



# Approaches to Making Live Code Accessible in a Mixed-Vision Music Ensemble

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## ABSTRACT

The Fil Laptop Orchestra, aka FiLORK, is an electronic music ensemble that performs through live coding, i.e. collaboratively editing in a shared document to generate sound. In forming FiLORK, we set out to use music performance and tactile graphics to address a lack of accessible tools and curricula for teaching Blind and Visually Impaired (BVI) people to code. In this poster, researchers and the high school members of FiLORK, who use screen readers and magnification, report their experiences composing and performing two original works that incorporate assistive technologies. We discuss a shift from instruction to open-ended experimentation, and we highlight technical and pedagogical opportunities for making live coding more accessible.

## KEYWORDS

Blindness, Vision Impairment, Accessibility, Electronic Music, Live Coding, Laptop Ensemble, Tidal Cycles

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## 1 INTRODUCTION

Computer Science education is often inaccessible to Blind and Visually Impaired (BVI) learners due to a prevalence of highly-visual programming tools that do not work with assistive technologies like screen readers and braille displays [2, 13, 22]. In response, researchers have developed non-visual programming interfaces and guidelines for ensuring inclusive educational materials and resources, e.g. [17, 20, 21, 33, 36]. The Fil Laptop Orchestra (FiLORK) is a radical approach centered around collaborative, live coding housed at The Filomen M. D'Agostino Greenberg Music School [8]. FiLORK leverages audio output, tactile graphics, and a performative computing environment [6], in which musicians incorporate personal experiences and aesthetics as they prepare to code live for an audience. The five BVI ensemble members do not sing or strum, but instead type, debug, and trigger code to generate dynamic, musical compositions. Our team of researchers (authors 1–4, 10) and teenage musicians (authors 5–9) aims to improve browser-based text editing for mixed-vision groups, teach code and music concepts with an accessible and tactile curriculum, and develop non-visual techniques for communicating during rehearsal and performance.

In this poster, we report findings from FiLORK's second semester in which the ensemble created two original compositions and gave two public performances with audience talkbacks. We reflect on how the musicians implemented their performances, and we discuss challenges we observed with the coding editor and curriculum.

## 2 RELATED WORK

In addition to studying BVI computer science learners, researchers have explored the technology preferences of BVI musicians [28, 32] and designed accessible interactions for production [15, 31, 37] and composition [25, 26]. FiLORK contributes an understanding of



**Figure 1:** a) two members of FiLORK coding on iPads in rehearsal. b) FiLORK in performance at the Andrew Heiskell Library. c) tactile graphic handout to demonstrate “slicing” audio files with Tidal code in braille.

how teens code music live. Additionally, FiLORK draws from the following areas:

*Laptop Orchestras (LORKs)* replace instruments [38–40] with laptops. Unlike most LORKs, FiLORK rehearses in a community school rather than a university, its members use assistive technologies, and most prefer tablets. Furthermore, LORKs use visual notations [7, 12], while FiLORK employs tactile graphics and non-visual cues.

*Algorave* is a performance practice combining composition, live coding, and immersive visuals in which algorithms are manipulated in real-time to generate intricate and evolving soundscapes. FiLORK uses Tidal Cycles (Tidal for short), a popular live coding language built on Haskell [19]. The Algorave community sets out to be inclusive: Most technologies, sounds, and tutorials are freely available. As with other open-source communities, installing software requires the use of the command line, while popular tools, like the Atom editor, lack screen reader accessibility. The practices of disabled live coders have only recently been studied [34, 35] while FiLORK is unique in focusing solely on BVI live coders.

*Live coding has been explored extensively in high school classrooms* [1, 3, 9, 18, 23, 30], demonstrating how live editing at teaching computer science concepts and engaging students through music. Educators to date have used tools and teaching styles (like projecting code) that may not be accessible to BVI learners.

Finally, accessibility researchers have developed systems to improve *collaborative writing within mixed vision groups* in shared documents [4, 5] and pair programming [29]. Collaborative live coding is a related, yet distinct practice in that collaborators instantaneously react to each other’s actions as they make sound and modify code-snippets.

### 3 METHODS

We provide a brief overview of the ensemble, describe the technology and curriculum created by researchers, and introduce the members of FiLORK (who helped prepare this document as co-authors).

#### 3.1 Ensemble Background

FiLORK emerged out of a three-year partnership between NYU and The Fil to meet the interests of musicians and the skills of the research team. This poster depicts the ensemble’s second active semester, building on prior work [27].

#### 3.2 Text Editor: text.management

Our researchers designed a text editor called `text.management` to facilitate collaborative coding. As described further in [14], it is built for browsers following WCAG and utilizing CodeMirror 7, a widely-used text editor library that improves screenreader and keyboard accessibility compared with past versions [10, 11]. Individuals edit code on personal devices, while a separate computer receives code and generates sound via a speaker system. Screen reader users wear headphones to hear personal device output, and screen readers are not amplified to audiences.

#### 3.3 Curriculum and Materials

In contrast with the first semester of FiLORK, in which researchers laid out a 12-week curriculum to teach Tidal fundamentals [27], the second semester was guided by the stated interests and goals of the musicians. Collectively, we selected two concepts to cover and aimed to compose two new works that demonstrate skill in those concepts. First, researchers covered *slicing* in which longer audio recordings, ranging from seconds to minutes, are chopped up, e.g. a drum pattern may be sliced into individual hits and rearranged to create new patterns. To help convey slicing, we created a tactile graphic handout with embossed braille and shapes that we cut up and rearranged (Figure 1c). Furthermore, researchers supplied handheld recording devices and planned an activity for the musicians to make an original collection of recordings. Second, researchers covered synthesizers, notes, and chords. The musicians learned to make use of functions, which take lists of numbers as inputs, and convert them to notes in a scale.

#### 3.4 Musicians of FiLORK

FiLORK’ teenage participants elected to enroll through The Fil and meet on Saturdays for one hour. They possess a range of vision abilities and technology preferences. Madeline and Vinnie use Macbooks with VoiceOver and refreshable braille displays. Diana and Matthew use iPads with magnification and external keyboards. Maya uses an iPad with VoiceOver and a Mantis braille display and QWERTY keyboard.

### 3.5 Compositions and Performances

The members of FiLork composed two works, “Cryptographic Meditation” and “What Instruments Taught Me.” Their performances at the Andrew Heiskell Library and NYU were attended by families and open to the public. In talkbacks, the musicians described their processes, demonstrated code, and answered audience questions.

## 4 FINDINGS

We describe each composition and how the musicians utilized text.management in performance.

### 4.1 Original Compositions

Both compositions feature starter code templates and written improvisation instructions, i.e. what code to modify when. Code templates were planned and written in text.management by musicians in the weeks leading to performance. Every performance and rehearsal of the music follows a similar structure but develops distinctly.

**4.1.1 Cryptographic Meditation.** The composition features melodies played with bass/guitar string samples and moments in which a subset of musicians make sound. The starter template consists of five melodies made up of letters from each musician’s name converted to pitches. The performance uses tactile and auditory cues to signal entrances and what notes musicians are “allowed” to use. The performance opens with one musician at the center triggering a slow bass line (Figure 1a). Gradually, the musicians tap their neighbor outwards to signal they may activate their code. One musician then activates high, percussive tones others may use, and later another introduces a special note C#. The piece concludes with the two members sitting on each end improvising complex clusters of sounds, such that the overall texture sounds abstract and less guitar-like. The two gradually remove notes until the texture fades to silence.

**4.1.2 What Instruments Taught Me.** The second composition is based on a prose poem written and spoken aloud by Madeline, while the others live code. It opens with a recording of the musicians walking through a reverberant stairwell with white canes. Upon hearing Madeline speak key words and phrases, the four others trigger pre-selected files from their collection of recordings. For example, when “cramped practice rooms” is spoken, one triggers a sound of knocking on a music stand. Due to limited time to prepare the code template, FiLork concluded this piece with an improvisation chopping up a long recording of group singing. While less planned, the improvisation is thematically cohesive with the final stanza in which Madeline discusses the laptop stating, “computer music has launched me into a new universe.”

### 4.2 Editor Limitations

text.management enabled collaboration and allowed for performances to be carried out without major technical issues. However, its integration with assistive technologies inhibited live performance as screen readers and braille displays did not consistently read code near symbols and did not update when multiple musicians edited the same line. As a result, in each template the musicians worked within distinct regions of text. They also felt they could not tell when their code had errors and relied on their ears to estimate

whether they had triggered a change. During each performance, researchers made syntax corrections when they saw repeated mistakes, and in one instance replaced code accidentally deleted by a musician when she pressed “return” on a highlighted line that had the effect of removing instead of triggering code. In both performances, Maya experienced especially low support on iPad where the braille display would cease to update even as she made changes, causing her to repeatedly turn VoiceOver off and on.

### 4.3 Syntactic Difficulties

Some members of FiLork found the Tidal syntax challenging, while all members experienced difficulties editing code, especially in front of an audience. For example, Matthew forgot the behavior of specific characters, Diana expressed uncertainty over using square brackets, and Maya admitted in the first talkback that she lacked confidence despite creating a memorable melody. Compounding issues memorizing syntactic rules, the ensemble only met once per week, and musicians faced difficulty practicing at home. (In rehearsal/performance a researcher computer was equipped to receive musician code and generate sound.) There is currently no way to install Tidal on iPads, and a web-based solution Estuary uses slightly different syntax and commands [24]. Furthermore, Tidal setups broke during a Mac update for Madeline and Vinnie, and researchers took a few weeks to determine how to fix the installation on Madeline’s computer.

### 4.4 Limited Time for Composition Work

The members of FiLork felt that preparing the template for “What Instruments Taught Me” was rushed and wanted more opportunities to improvise. Too much time was spent rehearsing “Cryptographic Meditations” and discussing ideas, while as one musician stated, “a lot of our cool ideas came from just screwing around.” While the musicians acknowledge time constraints resulting from technology setup and unforeseen technical difficulties, they believe that their foundation in Tidal prepares them for making sound immediately without preamble.

## 5 DISCUSSION AND FUTURE WORK

The musicians learned advanced electronic music topics, innovated in how they prepared code templates, and communicated using touch and music cues. Their experiences using assistive technologies factored directly into some audio samples played during “What Instruments Taught Me.” Below, we discuss opportunities to improve text.management and our curriculum design.

### 5.1 Design Opportunities for Collaborative Live Coding

During performances, musicians tapped each other and triggered recognizable sounds to signal progress. However, editor limitations reduced awareness and prevented collaboration, e.g. musicians editing each other’s code. Ahead we intend to draw from other accessibility research on audio-based web design [41] to improve text.management beyond a static editor. For example, the musicians suggested incorporating a combination of tones and different voices, ideally in a frequency/timbre that does not conflict with VoiceOver or the music, to signal events like syntax errors or other musicians

entering their lines. To achieve dynamic and responsive sound, we intend to utilize both the Web Audio API and screen reader notifications. We also envision opportunities to explore haptic feedback as during performance, musicians only tapped their neighbors and needed to take their hands off their devices [16]. Because live code is such a noisy, time-sensitive, high-pressure environment, technical solutions may perform well in other collaboration contexts.

## 5.2 Coding Performance as Individual and Group Development

The musicians of FiLorK possess a range of technology literacies, typing rates, comfort levels, and musical styles. Across their two works, they conceived of strategies where all could participate. For example, in “Cryptographic Meditation,” Vinnie performed the bass line – an important responsibility while requiring fewer edits. Madeline and Diana, who write code at a faster rate, performed the highest, fastest parts, and flexed their Tidal knowledge with a duet featuring highly complex code. “What Instruments Taught Me” is also *asymmetric* – Madeline recited poetry while the others activated code in response. Looking ahead, our aim is no longer solely teach everyone the same concepts because FiLorK has learned most of the techniques available in Tidal. Instead, our goal is to facilitate individual confidence and ensemble cohesion. We aim to create activities that aid in the process of turning an idea to a code template and performance instructions, and to make these activities generalizable to other ensembles.

## 6 CONCLUSION

We presented FiLorK, a collaborative, live-coding ensemble led by five BVI teens. We reported how FiLorK crafted two contrasting compositions that accounted for new electronic music concepts, lived experiences with assistive technologies, and non-visual communications during performance. Ahead, we aim to improve how text management keeps individuals aware of group actions, and to plan our curriculum around supporting improvisation.

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