognition, Joel Krueger argues that the experience of listening is itself highly interactive, as it “emphasizes the dynamic and agentic nature of music perception, urging that the embodied and situated listener has a central role in shaping both the character and content of musical experience” (Krueger 2011, p. 63). Krueger refers to this attentive and focused auditory experience as “deep listening” (Krueger 2009, p. 104). Of course, this unwitting appropriation of what is more commonly recognized among musical circles as Pauline Oliveros’s philosophy and practice (Oliveros 2005) might be forgiven owing to the overlap between theoretical frameworks. As Oliveros points out, developing a listening practice contributes to creativity and communication skills. Her techniques are “intended to calm the mind and bring awareness to the body and its energy circulation, and to promote the appropriate attitude for extending receptivity to the entire space/time continuum of sound” (Oliveros 2005, p. 1).

Oliveros’s Deep Listening was fostered as a core skill throughout the sessions. Her embodied practice

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was used to help pupils develop an awareness and practice of listening, both in and out of school. They were encouraged to listen to sounds from daily life and nature, as well as to silence. Interestingly, several pupils claimed that they recognized many of the abstract sounds played to them as part of the listening exercises, as well as during my own introductory laptop performances. Computer games and film soundtracks were cited as the source of this familiarity. Listening exercises also required that the pupils develop an awareness of their bodies in space. They were asked to consider their posture, how much they were fidgeting, how still they could sit while listening, and whether particular sounds made them feel (e.g., relaxed or agitated). They were also asked to experiment with both eyes-open and eyes-closed listening.

Working with Sound and Music's Minute of Listening software ([www.soundandmusic.org/projects/minute-listening](http://www.soundandmusic.org/projects/minute-listening)), which is commercially available and has been specifically designed to be used in classrooms, pupils were given time within the workshops in which to focus on their perception of sound. They were asked to describe the sounds they heard, whether natural or synthetic, and were urged to develop vocabularies for describing these sounds. Opposite word pairings, such as loud and quiet, or rough and smooth, were offered as prompts. Pupils quickly identified that many sounds lie on a continuum: For example, a recording of cricket chirps is actually made up of numerous short sounds.

### **Authoring Sounds**

Having developed an understanding of the importance of listening as a practice, pupils were given portable sound recorders. Tasked with collecting different sounds from around the school and grounds, the pupils were given free rein to experiment. They were shown how to excite different objects and materials, and how to work with the combination of headphones and a sound recorder to zoom in on sounds that may not have been deemed interesting without focused listening. This form of embodied learning enabled pupils to move around the school, seek out new sounds, discover inter-

esting action-sound combinations, and take on a truly investigative role. This activity reflects Mark Johnson's claims about the importance of artistic investigation: "the value of an artwork lies in the ways it shows the meaning of experience and imaginatively explores how the world is and might be primarily in a qualitative fashion. Therefore, art can be just as much a form of inquiry as is mathematics or the empirical sciences" (Johnson 2011, p. 149).

The Zoom H1 recorder was used because nearly all recording can be done using a single start/stop button. After the sound collecting was completed, pupils would play the recorded samples back to each other to guess and describe the sounds that had been gathered. They would then discuss how these sounds could be transformed into music. The collected sounds were reviewed, categorized, and named. Working with the IWB projector, pupils were encouraged to use their recorded sounds as compositional material within several specially designed Max patches. One of these was devised to allow a collaborative class composition. Pupils would collectively vote on several variable sound parameters. These included selecting a part of the sample to be played back and looped, changing the pitch, or adding an amplitude envelope over the duration of the looped sound. The pupils would quickly determine which settings would produce the most interesting, or indeed most humorous, results. For example, speeding up the sound of recorded speech, particularly when it was that of the teacher, was often requested.

Recording sounds also allowed us to introduce the technological part of the course with something that was (1) straightforward to work with and (2) could be used in small groups to share skills: One pupil would listen with headphones, one would excite the object, and a third might start the recording. It has been observed in prior work that this type of collaborative investigation not only reduces anxiety in pupils who might be working with technology for the first time, but is also helpful in "facilitating cooperation rather than competition" (Comber, Hargreaves, and Colley 1993, p. 132), particularly in relation to differences in genders. The sample libraries developed by the children grew throughout the sessions as pupils contributed numerous recordings that they had

made outside of the allocated workshop time. Each class collectively defined their own unique aesthetic.

### Making and Hacking

The importance of touch within the performing arts has been discussed extensively (Norman, Waisvisz, and Ryan 1998; Gunther and O'Modhrain 2003; Hayes 2012). Nicolas Collins points out in his book on hardware hacking that computers can be an awkward interface and "sometimes it's nice to reach out and touch a sound" (Collins 2009, p. xiii). By making new instruments and hacking existing devices, pupils were encouraged to use their imagination and discover new affordances of assemblages of objects, electronics, and computers. Junk materials such as paper tubes, water bottles, and elastic bands were turned into acoustic sound makers. Makey Makeys were connected to fruit, conductive tape, pencil graphite, and chains of the pupils' own bodies as a means to trigger sounds by high-fiving, drawing, and even walking on conductive materials. Pupils devised modifications to John Bowers's Victorian Synthesizer (Collins 2009) by sending electrical signals through sharpeners, spectacles, and their classroom furniture (see Figure 1).

Working with classes of between 20 and 30 primary schoolchildren would not suit a model in which each pupil worked individually on a computer. Furthermore, time spent focusing on the IWB projector had to be limited to keep attention. Collins's philosophy seemed even more fitting in this context: "The focus is on sound—making performable instruments, aids to recording, and unusual noisemakers. . . . The aim is to get you making sounds as soon as possible" (Collins 2009, p. xiii). This process of appropriation of materials enabled the pupils to gain authorship of their new instruments, and also become an intrinsic part of their deployment: An eight-year-old pupil might be the only person who understands how to play that pupil's newly fashioned creation. This type of playful embodied learning, involving the manipulation of physical objects, has been shown to enhance learning (Lillard 2013). It is perhaps not

Figure 1. Open experimentation with the Victorian Synthesizer, a musical instrument made from hacked loudspeakers based on electro-mechanical principles.



surprising that the Victorian Synthesizer continues to be used in numerous sound-making workshops because of the excitement that building one's own electronic instrument brings, the simplicity of the basic design, and the immediacy and tangibility of sound production that it enables.

### Improvisation and Collaboration

Improvisation was used within many of the sessions as a way to help the pupils make sense of the wide array of new sounds that were being produced. On the occasions that they were not forthcoming with their music, pupils were encouraged to play works such as John Steven's *Click Piece* (Stevens, Doyle, and Crooke 2007), or create and then perform graphic scores for each other (see Figure 2 for some

Figure 2. A variety of performance tools used by the pupils in this project. From left to right: commercial instruments, graphic scores,

hardware-hacked instruments, a portable Cracklebox synthesizer from STEIM, and software instruments.



Figure 3. GUI of the Max standalone application for augmenting acoustic sound makers, which allows different digital

effects and transpositions to be applied to sounds picked up by up to two microphones.

of the graphic scores and instruments used for improvisation). By being nonprescriptive about the aesthetic outcomes, there emerged a “space for open-ended inquiry, an investigation of cause and sounding effect” (Tinkle 2015, p. 33). The objective was to focus on the process of investigation and play over product, play being an essential component of meaning making and creativity (Winnicott 1971).

Collaborative working was encouraged. This took the form of whole class collaboration, where decisions on how to sculpt a piece, or select samples to use, were made either through voting, group discussion, or turn taking. Small group collaborations also enabled instrumentalists to work with newly appointed live electronic performers who would manipulate sounds made by their classmates through a Maxpatch that could be operated swiftly using a computer keyboard and trackpad (see Figure 3). Acoustic instruments, voice, and found-material sound makers were pitch-shifted, distorted, and delayed. Further collaboration took place around the physical instruments themselves, where often two or more players would perform on a single instrument at once. For example, when playing the Korg littleBits, one performer would select pitches, while another would open and close the filter (see Figure 4). Other forms of collaboration were established by the pupils themselves: Performances would often feature clapping, singing, speech, conducting, or, in the case of the Makey Makey sessions, movement and whole-body contact.

There have been recent pockets of activity exploring the design and potential of collaborative musical systems. Dominic Robson’s work in this area is geared towards “those who do not perceive themselves as musicians” (Robson 2002, p. 50). Other projects have been focused around instruments

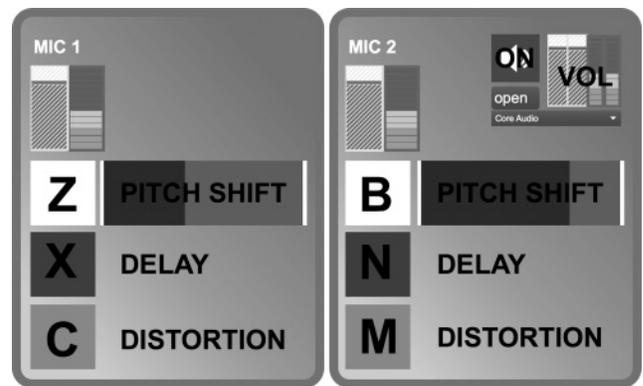


Figure 3

designed to foster collaboration within a particular aesthetic framework, such as manipulating sequenced rhythmic patterns inspired by minimalism (Bengler and Bryan-Kinns 2013). The approach used in Sound, Electronics, and Music acknowledged the broad range of collaborative processes that musicking (Small 1998) might encompass, including designing, building, and inventing instruments, in addition to creating music with them. From this perspective, children become agents in all aspects of their music making, and we need not delineate who is or is not a musician nor prescribe set aesthetic frameworks.

## Evaluation

I loved it because it’s two of my favourite things, tech and music, together.

—Pupil

Figure 4. A collaborative performance using a Korg littleBits Synth Kit.



The delivery of the project was evaluated by postworkshop surveys, which were distributed to all class teachers. The teachers were invited to assess various aspects of the course, such as the professional delivery of the sessions, as well as its impact on the education, the skill acquisition, and the health and well-being of the pupils involved. This was done through a rating system. This was combined with qualitative evaluation, which took the form of written comments from both pupils [P] and teachers [T] on the feedback forms. Additionally, in the final continuing professional development (CPD) sessions, teachers were invited to further expound on their opinions of what had taken place.

### Interdisciplinary Applications

One of the most common themes that appeared within the feedback—from both teachers and pupils—was the value of the interdisciplinary nature of the course:

This has been an excellent series of workshops, delivered in an interesting and interactive way. The pupils have all responded very well to them, exposing them to a wide range of skills and experiences (not limited to music, but including some science etc.) [T]

Teachers also noted that although much of the material was also new to them, they were confident

that many of the skills learned could be applied to other subject areas:

As a teacher I have learned a lot, as it was not an area I knew much about. I now feel I have new knowledge and skills that I can use with future classes and the workshop has demonstrated good links between different areas of the curriculum: music and science. [T]

In addition to identifying potential links with other academic areas, teachers commented on the benefit to the social and communication skills of the pupils:

Some of the sessions delivered were “cross-curricular.” That is, science with electricity, health and well being, and how music can make you feel different emotions, writing and responding, talking and listening, among others. [T]

The course was also successful in the two secondary schools in which it was delivered. Teachers remarked on how it complemented new MT courses that were being introduced:

I have already informed the music departments in all West Lothian secondary schools about the experience and have recommended it. . . . The subject matter was a departure from the normal curriculum delivered in the secondary music curriculum and this complemented the music technology course that we introduced this year at Nationals level [i.e., across Scotland]. [T]

The scope for experimentation and the hands-on approach, they suggested, could support the more individualized computer-based work that had recently been implemented in the curriculum.

### Specific and Transferable Skills

Many teachers remarked on how the workshops seemed to appeal to those children who would not usually engage in group work, as well as those who often struggled in class:

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Over the weeks I have witnessed some pupils being able to demonstrate their abilities in this area who find engaging in some academic work challenging. [T]

Involving a range of different practitioners to deliver the workshops gave the pupils a broad view of existing practices within experimental and computer music. Unsurprisingly, the pupils were most responsive to the more hands-on workshops such as hardware hacking:

The pupils all really enjoyed the workshops and were enthusiastic to learn new and different ways of making music. They also looked forward to the different “special guests” who were invited each week to share the expertise in different areas. A really worthwhile project. [T]

In rating the course, all teachers either agreed or strongly agreed that it had provided their pupils with new transferrable skills, as well as developing their social, emotional, and linguistic capacities. All of the responses to the question about increased employability either were neutral or deemed the question not applicable. Only a single response addressed this topic:

I anticipate pupils being more able to work independently in the expressive arts. [T]

The younger students gave appraisal by making thank-you cards with drawings of their favorite activity. Older pupils gave succinct statements such as:

I think this was really fun and I enjoyed it very much #WouldRecommend. [P]

In addition to the unanimously positive response from the pupils and staff, a further outcome worth noting was that in at least two of the schools, children took the initiative to set up their own electronic sound and music sessions. These took the form of lunchtime clubs where dedicated pupils took ownership of the equipment and would distribute it among other interested parties during the lunch hour. This often resulted in more sound recordings, short performances that were included in the next

official workshops, and further questions about how the equipment could be used.

## Conclusions

This article has described the development, implementation, and evaluation of a large-scale pedagogical framework for computer-based and electronic music undertaken within primary, secondary, and ASN schools in Scotland. This research provides evidence to support the assertion that computer music and music technology have a place within the preuniversity classroom. This is demonstrated, first, by the overwhelmingly positive feedback and evaluations that were received.

Second, experimental musical practice provides an excellent forum for inclusive and embodied learning to take place. By engaging in practices such as listening, sound collecting, recording, hardware hacking, and instrument building, pupils became physically invested in their own learning. As Adam Tinkle suggests, “Rather than relying so exclusively on externally imposed norms and traditions to determine and delimit each step up a child’s ladder to musicianship, what if instead music education was self-education in which students were, like citizen-scientists, set loose to probe and document the sounding world?” (Tinkle 2015, p. 33). This notion was also supported by the ease with which the course could be implemented within the ASN schools.

Third, this project builds upon related research—where teenagers were given the opportunity to design their own instruments, supported by mentors—that suggests that a participatory approach to MT can help to generate interest in the broader fields of science and technology across genders (Thaler and Zorn 2009). The potential interdisciplinary applications of the project were evidenced through the feedback received. Nevertheless, Born and Devine warn that despite technology’s potential for democratization, “existing ideologies of gender and technology, and social class differences, are being reinforced or even amplified through music in HE” (Born and Devine 2015, p. 167). Certainly, we must proceed with great care as we design and

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overhaul MT courses for future generations. One of the teachers involved in Sound, Electronics, and Music described it as:

A fantastic and motivating course. . . ideal for a very boy-heavy group, [T]

which clearly suggests that there is still work to be done.

Although legacy was an important consideration, further developments could improve the efficacy of the course. All the sounds and music produced were documented and stored on each class's laptop, with a view to being hosted on their school's Web site at the end of the course. Owing to security restrictions, this goal has not yet been implemented. It would provide further opportunities for pupils to discuss and comment on their peers' work. Developing cross-platform applications that could be shared by teachers on any laptop would be helpful, as would using open-source software such as Pure Data. However, after follow-up communication with many of the teachers involved, it was found that the biggest problem lay within the newness of the material for the teachers, as predicted by Sloboda (2001). Whereas I had the luxury of working with a team of invited computer music specialists, the lack of familiarity with both the concepts as well as the technology involved made it difficult for the teachers, despite our efforts to provide training, to assimilate the project into their curricula. This suggests that much larger institutional support would need to be at play in order to achieve this vision.

As I have attempted to remain formal in my description and evaluation of the project, this article may have conveyed neither the sheer enthusiasm with which this series of workshops was received, nor how rewarding it was to undertake. I observed that primary schoolchildren have plenty to say about how Clara Rockmore played the theremin; that they will comment astutely on gesture after watching a live electronics performance; and—given the tools, guidance, and vocabulary—that they can create a collaborative structured piece of electroacoustic music in under an hour, using samples they have previously recorded themselves. Two ten-year-old girls took the initiative and started an electronic

music club for a class of 30; a girl at one of the ASN schools assembled the littleBits in a way that bypassed the usual magnetic connections and created a uniquely playable instrument. There are countless other anecdotes that could be recounted. I can only speculate on what might be achieved if—like numerous initiatives such as, for example, Suzanne Thorpe and Bonnie Jones's *Techne* (<http://technesound.org>), or Franziska Schroeder's *Big Ears for Sonic Arts* (<http://www.crackle.org/touch.htm>), that have seized the opportunity to use the practices surrounding electronic music to educate and inspire younger generations—we start to become more generous and thoughtful in terms of whom we include in our communities, and with whom we share our expertise.

## Acknowledgments

This article is a revised and expanded version of a conference paper presented at the 2016 International Computer Music Conference (see Hayes 2016). This work would not be possible without the insight and expertise of Nancy Douglas, who facilitated the entire project through West Lothian Community Arts and astutely identified its potential impact. I would like to thank all of the experts involved for their enthusiasm and imagination: Jessica Aslan, Emma Lloyd, Christos Michalacos, Zack Moir, Yann Sezec, Greg Sinclair, and Shiori Usui. This project was generously supported by Creative Scotland.

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