Components of a Digital Technology Music Class

Approaches to Music Technology and Training to support the pedagogical practices in the Regent Park School of Music's Community Music Program

Document 1: RESOURCE GUIDE

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ABSTRACT

There is a general need for more technological aids and better designed digital tools for matching the vibrancy of the instructors and instructional curriculum. As researchers into pedagogy, we are less interested in measuring success or “literacy” as is traditionally understood in pedagogy, and instead seek to understand the cultural capital of music software, hardware and other hybrid and virtual tools that people use now. Far too often, digital literacy metrics assess students against a generalized and marginalizing set of criteria e.g. how well they complete a task online, or how well a particular piece of music is ‘mastered’ according to a set of predetermined guidelines. Moving against the grain of the Western musical tradition and its evaluation strategies, digital instrumentation with its breadth of multi-sensory and interactive tools allows for a pedagogy that measures its success through the extent of individual and/or collective expression, inclusivity and accessibility within diverse communities.

We aim to provide a multi-dimensional approach to Music Technology and training, focused on the integration of analog and digital tools, and offer multiple strategies for an ‘anti-metrics’ approach to musical and digital literacy. At the same time, It has been our experience that younger children’s abilities in learning in general and music in specific are often underestimated and conversely, that older children’s/young adult’s knowledges of technologies are often overestimated. In order to provide a more democratized approach to learning, the members of this research group have created a Resource Guide that grows from listening as a rudimentary creative practice to its implications in the use and “creative abuse” of emerging technologies today. Above all, we focus on children as the inspiration and protagonists of our survey, and also provide a review of the digital environment today that will help us understand the challenges they face on- and off-line in our current era of hybrid synchronous and asynchronous learning. While targeted at the Regent Park School of Music’s classes that explicitly involve technology (Music Technology, Keys and Beats, and Keyboards), it is compiled with the intention of being broadly applicable to all classes in music instruction there. Although structured as an informative series of documents, this guide is envisioned as a seed for further conversation and creative work rather than a didactic or closed loop.

The project has 3 documents:

1. The **Resource Guide** begins with an introduction to the project, the research team and the research methodology, followed by an expansion of the literature surrounding each of our key thematics: Listening, Emerging Technologies and Techniques, Digital Environment, and Children. An appendix of technological resources that may be useful to the setup of a classroom studio is provided at the end of this document.
2. In the second document entitled **Educational Workshops** a list of workshops meticulously designed by the research team and external guest is provided for easy access to pedagogical exercises that may help to augment the classroom.
3. A third document - **Literature Review** - compiles all the bibliographies, abstracts and pertinent information for further reference.

CONTRIBUTORS' BIOS

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Dan Tapper is an artist who explores the sonic and visual properties of the unheard and invisible. From revealing electromagnetic sounds produced by the earth's ionosphere, to exploring hidden micro worlds and creating imaginary nebulas made from code. His explorations use scientific methods alongside thought experiments resulting in rich sonic and visual worlds. Dan also regularly uses his skills as a creative coder and interactivity designer to help artists and musicians facilitate projects, these range from building a 20 ton stone boat embedded with interactive soundscapes and pressure sensors to digital video feedback software and audio reactive light environments.
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Emily Collins is a Toronto-based interdisciplinary researcher, arts administrator and PhD student in Cinema and Media Studies. She has worked across arts organizations in local and international settings, including the Walter Phillips Gallery at the Banff Centre for Arts and Creativity, Festival Scope (Paris), VUCAVU (Toronto), PUBLIC Journal (Toronto), and the Toronto International Film Festival. She holds graduate degrees in Arts and Culture from Maastricht University (Netherlands) and Cinema and Media Studies from York University (Toronto). Situated at the intersection of film and media, sound studies, cultural studies and gender studies, Emily's PhD research considers practices of deep listening, sonic epistemologies and embodied soundscapes. Namely, her project examines how sonic intervention and experimentation within audio-visual works can function as tools of resistance, instruments for disruption and modes of trans-sensory knowledge formation.

Jacky Sawatzky is a conceptual artist with an interest in scientific inquiry, currently a PhD candidate in Theatre and Performance Studies at York University, Toronto. Her interdisciplinary research investigates the meeting point of animal behaviour science and performance studies. Her current research project, "How Are We to Listen to You, Llama?" explores the perceptual world of llamas by approaching the act of listening as a methodology that interweaves the full range of sensoriums. She writes a blog "The Drama of the Llamas" about her observations on the behaviour of the nine llamas living in Toronto's High Park Zoo. An earlier research project, "A Memorial for Our Commodified Giraffe," was published in the Special edition of Canadian Notes & Queries "Writing in the Age of Unraveling," January 2020.

Prior to starting his PhD in Cinema and Media Studies at York University, **Marko Djurdjić** received a BA from McGill University, a BEd from the Ontario Institute for Studies in Education, and an MA from York University. His work focuses on media, education, and space, particularly through the lens of philosopher Henri Lefebvre. His other interests include middle-brow entertainment, coming up with hypothetical band names, and basketball.

Michaela Pnacekova is an XR creator, producer, a PhD student and ELIA scholar at York University. Her focus lies in the ways new media impact the real through interaction with algorithmic processes and artificial intelligence. Her first VR piece Symphony of Noise was shown at festivals such as VRHAM!, Reeperbahn Music Festival and IDFA 2019. She co-produced Chomsky vs. Chomsky: First Encounter with NFB and Eyesteel Film, which premiered at New Frontier Sundance Film Festival 2020. She created an interactive predictive policing app Pre-Crime Calculator and produced three feature length documentaries (Border Cut, Scars, Waterproof), which have been shown at DOK Leipzig, IDFA, Prague One World Film Festival, Warsaw Film Festival, GoEast Film Festival, and more. She also worked on the Oscar® nominated documentary Last Men in Aleppo as the German production coordinator which premiered at Sundance Film Festival 2017. She received EWA Development Award 2017, Special Mention at the Bosch Stiftung East European Co-Production Prize 2014 and Golden Frog for Best Feminist Play in 2009.

Natasha Walsh is a PhD Candidate and Educational Developers Caucus-accredited Graduate Teaching and Research Assistant at York University, where she conducts the undergraduate concert choir, performs as a soprano soloist, and has taught undergraduate music theory, choir, and Western Music history compulsory courses. Ms. Walsh holds a research position under Dr. Lisette Canton and is a research collaborator on the Healey Willan Communication Database Research Grant with the Library & Archives Canada and Stephanie Martin of York University. Ms. Walsh holds awards from the Canadian Council of Christians and Jews, and the Hymn Society in the U.S. and Canada. Ms. Walsh presented with the Canadian Society of Church History (virtual), the American Musicological Society (Columbia University), the College Music Society (Vancouver), and the Canadian University Music Society (University of Toronto). She earned her M.Mus. in Vocal Performance from Université d'Ottawa and a B.S. in Vocal Performance from Roberts Wesleyan College.

Joel Ong is a media artist whose works explore emergent ways of interfacing with the environment through hybrid discourses of art and science. His works often begin in improvised ensembles where members come in the form of live instrumentalists, robotic assemblages, scientific apparatus, and digital data. Ong is an alumni of SymbioticA, the Centre of Excellence in BioArts and DXARTS at UW(Seattle), and is affiliate artist at UCLA ArtSci Collective. He is currently Assistant Professor in Computational Arts at York University in Toronto, and Director of Sensorium: the Centre for Digital Arts and Technology.

Walter S. Gershon) is Associate Professor of Critical Foundations of Education and Program Coordinator of Urban Education in the Department of Language, Literacy, and Sociocultural Education at Rowan University. His scholarship focuses on questions of justice about how people make sense, the sociocultural contexts that inform their sense-making, and the qualitative methods used to study those processes. Although his scholarship most often attends to how marginalized and vulnerable youth negotiate schools and schooling, Walter is also interested in how people of all ages negotiate educational ecologies outside institutions. In addition to peer reviewed articles, book chapters, and other scholarly publications, Dr. Gershon is editor and/or author of five books, including two national book award-winning monographs.

Peter Appelbaum is Professor of Education at Arcadia University in Philadelphia, USA, where he directs the sTRANGELY fAMILIAR mUSIC gROUP. He works with invented notation and sound structure composition, environmental sound art, and expanded conceptual definitions of sound; he plays horn and cello, and uses ethnomusicology as a tool for community development and academic collaborations. Appelbaum's scholarship is in psychoanalysis and public pedagogy, mathematics education, arts-based research and alterglobal social movements. His Children's Books for Grown-up Teachers: Reading and Writing Curriculum Theory (Routledge 2008) received the AERA Outstanding Book Award. Recent projects include: the Youth Mathematician Laureate Project (http://yomap.org), in which youth are provided the resources to serve as inspirational laureates, using mathematics as the art that builds communities characterized by joy, a can-do attitude, and the courage to act on their convictions; and Vomit! Slaughter! Block Chain Corporate Social Impact Investment Markets! Gleefully Murdering Public School!, a multi-media cantata interweaving experimental sound art, classic texts of educational foundations, circus arts, and projected media.

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INTRODUCTION

A research team of 8 graduate students and practitioners representing multiple disciplines and pedagogies was assembled. Initially the team focused on 4 main thematic blocks that would provide inroads between them in order to allow an interdisciplinary and generative framing for Digital Music Pedagogies based on what was identified collectively as important and crucial to our current conditions. Thus the notion of "situated knowledges" became for us both a pedagogical tool to be discussed in the classroom, also as a meta-organization of our research experiences, interests, inspirations and personal experiences in and out of the classroom. Valuing experience as evidence, the resulting document is a testament to the way teaching today may succeed through a consolidation and experimentation of emerging media and technological offerings; and a sustained approach towards individual mentorship and the engagement of students in an assiduous process of self-discovery through creative and unconventional practices.

Over a short but intensive 4-week research journey, each of the researchers engaged in a literature review of topics aligned with the general thematics and analysis questioning:

1. **ANALOG to DIGITAL**

In addition to tutorials on GarageBand/Audacity/DAW, mics, and other entry level musical tools, what analog processes for exploring sound from fields such as sound studies and musical knowledge (tradition/nation/culture open) can help students explore digital sound-making and vice versa?

2. **LISTENING**

Listening (and/or hearing) is of utmost significance to overlapping fields of musics, arts, sound studies (for example). What does it mean to listen, who can be heard, and what are some theoretical and material tools for deepening listening experience?

3. **DIGITAL AWARENESS**

Use of digital tools, regardless of application, purpose, or device, calls for the necessity of important questions about privacy, information, and individual rights; How music technology can be adapted to digital/telematic formats related to the current COVID-19 situation.

4. **CHILDREN**

What pedagogical practices and curricular understandings are helpful in working with young people to learn digital technologies in ways that are ethical and take students' experiences and expertise into account?

Given the diverse experiences within each group, these thematics oscillated between being expanded into broader interdisciplinary conversations, or more directed towards the specific interests of the researchers.

1. LISTENING

“The first task of the acoustic designer is to learn how to listen. Ear cleaning is the expression we use here. Many exercises can be devised to help cleanse the ears, but the most important at first are those which teach the listener to respect silence”

R Murray Schafer (1977)

1.1: Approaches to Listening in Musical and Non-Musical Ecologies

- Canadian composer and founder of the Acoustic Ecology movement **R Murray Schafer's** quote begins this chapter with a process of ear-palette cleansing amidst broader theories of sound, especially in more current debates in media and technology, that point to its immersiveness, ephemerality and multisensory engagement:
- "The primary task of this course was to open ears. I have tried always to induce students to notice sounds they have never really listened to before, listen like mad to the sounds of their own environment and the sounds they themselves inject into their environment (1)."
- "By giving the paper a voice we have exposed its sound-soul (38)."

- Schafer led an experimental music course in the seventies for an undergraduate course at Simon Fraser University. The lectures include Noise, Silence, Tone, Timbre, Amplitude, Melody, Texture, Rhythm, The Musical Soundscape. Each lecture comes with assignments, examples of student projects, and background information. Objects like paper, wood, and vocals through words and the sound-poems to open the ears to the sound's made. Listening is not connected to a musical instrument and the ability to play an instrument. The target group is music students.
- He also presented a graphic notation system whereby the visual act as metaphor for sound has potential for pedagogical applications in situations wherein the focus needs to be on the objects of sound.

- **Pauline Oliveros** describes the *act of listening as a balance between the local and the global"*. This turns listening into a form of discovery, very different from Schaffer's ear cleaning wherein listening is a craft needed to acquire.

- **Andra McCartney's** "How am I to listen to you?" (2016) proposes a listening that is interpersonal and has an ethical consequence she writes (37). She attempts to develop a strategy to include improvisation into a soundwalk. The strategy includes feedback and letting the sounds determine the route, other than relying on a predetermined route.

- According to **Salome Vogelin**, listening as a form of knowledge production (2018), but needs to implement an approach away from the current theoretical engagements in sound studies that uphold subject-object dualisms (Thompson, Goh):
- "Listening offers another point of view, an alternative perspective on how things are, producing new ideas on how they could be and how we could live in a sonic possible world, and how we could include sound's invisible formlessness in a current realization and valuation of what we understand to be the actual world. Listening, we will not automatically get to a better world, or a better philosophy. Sound does not hold a superior ethical position or reveal a promised land. But it will show us the world in its invisibility: in the unseen movements beneath its visual organization that allow us to see its mechanism, its dynamic and structure, and the investment of its agency, which might well be dark and forbidding. A sonic sensibility reveals the invisible mobility below the surface of a visual world and challenges its certain position, not to show a better place but to reveal what this world is made of, to question its singular actuality and to hear other possibilities that are probable too, but which, for reasons of ideology, power and coincidence do not take equal part in the production of knowledge, reality, value, and truth." (Vogelin, 2018)

- Practices of listening are shaped by the situation, environment, genre of music (Stockfelt) as well as the technologies and their interfaces and affordances (Rice)

- Dualisms between phenomenological and materialist perspectives run within sound studies and theory in a more specific way that **Marie Thompson** elucidates, in a critique of R. Murray Schafer in Beyond Unwanted Sound: Noise, Affect and Aesthetic Moralism (2017), where she repositions noise outside from the negative connotations and perception that it has historically been positioned within, towards a relational ground of being in which all bodies are immersed and transformed

- **Tara Rodgers** also argues against the tropes in sound theory and electronic music history of noise and silence through the use of the avant-garde Futurist origin story, which normalizes the hegemonic cultural practices that follow, including colonist discourses, sexist imagery and militaristic language

1.2: Listening as Awareness

- Running themes/commonalities among the texts:-listening often defined and positioned in relation to hearing and then subsequently to seeing/ visual culture (hearing vs. listening forms the basis of the practice of deep listening)
- Listening techniques and approaches shift according to developments in the technologies used in sound production but also, more crucially, for consumption and mediation
- Importance of being embodied and embedded in the acoustic experience
- Sound invites listening, but also much more than that; it invites a multi-sensory engagement that is not restricted to aurality.

- **Hildergaard Westerkamp** (2015): “A true state of listening cannot be acquired by force. The order to listen - LISTEN! we all have heard and experienced it - guarantees a closing off, a turning away, a non-listening, possibly even a permanent disturbance in our once open and trusting listening channels. It is perceived like any sound that annoys, disrupts, hurts, or injures: we cringe, we try to block it out, might fight it, may want to get rid of it, but we will not listen. **By its very nature listening is a continual and gentle process of opening.** We usually know when we are in that place of perceptual receptivity and we know when we have lost it. **Listening is never static, cannot be held on to, and in fact needs to be found again and again. As such, it is disruptive in its nature**. Paradoxically, while a grounded and calm state of mind, a sense of safety, peace and relaxation are essential for inspiring perceptual wakefulness and a willingness and desire to open our ears, normal routines, habits and patterns will be disrupted and laid bare in such a process of listening; noises and discomforts inevitably will be noticed, and all kinds of experiences will be stirred and uncovered. **Listening in fact implies a preparedness to meet the unpredictable and unplanned, to welcome the unwelcome.** How do we reach such a state of listening, why would we want to?”

- In Schafer, Westerkamp, and Oliveros' theories of sound, becoming more aware is the goal; however, the goal itself is not questioned. Is awareness always beneficial, and with this, the potential need for safe zones away from sounds. Maybe to not listen is a possibility? Awareness might not always be desirable. I am thinking here of people on the autism spectrum who can have a sound sensitivity or misophonia were by hearing people chew, and slurp evokes rage, fear and anxiety. For us, earplugs and headphones are essential attributes, as well as the agency to walk away and hide.

- Moreover, sounds that can evoke past traumatic experiences, an example the sound made by the fighter jets flying over the city during the labour day weekend air show, can be traumatic for people fleeing war situations. Maybe simply blocking out sound is, at times, desirable and should have the opportunity to do as such. Thus in light of the question which sound theories can be applied across multiple ages, offering agency to do just that, blocking is detrimental in my own experience. An acoustic safe place, if this is through headphones (noise cancelling) or earplugs, or simply walking away without being excluded, is critical.

- Another strand of sound discussed is vocalization without signifying a recognizable word and with this sound signing. Although Tonelli and Rasula describe the discomfort the audience might have with sound signing, in my experience, the playfulness and lack of musical expertise made it possible to have multiple generational participation.

- **Christine Duncan** and her "Element Choir" is an example of Tonelli's approach in the workshops for this see Jonathan Bruce's article. The gestural conducting technique can be potentially taught to multiple age groups, thus having a child conductor in front of adult singers.

- **Tim Ingold's** approaches sound as a medium of perception and not an object of perception. Listening happens in a medium. Sound connects to meteorology and the weather, not the landscape. Sound in this context can be heard, seen, felt, theorized, and imagined. Even inside, the weather can be experienced. For example, in the Winnipeg winters, the temperature can be experienced through the frequency of the heating system kicking in. This approach to sound can be applied to multiple age groups; we all live with the weather.

1.3: Rethinking Social and Sensorial Biases as a Form of *'Queering'* Listening

- **Dylan Robinson's** decolonization of listening whereby the consumptive approach of 'hungry listening' becomes not knowing for sure what listening is. His event score included in this literature review is a form of decolonial listening that can be applied in a pedagogical situation. Robison asks himself, "how I might listen as a respectful guest, and in ways that do not seek to extract and apply a particular Haudenosaunee or Anishinaabe listening practice, but nonetheless listen in relation with their knowledge system (51)" - the respectful quest as pedagogical practice leading towards a decolonial listening.

- **Marie Thompson** advocates that a "(re)turn to ontology in sound studies is predicated on an 'origin myth' that disavows 'old' questions of culture, signification, discourse and identity, and

promotes ‘new’ questions of materiality, affectivity reality and being”. Christopher Cox’s Sonic Materialism theory is criticized by Thompson for taking a “racialized perceptual standpoint that is both situated and universalizing” and exemplified through a particular critique of John Cage’s positions in what Thompson perceived as reproducing a problematic “white aurality”. Thompson’s argument underlines a need for a new resituated ontology enabling other hearings. Furthermore, Thompson analyses two sound works: The first one being Lawrence English’s compilation Airport Symphony and the other one Chino Amobi’s Airport Music for Black Folks, both made in resonance to Brian Eno’s Music for Airport. English’s airport symphony (featuring a cast of sound artists each proposing a track) is analysed as being mostly focussing on abstract, depersonalized and virtual dimensions of sound resulting in a somehow reductive aestheticization of airports and/or aircrafts drones and field recordings. According to Thompson, Amobi’s work addresses on the contrary the perspective of power relations, visible and invisible structures creating binaries and inequalities in society.

- The article by **Mack Hagood** on tinnitus and the recognition of this disability henges onto lack of not being medically legible and socially visible bring out a relevant and often missed discussion around diversity and inclusion. This invisibility of a disability renders voices inaudible.

- **Douglas R. Ewart's** “CREPUSCULE” in Guelph, 2015-2016 is an example of a workshop leading to a performance wherein diversity and inclusion are paramount. A few key elements he uses are the circle, understanding how a community is constructed, improvisation, and finding the invisible 'voices' in the community working with.

- **Kathy Kennedy's** radio walks. Radio as a queering technology as it connects the local without it being filtered through the global (world wide web). Radio transmitters are accessible DIY technology and low budget

- **Mara Mills and Jonathan Sterne**, leading scholars of media technologies who have long incorporated disability into their analyses, propose “dis- mediation” as one avenue for the cross-pollination of disability and media studies. Referencing current scholarship in both fields, and engaging with a rich tradition of critical media studies, they argue that dismediation understands disability and media as mutually constitutive, while urging the ongoing interrogation and revision of media systems.

1.4: Connecting Listening to Pedagogy

- The idea of ‘learning to listen’ runs through several of these texts, in both a generative and critical way, meaning that some scholars advocate for a listening education to create a sense of literacy and confidence with sound, while others mention the ways in which listening etiquette and expertise has led to a performance of listening linked with esoteric auditory knowledge such as in classical music concert halls (Rice). Regarding the former, part of this idea though involves bringing “artistic ambiguity and doubt into the verifiable, bringing the sensibility and concepts of the invisible and the contingent to scientific reliability.”

- Contrasting the phenomenological perspective (individuated, immediate, symbolic, socialized subject) vs. a materialist expanded perspective of listening, which, the latter, runs the risk of perpetuating and reinscribing dualisms and the presumption of a universalized, qualified and focused hearing subject. Thus a phenomenological approach is preferred, or at least would be the most useful in a pedagogical context.

*For workshops on listening practices, see **pages 9-10** of the Educational Workshops document.

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2. EMERGING TECHNOLOGIES & TECHNIQUES

2.1: Emerging Technologies

- "Regardless of whether it is a purely artistic or aesthetic pursuit, an informed extension of existing practice, or a deliberate disregard for accepted practice, the notion of music production being driven by creative abuse appears to stand up as a premise. Much studio equipment design and manufacture can be seen to follow emerging production techniques, which have actually been discovered through acts of (creativity) on previously available equipment. Multi-track tape machines, spring reverbs, distortion, flange, and delay became standard studio tools. Recent production features and tools are enriched by the sonification of digital errors . .. Many of the techniques have become so accepted that 'more and more audio software is being developed which enables one to simulate the sounds of digital failure without actually experiencing it." (Phil Thompson 2004)

- Current research and discussions of emerging technologies are extremely relevant for understanding the trends of research in music technologies and can inform us to better identify music education and sound creation technologies, tools, and games that can be effective and relevant for today's music classrooms. However, as 'emerging' technologies are continually evolving (Veletsianos, 2010), current research must accompany the growing availability of technologies in order to best understand and make use of them. Even at this point of writing, new technologies continue to arise and our data will predate the continually renewing availability of technologies. While this might create an inevitable 'gap' in our understanding of 'current' emerging technologies, research allows us, nonetheless, to understand the themes and trends of technologies that aid the music classroom.

- See appendix for a list of technological resources (including handheld recording devices and software tools/games/online resources for music education and sound creation)

2.2: Distance Learning

- Emerging technologies for music making and teaching have expanded and supported teaching and learning through distance education (Blake, 2018; Dammers, 2009; Kruse et al., 2013).
- Current literature on emerging technologies in the music classroom that emphasize telematic and virtual modalities cover:
    - **Distance Learning/Education**: Real-time Videoconferencing, Virtual Rehearsals, Telematic Performances (Synchronous Learning)
    - **The 'Flipped' Classroom and Individual Learning Spaces:** Music Creation/Composition-Based Technologies**,** Mobile Music Technologies (Tablets, Smartphones, Virtual Reality (VR) and Game-based Learning)

- To note, distance education might occur in a 'synchronous' or 'asynchronous' environment. In a **'synchronous'** setting, participants will interact through real-time, telematic means. In an **'asynchronous'** setting, participants might communicate through virtual communication at one's own convenience or availability (i.e. social media posts, emails, pre-made video instructions) rather than interacting at the same time.

- As Blake (2018) discusses, the distance learning environment is “heavily saturated with technology” (p. 2) as distance programs that do not have physical, face-to-face connections inevitably rely on online instructional methods and web-based learning strategies.

- Such technologies include:
    - **Synchronous** environments of real-time videoconferencing/music lessons, virtual rehearsals, and telematic (real-time) music performances, and;
    - **Asynchronous** environments of web-based platforms and video instruction (i.e. YouTube)

- **Synchronous**: There is growing research on synchronous learning environments through real-time videoconferencing software and apps that include teaching music lessons, conducting virtual rehearsals, and collaborating through telematic music performances. For example, through an exploratory study of online trumpet lessons via entry-level videoconferencing (personal computers, web-cams and Skype), Dammers (2009) explores the feasibility of music lessons through Skype and aims to identify the benefits, challenges and external considerations of teaching musical skills through videoconferencing. The researcher confirms the potential of teaching music through videoconferencing, and discusses how such technologies would require developing a new spatial relationship between the participants.

- Similar studies include Kruse et al. (2013), who explores the benefits of implementing distance learning in instrumental music through a case study of Skype piano lessons.
- While Skype is an under-used software at this point of writing, the above research informs us about the benefits and use of free and accessible videoconferencing technology for teaching and learning music.

- Moreover, through an educational guide that discusses the potential of videoconferencing technologies in teaching music, Criswell (2016) discusses popular and accessible video-conferencing tools that have been implemented in the music classrooms, including **Skype, FaceTime, Google Hangouts, Adobe Connect, iStream, and Zoom.us**.
- Other free and accessible videoconferencing tools not mentioned on the above list includes: **Google Meet** (used within the Toronto District School Board during school closures), **Houseparty** (used primarily for virtual social-gatherings), **Discord** (used mainly for larger gaming-communities, but with higher video and audio capacities, can be suitable for music lessons), **Facebook Messenger ‘Rooms’** (a recent feature of Facebook that supports larger virtual gatherings), and many more.

- Two of the most common videoconferencing tools currently used for teaching music seems to be **Zoom.us** and **FaceTime**. However, it is important to consider how Zoom has had issues with privacy/end-to-end encryption and suffers insufficient audio quality, while FaceTime is only accessible to those on macOS or iOs devices. Moreover, such videoconferencing technologies have not been built exclusively to support the audio component that music lessons require. There have been attempts to improve the audio quality of Zoom calls for music lessons by altering audio settings within the program. For instance, the Dispersions Lab led by Doug Van Nort at York University has been hosting regular improvisational musical performances through Zoom that make use of the advanced settings on the Zoom platform.

- In addition to teaching, video-conferencing software has influenced virtual environments to support music rehearsals, as discussed in a pilot project at the New School for Social Research (Schober, 2006). The author discusses how virtual rehearsals can allow a re-imagining of co-presence in rehearsals or performances: a remote, virtual co-presence "of breathing together, of being able to anticipate each other's moves, of feeling both independent and like one being" (p. 85).

- In order for real-time rehearsals to occur, the virtual environments must be **low-latency,** where the participants and listeners will experience **little to no audio delay**, to allow simultaneous playing/singing in time.

- Researchers discussed the possibilities of novel technologies that could allow real-time performances in **low-latency environments**. There was a comparative examination of 'generic' videoconferencing software (i.e. Skype, FaceTime, or Google Hangout) over software requiring higher bandwidth and stable internet quality (Carney, 2014; Rofe et al., 2017). **Zero-latency audio programs** were identified such as **JackTrip, JamKazam, Jack Trip** (Clauhs & Cremata, 2019; Oliveros et al., 2009) and **Artsmesh**, with the idea that "ensemble-based collaboration is an emerging phenomenon and one that will likely become more and more feasible as technologies related to latency and sound quality catch up to the standards to which [users and listeners] are accustomed" (Clauhs & Cremata, 2019, p. 59).

- The above zero-latency audio programs require a substantial amount of audio set-up, hardware requirements, and high-speed internet, which may not be accessible to all students and teachers at this point of writing. It is a hope that the accessible programs discussed can become more suitable for real-time rehearsals (instead of one where all the players 'mute' their mics except the teacher), as well as the zero-latency programs become more accessible for the wider public.

- **Asynchronous**: Some studies have focused on emerging technologies in asynchronous classroom environments of web-based platforms and video instructions, including the impacts of YouTube in the music classroom. Webb (2010) has referred to the increase of online videos in the classroom as 'clip culture', as he notes the adaptability, flexibility, and accessibility of video-clip uses in the classroom.

- Sharing YouTube videos and tutorials are already a large part of the music education scene. Some features to support music education include: creating your own channel, curating playlists, YouTube Kids, subscriptions, as well as livestreams.

- As YouTube videos are essentially a pre-made, 'one-way' deliverable, teachers can negotiate how much YouTube instruction versus synchronous (two-way) instruction they wish to provide to best suit the needs of the students.

- In the ethnographic study of two secondary schools in London (Stowell & Dixon, 2011), the researchers look at the role of YouTube, mobile phones and MP3 players within the classroom and how such technologies can be negotiated for learning musical concepts. Similarly, Hanson (2018) identifies the benefits inherent to web-video technologies including

its immediate availability for instruction and its features of content sharing with other online participants or audiences.

- Moreover, Waldron (2013) examines two online music communities in order to examine the implications of user-generated content and YouTube for music teaching and learning in online communities. Here, the accessibility and availability of user-generated and YouTube content are noted as important factors for using web-based platforms and video instruction in teaching music. While sharing videos through YouTube may not necessarily be a radically 'disruptive' technology for the music classroom, the use of asynchronous videos for delivering and teaching music can act as "vehicles of agency" to increase collaboration in online communities (Waldron, 2013b, p. 4). By 'vehicles of agency', we are referring to the ways YouTube teaching and learning promotes "participatory culture through discourse" (p. 4) amongst online communities or any group of learners within the spaces of engaging with the video-content. The videos thereby provide informal (online) spaces for community-formation and engagement during the act of watching the videos together, discussing the content and ideas through chats/comments, and learning from the content and amongst the various participants.

- We recommend some emerging technologies, online resources, games/tools for music education and sound creation here.

2.3: Virtual Reality (VR) and Game-based Learning

- Emerging technologies in virtual environments, virtual reality (VR) and game-based learning are growing in popularity in both music research and practice.

- Psotka (2013) asserts how "the most longstanding and direct benefit of VR and games for education has been their power to motivate learning…. [which] was thought to be a novelty effect, but it has sustained its power over the years" (p. 70). In this way, VR and educational games have developed into a disruptive, emerging technology to change pedagogy and classroom learning.

- For example, through an investigation of primary music teaching with mobile VR use, Innocenti et al. (2019) presents a framework for primary music education on a mobile VR application (VR4EDU). They suggest that the blend of mobile VR technologies combined with traditional teaching methods can produce more effective learning experiences for children, especially "in terms of active listening, attention, and time" (p. 102).

- On utilizing VR for music performances, Hamilton and Platz (2016) offers an interactive music performance of 'Carillon', where the performers collaboratively control a virtual instrument with gesture-based technologies, presented through head-mounted displays (HMD).
- In another study, Orman et al. (2017) utilizes immersive VR and AR technologies to enhance music conducting skills (eye contact and gestural behaviours) for new conductors.

- Research has also proposed new VR interfaces for musical expression and sound computing (Serafin et al., 2016; Serafin et al., 2017), where the researchers suggest new possibilities for VR and AR (augmented reality) technologies in K-12 music education.

- One such emerging interface includes Virtual Reality Musical Instruments (VRMIs), where a head mounted display or various forms of immersive visual systems simulate the visual component of the instrument. The authors discuss how VRMIs have the capacity to "stimulate intelligent visual feedback that may aid the player in performing… [their] physical instruments, where visual feedback is directly connected to the sound production mechanism, e.g. vibrating strings" (p. 1).

- Berthaut and Hachet (2016) also proposes 3D graphics and immersive displays and interfaces for music performances, arguing that such new environments can provide "novel playgrounds to musicians who can explore new dimensions in music creation [and] where audiences can experience new forms of performances" (p. 87).

- On game-based learning and technology-mediated play, Cassidy and Paisley (2013) argue that "music-games present one of the most pervasive and popular digital music participation contexts, with growing evidence indicating that informal music making with music-games is inspiring greater interest in music and potentially impacting upon wider musical behavior" (p. 120).

- Defining music-games as "a digital game-based activity in which music (performance, appreciation and/or creation) is integral to the game mechanic, and in which the player interacts with music through an interface such as conventional or adapted instrument controllers, microphones, dance mats or music creation software, in single or multiplayer contexts" (p. 120), the researchers present an exploratory study of the impacts of a music-game called Rock Band 3, to address and understand learners' attitudes and experiences of music-games.

- The authors believe that music-games can "promote inclusive music participation and personal and academic wellbeing; embody fundamental musical concepts in gameplay; and authenticate formal participation to help learners see the relevance of music curriculum to their own experiences and aspirations in the wider world (p. 135)".

- Through an exploratory study of a digital game-based music learning system, Liang et al. (2016) examines how game-play might provide novel learning environments that can enhance the effectiveness of student learning. Moreover, while not a music education-related study, various literature looked at children's play and gaming in virtual worlds (Marsh, 2010) to develop literacies (Merchant, 2010; Qian, 2008), as well as the impact of multiplayer online games (MMOs) in the classroom (Delwiche, 2006).

2.4: Potential Uses of VR for Pedagogy Today

- Potential uses of VR for pedagogy include immersive experiences for authentic engagement and learning, including learning a new language, learning a VR musical instrument, and learning a skill by doing (i.e. driving, constructing, job training, and other kinds of simulation experiences).

- This would further engage students who best learn ‘hands-on’ or ‘tactile’, and allow students to learn by ‘doing’ in the virtual environment rather than learn through reading or hearing about a concept. VR can also expand possibilities in remote/distance education settings, where the participants of learning can come together in collaborative work through multi-user VR settings.

- This would go beyond the screen-to-screen video-chatting communication typified for the distance classroom, and allow virtual (but real) social interactions amongst participants. Through utilizing VR products like Google Expeditions, classrooms can embark on virtual field trips around the world, encouraging explorative learning beyond the confines of the classroom/school walls.

- In this light, teachers can encourage culturally responsive and relevant learning through VR engagements that connect students to a cultural ‘expert’. VR also has a high capacity for game-based learning and technology-mediated play, which can motivate students to initially enter the learning experience. VR can also aid the special education classroom or students with IEPs (Individual Education Plans) for focus/attention issues, as certain VR environments (with a head-mounted display) can block out distractions in the classroom and improve student focus. The case study in 2.6 discusses one potential use of VR in pedagogy and provides implications for classroom use.

2.5: On Teaching Music Digitally – Before, During, and After the Pandemic [Chris Taeyoung Kim]

Teaching online or digitally has developed a renewed meaning since the brink of the pandemic: remote education has become a norm to many, an inconvenient reality to some, and a new opportunity for others. As such, there has been an abundant number of music teachers and teachers at large expressing their two cents on teaching post-pandemic through social media posts, blogs, and online community groups. As a music educator, myself, I learned more about new digital resources and ways to engage students in virtual and telematic connections than I ever had. The focus of the discussion on music educator online, informational platforms shifted to a constant sharing of which videoconferencing software to use, the best online music theory tools, how to reduce latency issues for real-time ensembles, how to organize a virtual music recital, issues of increasing accessibility and affordability of certain technologies for our students, sharing knowledge on freeware or reduced fees on many music education/sound creation software, discussing issues regarding privacy for students, or offering to share user-generated content and resources. Music ensembles (choirs, bands), too, saw a new wave of coordinating virtual performances, rehearsals, and online collaborations.

At first, it seemed like a ‘desperate times call for desperate measures’ scenario: this was only a temporary ‘alternative’ to the physical spaces and live performances pre-pandemic. While I do not intend to downplay the importance of physical interactions and learning and playing music in ‘live’ spaces, I began to see the value and effectiveness of many digital tools that I had not considered in my classroom beforehand. I began to see my students succeed and thrive in our virtual environment, and saw the potential of digital connection and collaboration. I realized that relationships and teacher-student rapport can still continue through virtual connections – the intimacy still present screen to screen, as in the classroom. Hence, rather than an ‘alternative’ pedagogy, incorporating digital music literacies and virtual

ways of creating and making music has become a realistic possibility for the future of my (and others') classrooms, post-pandemic.

As a faculty at the Regent Park School of Music (RPSM), it has been an interesting journey of coming together with the teacher-community to deliver online engagement tools to students during the school closures. Through online music educational tools, YouTube tutorials, video collaborations between faculty, DJing on Instagram live, and more, our engagements have aimed to utilize our virtual and social media platforms for students to continue engaging in music in any way possible. Prior to our school closures, for the most part, teaching and learning at RPSM has been analog: acoustic instruments, live interactions, sheet music and books, with the occasional iPad uses. As a piano teacher, while I was aware that RPSM offered music technology classes, I had zero interaction with the teachers or students who were part of the digital music program. Hence, there had always been an unsaid 'divide' between the many of us who delivered the traditional methods of music teaching and the 'other' digital music classes. Now, at this point of the pandemic, this aforementioned divide is probably less overt as we are all trying to increase digital music literacies and deliver effective content through technology. Will we keep up our digital lens once we go back to the physical classes? Should we?

As a community music school that emphasizes community engagement and collaborative efforts, I believe it is crucial for the faculty to minimize our gap between the analog to digital teaching styles at the school in order to encourage a dynamic, interactive, and collaborative learning environment for all our students across disciplines. For example, can a classical voice teacher co-teach with an iPad ensemble group to experiment with ostinatos, looping, and free improvisation? Can the senior string ensemble collaborate with the DJ class to co-create, record, mix, and publish a song using both traditional and virtual instruments? Can we orchestrate a real-time, virtual space for multiple instrumentalists and digital technicians to come together to jam, improvise, and share sounds? There needs to be such kind of critical consideration to re-develop a music curriculum that can take full advantage of the vast resources, tools, and emerging technologies available to us at the present state.

As discussed in the literature review, one pedagogical and classroom consideration to aid a collaborative and interactive learning experience can be through the flipped learning model. As a group piano teacher, myself, I have often incorporated flipped learning opportunities to focus on student-centered and project-based learning. With the advantage of having digital keyboards in my piano classes, I facilitated improvisation sessions where students could experiment with the different sounds and styles available on their keyboard. At first, students were individually immersed in finding the 'coolest' or 'funniest' sounds on their keyboards. Eventually, the students shared their sounds with one another and tried to locate sounds to match or complement their classmates' sounds. Without a specific prompt from my end, the students began to collaborate in order to achieve an ensemble sound. On a few occasions, we audio-recorded our digital-keyboard-noise-fest to capture our ensemble moments within our typically-soloistic instrument. To extend this improvisatory and collaborative exercise, I incorporated music creation tools and websites on the iPad for students to experiment with. One of my favourite tools has been using Kandinsky on Chrome Music Lab, where the students can draw colourful shapes and lines which become 'playable' music loops. *(To see workshop ideas with Chrome Music Lab, see **pages 32-34** of the Educational Workshops document.)* After experimenting with the tool on an individual level, students would collaborate and layer the sounds as an iPad ensemble. In this way, not only would students explore composition, improvisation, and collaboration skills, but they could renew their understanding of mobile technologies like the iPad to represent a virtual, but *real* music instrument, accepted and encouraged in a space of music-making.

At the personal level, I have been pushing the need for collaborative learning and co-creating as a group. Sometimes my students would just want to get through their piano book and feel accomplished when they move to the next book level. While these personal accomplishments are nonetheless a valuable goal, making use of interactive digital resources to create music together (especially in a group or classroom setting) can allow students to value collaborative music-making goals and forming social bonds. With the telematic, digital tools available today, we are able to connect with our students across distances, at the leisure of our comfortable, home-spaces. Students, too, are able to contribute their musical work at their own convenience and at a time that works for them. In this way, students' learning truly becomes student-centered and self-paced, fulfilling the 'flipped classroom' model as previously discussed. With emerging music education tools that allow teachers to keep tabs on individual students' progress on music creations, theory exercises, practice sessions, etc., teachers are able to view students' progress in a more concrete and efficient way. Moreover, virtual spaces of teaching can allow more time/room to structure in music theory and other crucial skills like composing and using digital tools to mix sounds, which might have been neglected in the physical classrooms due to a constant focus on performance. Teachers can also facilitate online collaborative projects like virtual ensembles, singalongs, or group songwriting, and thereby amplifying the collaborative and community aspects of teaching music.

Outside of RPSM, teaching through the pandemic has been a mixed bag across my colleagues: some who cannot wait for the day we can return to our physical studios, some who rejected and completely devalued online teaching through videoconferencing, and some who are excited by the opening of the remote, telematic teaching/performing world, along with the digital capabilities within them that they did not know they possessed. At present, I am preparing piano students to take their Royal Conservatory of Music piano practical exams through Zoom.us (the same way I am virtually communicating with my students). I am collaborating with students and colleagues through musical collaborations on Acappella by Mixcord, and spending many hours recording, editing, and mixing videos/audios on DaVinci Resolve and Soundtrap. I have sent my younger piano students self-made piano tutorial videos/video compilations and music theory exercises through online music education software like Breezin' Thru Theory and musictheory.net recommended to me through my colleagues who are finding newer and better tools each day.

All in all, myself and many of my music teacher colleagues are doing a lot of active and consistent work – arguably more work than we used to do in the physical classrooms. So, the informational networks where we share information between teachers are crucial - to not only provide effective and engaging resources for our students, but to develop our learning and perspective of how to teach (and learn) in today's climate. It also allows us to build online musical communities for teachers and to look at the trends, hypes, latest knowledge of technologies.

Consequently, teaching and learning post-pandemic will most likely not resemble teaching and learning pre-pandemic. I speak to situations where not only the increase of digital and virtual tools will take a bigger presence in the classroom, but the way that teachers and students perceive and understand ways of teaching and learning will have changed. At present, it seems crucial to evaluate and consider the emerging technologies that could expand our current and future virtual spaces of teaching and learning.

2.6: Case Study: Symphony of Noise VR [Michaela Pnacekova]

Recording sounds and making music out of them is a way to compose for anybody, who is interested in sound. When we developed the VR experience *Symphony of Noise* (SON VR), we wanted to reach as large an audience as possible, which is why we decided to use ordinary sounds and the sounds from our bodies to create surreal and personalized scores. You don't have to be a musician in order to enter this VR piece and co-create with algorithms.

We were inspired by the UK musician Matthew Herbert, who sees himself as a sound documentarian - he records everyday sounds and makes them into music. It was the virtual reality form that could best translate Matthew's vision to the end user – to 'experience' the world differently through the super-sense of hearing and become the conductor of the world. The project is strongly inspired by Herbert's book 'The Music' where he creates soundscapes by association in the reader's mind. The idea of the VR piece is however not to translate the book word by word but to let Matthew's poetry be the introduction to a new world of sounds that is inspired by it but which is created by each user interaction differently.

SON VR offers to the visitors an insight into the world full of sounds while making it an experience as personal and individual as possible. To experience sounds of the world around us, but also the world within us. We want the visitors to use the virtual reality and make it their own reality; by zooming, gesturing, making sounds, breathing and moving within the soundscapes on offer, visitors can listen and hear sounds that they would normally not have access to.

The user journey flows through four sonic and surreal spaces. In Space 1 users are in a liquid space, seeing weird, fluid shapes floating around, inviting them to interact with them. By activating sounds through breathing and via controllers, they will create the first track of the composition of that microcosmic world - a surreal breathing bass.

In Space 2, users will become one with nature. In this world of ice, they will interact with crystal objects hovering in the space and unlock the soundscape of the wild. Northern Lights fill out the air as they are connecting with the universe by using your voice (singing, whispering, screaming into an icy cave-instrument). Harmony is created.

In Space 3, users will feel the chaos of everyday life and civilization as they walk through a typical supermarket. They will transform urban sounds into rhythm when they turn a milk fridge into a drum instrument. Rhythm is created.

In the final Space 4, users will feel the power of existence. Everything comes together sonically and visually - they become the conductor of their world and put together their own Symphony Of Noise connecting the bass, the harmony and rhythm they created through their bodies with surrounding activated ordinary sounds.

Through the following non-fictional techniques, there are specific goals of this project that impact the real, such as new storytelling techniques where co-creation with technology is key. The user is the core of the experience and its co-creator. Via users' actions such as playing with sounds and interacting

with environments through moving, hand-gesturing, breathing and voice, it is our aim to create sonic sonic landscapes that are universal but at the same time highly personal; the user will thus also document their own bodily sounds in order to create their own symphony of noise.

The co-creation with technology takes place when the bodily sounds become the tools for the algorithmic score. Once produced by the user, they take their own journey and their sound is re-created through the software. The body becomes the narrative and musical tool. The project is about listening to ordinary sounds differently by interacting with the objects and diving into spaces one could normally never enter. Plus, the creators worked with binaural 3D sound which enhances the experience in such a way 2D formats could never do.

With the field of Virtual Reality still being a platform that is constantly developing and evolving, both regarding the technology and the reception of it, this approach will help establish Virtual Reality, as well as convey not only our concept of music and sound. Our aim is to seduce, surprise and provoke the user to open up to a world of music happening around them everyday. It is to re-imagine, re-experience sound and hence our bodies, daily lives and world through new ways of Virtual Reality tools. *Symphony of Noise VR* will be released on Steam in fall 2020 for HTC Vive Pro and Oculus Rift.

2.7: Studio 1. Music Technology Studio Built around Synchronous/Asynchronous Learning

Hardware:
Apple Mac
Apple iPad
Podcast studio for staging synchronous or asynchronous recording [Microphone and recorder]
Webcam
Audio Interface e.g. Focusrite Scarlett or higher, MOTU M2 or higher

DAWs:
GarageBand
Logic Pro
Ableton Live
Audacity

Video Conferencing :
Zoom
Skype
Discord

Audio Routing Software:
LoopBack Audio

The DAWs selected are based around providing access to a variety of user needs and skill sets.
In considering the studio as a space for teaching, but also as a space for catering to the needs of remote learning, the addition of a Podcast Studio for staging synchronous or asynchronous recordings is proposed. The microphones are typically condenser microphones are studio-quality though this may vary based on the need for recording instruments as well. These are either directly connected to the computer through an audio interface, or are attached to an audio recorder such as the ZOOM H1n. The benefits of having a handheld recorder such as this is its portability in situations where ensembles or

performances need to be recorded outside the studio. In such cases, an external webcam will also help to facilitate the video conferencing/recording's reach outside.

DAWS:
GarageBand is an easy entry level DAW for music production, **Logic Pro** is a logical next step as it has similar layout and usability combined with more advanced tools and functionality. **Ableton Live** provides a different way of working to GarageBand and Logic which are more focussed around building music in a linear fashion using a timeline. Ableton Live provides an environment that allows for easy access into performative practice, real time sampling and sound manipulations. Ableton Live also incorporates a powerful timeline based sequencing capability.

Audacity — Open source recording software. It is a great tool for learning about how to edit and work with sound as a waveform. I find Audacity's spectrogram view to be a particularly useful feature for sound education as it enables students to see an FFT based visualisation of frequency information in their recordings. https://www.audacityteam.org/

Loopback — A Mac app that allows signals to be routed electronically between applications. This is useful for recording sound directly from the sound card I.e audio from YouTube or recording stand alone software or VSTs into DAWs. https://rogueamoeba.com/loopback/

Orca — Simple and intuitive live coding environment. Can be used to create unique sequences and rhythms through functions such as euclidean rhythm and random logic very quickly. ["Orca is an esoteric programming language, designed to create procedural sequencers in which each letter of the alphabet is an operation, where lowercase letters operate on bang, uppercase letters operate each frame.The application is not a synthesizer, but a flexible livecoding environment capable of sending MIDI, OSC & UDP to your audio interface, like Ableton, Renoise, VCV Rack or SuperCollider."] https://hundredrabbits.itch.io/orca

Apps:
Samplr — Samplr is a powerful sampling and performance app for iPad. It has been used by many well known sound designers and performers such as Richard Devine.
"If you asked someone to say "what's the best live sound manipulation tool" for iOS, the two answers you'd like get first would be Borderlands Granular (for granular sounds) and Samplr (for loop manipulation). They're both deeply intuitive, immediate apps ideal for live performance."
Create Digital Music https://cdm.link/2020/02/samplr-ipad-update/

Samplr can be purchased on the app store.

SunVox — SunVox is a tracker based synthesis and music sequencing engine. It is completely open source and has great sounds and synthesis. Creating music using a tracker is quite unfamiliar for most people and can provide a unique new insight into creating music.
"SunVox is a small, fast and powerful modular synthesizer with pattern-based sequencer (tracker). It is a tool for those people who like to compose music wherever they are, whenever they wish. On any device. On any system. And it's free for most of the systems, except the Android and iOS."
https://www.warmplace.ru/soft/sunvox/

SunVox is open source and can be used on Apple computers, tablets, phones and most computers.

AudioBus — A tool that lets the user route sound between multiple apps. This is useful on the iPad where you might want to record the output of an app such as Samplr into GarageBand for further editing and manipulations.
https://audiob.us/

2.8: Studio 2. Open Source Studio & Creative Coding

- The mission statement of One Laptop Per Child (OLPC):
- "To create educational opportunities for the world's poorest children by providing each child with a rugged, low-cost, low-power, connected laptop with content and software designed for collaborative, joyful, self-empowered learning. When children have access to this type of tool they get engaged in their own education. They learn, share, create, and collaborate. They become connected to each other, to the world and to a brighter future"

The open source studio uses a Raspberry Pi 4 model B running the operating system Raspian. I purchased the unit for $88.75 from Creatron. The peripheral devices such as monitor, keyboard and mouse are not included with the machine and need to be purchased separately.

This music technology studio is based around the Raspberry Pi as it is a versatile and machine that is more accessible cost wise than a Windows or Apple computer or tablet. The Raspberry Pi also includes a number of resources for learning more about computers and programming through creativity such as Sonic Pi — a live coding environment for sound and Scratch which is a visual programming tool developed by MIT.

Hardware:
Raspberry Pi 4 model B, 4GB ram, Raspian OS

DAW:
Reaper — An open source DAW which can work with audio and Midi. Reaper is used widely in the sound arts community and by sound designers for video games. It is open source and available for free with a donation suggested if you like the software. It operates similarly to other DAW and is versatile across audio formats and I can incorporate media such as film. Reaper is reasonably intuitive but not quite as accessible as GarageBand or Logic.
https://www.reaper.fm/

Apps:

- SunVox and Orca paired together. — Orca as a sequencing tool and SunVox as a sound generator. The output of these sessions can be recorded using Reaper and then edited/manipulated and combined with other recorded materials.

- Audacity as part of the Raspberry Pi studio as it provides some useful and fundamental tools for investigating and understanding sound.

- There are many interesting pieces of software written for the Raspberry Pi but this selection has been chosen because it is particularly interesting and closely links into technologies available on the Apple machines at the RPSM.

- Part of the beauty of systems like the Raspberry Pi is self exploration and working out new ideas and solutions to problems through creativity and play.

*See appendix for a list of recommended technological resources (including handheld recording devices and software tools/games/online resources for music education and sound creation)

*For a list of workshops using DAWs, see **pages 20-22** of the Educational Workshops document.

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3. DIGITAL ENVIRONMENT

What is truth in digital media? Where is truth? When are untruths acceptable in digital technology? Consistency, Erasure, Palimpsest, Pentimenti, Field of vision? Transparency and reflection. How is identity affected (shaped, formed, reflected) by digital technology? Networked identity, networked-self, Loss of identity due to loss of technology. Whose digital metaphor is whose? Multivocality, multilinear. What is digital time? How does digital technology affect our sense of time and our representations of time? Synchronous, asynchronous, intertextual (inter-time?). Where is digital place? Where is digital space? How does the space between digital perspectives affect our view or perspective? Movement through space, instantaneous relocation, transience, transparency, reflectivity, multidirectional, interrelated, connected, visual cultural space Who owns what in digital technology? Where is ownership? How is ownership redefined? Repurposing, rearrange, reperform, retell, appropriation. When is digital technology finished? If the story goes on without us, how do we know? Does it matter? Should it?
(Taylor & Carpenter, 2007)

3.1: A Comment on Today's Condition

In the past six months, due to the current crisis, the discussion around privacy issues became more present again. Several countries dealt with the situation using modern technology each differently. The non-democratic and totalitarian systems battled the pandemic via all means necessary - surveillance and contact-tracing apps were the pillars of the battle in China and Russia. Interestingly enough, after the virus spread to Europe, EU countries were looking at the communist China as an example, which was pretty surprising as it was apparent that totalitarian tactics were applied to fight the virus. The city of Wuhan was closed, people were not allowed to go outside at all, and each citizen had to install the Covid-19 app, which measured temperature and tracing their movement. Authorities used drones "to scold people in Inner Mongolia - more than 1,000km from Wuhan - who had gone out without masks....Some buildings will only let in those who have got the go-ahead from a software called 'Health code' that gives individuals one of three colours, based on their recent travel history."
Russia used surveillance and face recognition software as the most effective technique to control its citizens. This is done through a network of "tens of thousands of cameras - installed with facial recognition software - which they plan to couple with digital passes on people's mobile phones." Facial recognition software has also been used in the Black Lives Matter protests to trace the protesters, which is a large breach of the citizen's right to demonstrations against their government. This software is used by the U.S. police via third parties such as Facebook and Instagram. Due to these breaches, however, producers of these pieces of software are re-considering their businesses. IBM announced that they will not produce facial recognition software. IBM chief executive Arvind Krishna announced that "IBM firmly opposes and will not condone uses of any technology, including facial recognition technology offered by other vendors for mass surveillance, racial profiling, violations of basic human rights and freedoms."

Moreover, thanks to increasing digital literacy of the citizens themselves, the developer Noah Conk and an anonymous group of developers recently released an iOS shortcut that blurs faces of the protestants in order not be identified by facial recognition software and deletest metadata, so that one can't trace when and where the photo was taken.

Nonetheless, there are also positive examples of using technology to battle the Covid-19 pandemic, for instance. Germany is one of the countries which uses a prediction model which "It attempts to capture the mathematical structure of the phenomenon – in this case, the pandemic – and to understand the causes of what is observed." This model is trained by legally gained data by the government, and that is through testing and identifying outbreak hot spots in Germany. Then the further testing is targeted to specific places and groups of people in order to eliminate the virus. One only wonders, why other countries didn't take Germany as an example but rather the totalitarian China. Our suggestion to answer this: it was simply cheaper and faster without needing the human and financial resources.

All in all, there is a certain paradigm shift going on due to these crises where digital literacy will lead to increasing citizens' agency and justice. Therefore, it is more crucial than ever that students are 'digitally empowered' more than ever.

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4. CHILDREN

It was the end of the day. It was August. It was hot. The classroom had no air-conditioning. The kids were tired, cranky, and restless. The usual end-of-the-day story time was failing miserably. So we got them to sit down on the collection of mats we kept on one side of the room, and told them we would do a short "repeat after me" song. The song was going to be recorded, and we were going to show their parents, so they had to be REALLY good and REALLY focussed in order to put on a good performance. I told them we would first listen to the song, and then, we would teach it to them.

And then I pressed play.

CRASH! BUZZ! VROOM!
There was a veritable explosion as a razor guitar, lightning bass, and cacophonous drums broke the silence.

And then, I jumped up, and started SCREAMING along to the chant now blasting out of the industrial Bluetooth speaker we had in the classroom:

HEY! HO! LET'S GO!
HEY! HO! LET'S GO!
(bass)
HEY! HO! LET'S GO!
(guitar)
HEY! HO! LET'S GO!

(Marko Djurdjic)

[Anecdote from Case Study 4.5 below]

4.1: Building the Music Classroom

- Building on the philosophy of improving digital literacy and removing barriers to entry within instructional curriculum, structured by Krish Chetty, Liu Qigui, Nozibele Gcora, Jaya Josie, Li Wenwei, and Chen Fang in “Bridging the digital divide: measuring digital literacy,” this literature review offers a variety of pedagogical approaches to technology in the classroom, and more specifically, technology catered to children learning music at Regent Park School of Music in Toronto, Ontario, Canada.

- Congruent with the already accessible and nuanced nature of contemporary education, suggested pedagogies consider mitigating factors such as social, economical, and financial concerns, different learning abilities, and age-(in)appropriateness. Through analyzing the interwoven relationships between pedagogues, students, and digital technology in an ever-changing technological atmosphere, instructional suggestions are made in hopes of meeting students where they are and abandoning outdated one-size-fits-all standardized teaching methods.

- A study conducted by Louise Archer, Emily Dawson, Jennifer Dewitt, Spela Godec, Heather King, Ada Mau, Effrosyni Nomikou, and Amy Seakins about the Bourdieusian-inspired pedagogical approach attempted to justify the use of socially-just pedagogy to engage students with science in an encouraging manner, as it produced positive results in student participation and an increase in the number of students speaking up in class. (Archer, et al. 2018)

- With similar intentions, from the LGBTQ youth advocacy perspective, Boni Wozolek’s “In 8100 Again: The Sounds of Students Breaking” identifies the significance in allowing ample space for queer voices in the classroom so as to prevent or greatly reduce the adolescent suicide toll from this group of students (Wozolek 2020).

- Pedagogical journals of different fields tend toward discussing undergraduate-level teaching. Some older, advanced children can benefit from university style instruction. Employing these technologies from the lecture halls to the music classrooms, challenging students within their means while also preparing them for what is to come in the near future should they choose to pursue music seriously.

- “Pursuing an Ethical, Socially Just Classroom: Searching for Community Psychology Pedagogy” urges community psychologists in faculty positions to emphasize their impact in the community and avoid treating their classrooms as merely vessels for delivering knowledge (Lichty and Palamaro-Munsell 2017, 1). It is the duty of ethical and responsible pedagogues to resist and actively counter Eugenics (a deep seated pillar of childhood education history that has no place, nor should have ever had place, in the current climate) and Blockchain Technology in the classroom.

- Childhood education serves itself and should not attempt to commodify children as assets. In her book *Ethnocinema: Intercultural Arts Education*, Anne M. Harris reports her analysis of Sudanese students and discovered that focusing attention on the engagement of students amongst themselves rather than on proper Western instruction and learning outcomes was crucial in breaking barriers that could potentially divide the students (Harris 2012).

- Rachel Ruggirello identifies the shortcomings of the Teach for America program in that pedagogues often receive training from textbook examples of urban classroom scenarios but when faced with real-life situations are not able to properly respond. She argues that easing instructors into these roles by allowing them the chance to shadow teachers in the urban classrooms and experience the nature of these environments is the best practice for the students' best interest. (Ruggirello and Flohr 2018)

4.2: Socially-Just Pedagogical Practices for the Musical Classroom

- Anne Harris and Daniel T. Barney praise the way in which arts-based research has become a greater consideration in the critical theorizing of pedagogical dynamic; they argue that continuing this incline will strengthen and empower the potential for cross-disciplinary collaboration and dogmatic social change. (Harris and Barney 2015)

- In an effort to build upon Maria Montessori's philosophy, Diana R. Dansereau and Brooke Wyman developed strategies that increased the level of child-driven musical instruction usually in curriculum; they found that the students gained confidence in their musical abilities and that the students also excelled in other subjects as a result. (Dansereau and Wyman 2020).

- Musicologists and scholars from other fields make known their support of incorporating socially-just pedagogical practices in the musical classroom for similar (as mentioned in the prior section) and discipline-specific reasons. Jon M. Wargo elaborates on the notion of sound transcending usefulness within the inner-workings of educational institutions and works as a key to understanding (in)equity in social relations within the musical classroom. (Wargo 2020)

- Cassie J. Brownell, David M. Sheridan, and Christopher A. Scales explored the meaning of student-produced compositions in context of the students' communities, as an annex to the classroom; the compositional skills learned in the musical classroom transferred outside in a valuable way. (Brownell, Sheridan, and Scales 2020)

- Using polyphony as a metaphor for listening to and understanding multiple voices, Orit Schwarz-Franco describes a philosophy for absorbing the numerous needs of students at once. (Schwarz-Franco 2020) Michael Gallagher, Abigail Hackett, Lisa Procter, and Fiona Scott make a case against skills-based pedagogical approaches in the musical classroom and, rather, emphasize the importance of valuing not only verbature in early childhood literacy but in sound-making and listening practices. (Gallagher, et al. 2020)

- Noguerón-Liu investigated technology lending initiatives and device purchase requirements in new immigrant communities in the U.S., particularly among Spanish-dominant immigrant families, in an attempt to ensure schools use an equitable approach in their requirements with consideration for socioeconomic factors (Noguerón-Liu 2017).

4.3: Digital Technological Approaches in the Music Classroom

- The pedagogical practice of incorporating digital technology in the music classroom evolves along with technological advances. Especially in Australia, continual assessment of these strategies is performed by musicologists to ensure the most efficient methods of instruction are used.

- An intensive study of children aged five to eight years in five early childhood classrooms encompassed these students' responses to a variety of music technologies (McDowall 2009).

- The College Music Society (CMS) offered a workshop on women and music technology to orient female faculty with available technologies in an often male-driven environment, where women may fall behind in these advancements ("Women and Music Technology" 2000).

- Sam Reese and James Rimington identified evidence of major financial investments out of a growing concern to bridge the gap between technological exposure in the outside world and technology (or lack thereof) available in public schools in the U.S. (Reese and Rimington 2000).

- Similarly, Renee Crawford investigated digital technology standardly available in the music classroom in Victoria, Australia and, further, found that though technologies were available, they were often not utilized to full capacity or in a relevant way in line with the times (Crawford 2008).

- The following year, Crawford reported a significant change in the issues previously presented, noting that resources were used well (Crawford 2009).

- Although much has changed since 2006 in the world of technology, the "Technology Guide for Music Educators" is a thorough manual for confronting and then mastering music technology-teaching tools with insight from an assemblage of music pedagogues and technology experts in North America (Stubbs 2006).

- Kimberly C. Walls observed in 2000 the growing attention to educating incoming teachers with technological competency as a requirement for accreditation through the National Council for Accreditation of Teacher Education (NCATE) and the National Association of Schools of Music (NASM) (Kimberly C. Walls 2000).

- A study conducted in 2013 by Peter de Vries found that although preschool teachers had access to new music technologies they tended to rely on ones over which they had mastery but that did not match the current needs of the students (de Vries 2013).

- We recommend some online resources, games/tools for music education and sound creation here. Refer to the evaluation chart for recommended age/grade ranges.

4.4: Pedagogical Considerations

- One must consider the reasons for using a certain technology. Employing strategies that involve technology simply for the sake of including it are shallow and short-lived. Likely, students arrive in the classroom with knowledge of basic technological tools seen in other classrooms, such as Kahoot!

- Should these familiar and readily available resources enhance the lesson, the pedagogue may choose to use them within his/her comfort range. Another concern is balancing the company profit versus student access.

- Can each student's family afford to purchase the necessary technologies for at-home development? If not, can the budget support subsidizing lower-income families? In some circumstances, a flat fee is paid by the school and access is shared or purchased by students; this would allow the school a small profit while also allowing reasonable admission for students to use the program.

- Many publishing companies offer accompanying online resources with their textbooks. For instance, "The Musician's Guide to Theory and Analysis" (third ed.) by Clendinning and Marvin, through W.W. Norton & Company offers several online devices through its "Know It? Show It!" pedagogy coursepack, to assist older children with music theory at the undergraduate-level. These include: Ebook, video tutorials, "InQuizative" formative quizzes, and workbook assignments.

- Additionally, semester plan templates, corrected workbook pages, and exam copies are available to the instructor, who can view student activity, course progress, and automatic grading asynchronously. This comprehensive package is geared toward students who benefit from instant feedback and are motivated by competitive games.

- Of course, one must consider equitable instruction in any classroom. Children learn differently at varying stages of development and (dis)abledness. Therefore, pedagogues must ascertain that their instruction methods and choices made in the classroom are in-line with the students' needs.

- While digital technologies may resonate with a select group of children they will not necessarily with all of the students -- the pedagogue must then decide whether the cost-benefit of including the technology is worth involving the whole class at the expense of a few students or whether an alternate lesson plan is available for those students in need of it. Hopefully, the pedagogue develops individualised education plans in these cases.

- Especially in diverse cities, race, culture, and religion are of utmost importance in pedagogical considerations. In remaining cognisant of this notion, socioculturally respectful and sustaining practices will allow for fluid instruction for a wide range of children from differing backgrounds. Reagan Patrick Mitchell explored the socio-sonic spaces in African diasporic musical tradition of New Orleans, Louisiana. (Mitchell 2020)

- The important qualities of diasporic sound brought to the musical classroom produces a familiarity on which to build new concepts. Walter S. Gershon provides an alternative to teaching from a Eurocentric, colonialist perspective (Gershon 2020).

- In “Musicking in the City: Reconceptualizing Urban Music Education as Cultural Practice,” Ruben A. Gaztambide-Fernandez seeks to dismantle the institutional profiting off of “urban music” as it has been sequestered as a consumerist method of teaching instead of a priceless exploration of African American culture. (Gaztambide-Fernandez 2020)

- Further to this point, Jung Kim and Isuara Pulido caution that including hip-hop theory in curriculum is quite important, but not without careful examination of its impacts and the context to which it fits the students’ relationships amongst themselves and beyond the classroom. (Jung and Pulido 2015)

- Catherine Gaynor and Mehtap Akay justify the use of Culturally Sustaining Pedagogy (CSP), introduced by Django Paris in 2012, to include normalities of demographics other than the usual White narrative (Gaynor and Akay 2020).

- Two years following Paris’ CSP publication, Gloria Ladson-Billings wished to “remix” some of the core ideas to exemplify the ways in which she had benefited from using it (Ladson-Billings 2014). Joan Russell created a student-led music theory which allowed Inuit students among qallunaat (non-Inuit) students to unite with the land, moving the discussion away from a Eurocentric one. (Russell 2006).

- Shana Kirk inserts a new concern into the list of pedagogical considerations by shining light on the duty of music teachers to protect children, which now, more than ever, includes the cyber-classroom; she describes several technologies to secure student safety in the classroom and in home-studio settings when music technology use is assigned for outside of school. (Kirk 2020)

4.5: Case Study: City of Toronto Children and Youth Summer Day Camp [Marko Djurdjic]

Music can be strenuous, it can be stressful, and it should be learned and studied. However, music should also be expressive, it should be personal, and above all, it should be FUN, especially for children. I can listen to pretentious, drone-y, experimental music all day, but every now and again, I want to put on the Ramones. And that's reflected here, and in our first anecdote.

As a City of Toronto children's and youth summer day camp counsellor, I have utilized any and all methods to engage children, to get them involved, thinking, and at times, screaming. Having worked with children as young as four, creativity, as well as a *complete* disregard for your own hearing, are sometimes necessary to show kids the fun, excitement, and expressive opportunity that music affords.

One telling example came with the "Junior Jammers," our preschool program. It was the end of the day. It was August. It was hot. The classroom had no air-conditioning. The kids were tired, cranky, and restless. The usual end-of-the-day story time was failing miserably. So we got them to sit down on the collection of mats we kept on one side of the room, and told them we would do a short "repeat after me" song. The song was going to be recorded, and we were going to show their parents, so they had to be REALLY good and REALLY focussed in order to put on a good performance. I told them we would first listen to the song, and then, we would teach it to them.

And then I pressed play.

CRASH! BUZZ! VROOM!
There was a veritable explosion as a razor guitar, lightning bass, and cacophonous drums broke the silence.

And then, I jumped up, and started SCREAMING along to the chant now blasting out of the industrial Bluetooth speaker we had in the classroom:

HEY! HO! LET'S GO!
HEY! HO! LET'S GO!
(bass)
HEY! HO! LET'S GO!
(guitar)
HEY! HO! LET'S GO!

One of the kids fell back in mock exasperation, so others followed. One girl slapped her hands to her forehead and shook her head. And as the song progressed, I danced, and sang along. The other two leaders also danced along, grabbed the kids by the hands and got them to jump up and dance with us. Soon, we were all bopping along to the music. And exactly two minutes in, I abruptly stopped, and once again repeated that eternal credo:

HEY! HO! LET'S GO!

And just as soon as it started, it was already over.

The following instructions were simple as can be:

1) The words are HEY! and HO! and LET'S GO!
2) And yes, you can shout them. In fact, we *encourage* you to shout them.
3) Just do it in the right place.
4) But remember to HAVE FUN!

It took less than a minute, and they got it.

And they were four years old.

We filmed them running through the song twice, dancing and shouting and starring "punkingly" at the camera, and when one parent came early to pick up his daughter, he heard what we were singing, and instead of getting angry that his daughter was sweaty and screaming at 3:52pm (or thereabouts, the day ends at 4pm), he joined us and danced with her. It was a wonderful, transgenerational moment, and I wish I still had the video but when a computer crashes, so to do your files, and memories.

The next day, I brought my computer, hooked it up to a TV, and showed them their performance. And they, of course, loved it. They repeatedly wanted to watch themselves doing this simplistic chorus, and would sing and clap along, screaming with the words as if they were still being filmed. The documentation aspect here became key, both as a teaching tool, and as a way for the children to view themselves in the throes of musical enjoyment. The knowledge that they were being filmed got them even more excited and invested because they *love* seeing themselves act silly on camera. Because the chant was so easy, they were able to memorize it, perform it, and still "move" to the music without falling out of chant, or the rhythm (for the most part). When the song began, they went wild! (It *is* the Ramones, after all; how could you not!)

The best part was that they didn't even *care* about what was happening in the rest of the song. To them, there was an intro, and an outro, and the rest was just dance time.

The main purpose of this exercise is therefore two-fold:

1) Chants and repetition are great ways to learn rhythm and tempo. These songs can help students understand tempos and, for those reading sheet music and notation, Italian musical terminology, which is frequently used on sheet music, and which utilizes a series of common tempo marks.
2) (And this one, I think, is the most pertinent) By using pop music and coupling it with an activity, you will eschew traditional nursery rhymes and "children's" music, in favour of music that may be more applicable, more interesting, and more "real."

*For full workshop details of the above, see **pages 11-14** of the Educational Workshops document.

4.6: Case Study: Turning Point Music Lesson [Adam Faux]

We met the student “Julian” (not his real name) at Native Child and Family Services, and at a time when he had no home, and was struggling with substance abuse. His birth home is in a near suburb of downtown Toronto. At first Julian appeared mildly confrontational, but later I learned that he was struggling with panic attacks. These attacks became a regular part of almost every lesson. During the first lesson, I requested the use of a much quieter office space just off the main room, so that we could relax a little. We worked on naming a few first position guitar chords, and when I asked whether there was content that he wished to learn, many of the songs fell into the Americana genre, such as “I Walk the Line” by Johnny Cash. A follow up lesson started in the back room on another day and this time, Julian and I were joined by an unscheduled teen from Hamilton who asked to be identified as they, and gender fluid. We’ll call them Jamz.

Our guitar playing was gently interrupted in order to listen to and learn some dark indie music, and we attempted to support Jamz’s singing. Eventually what worked for Jamz, was for them to wear earbuds plugged into a cell phone, and to sing at the top of their lungs. The effect was powerful, and Jamz was clearly feeling safe and heard. On another occasion, Jamz would inspire a spirited discussion about race and identity and played a frame drum while performing their own lyrics and dancing confidently, and with a full-bodied commitment that to me felt like an epiphany. Later Jamz would post that singing moment to their web based social app. What I would like to impart here, is that both student and teacher benefitted from a simple ADAW environment and attitude.

On another occasion, Julian arrived, and was extremely agitated. We played a little guitar together until he paused, unable to engage; we talked about the wood that my Taylor guitar was built from and that he was playing, and the environmentally sustainable Mango wood of my Ukulele. He broke down and sobbed. His girlfriend of many years had left him, his closest friend had shot himself in the head only two days before. We talked, hugged, and then I asked if it would be alright if I fetched the in-house counsellor.

During our next visit Julian told Grouch and I that he would show us what he would like to emulate musically. We watched a music video supporting anarchic and violent gang-based content, that included a suggestion that the artist had shot and killed someone off screen. Both Grouch and I spent some time de-escalating and expressing our unwillingness to support the content that we had seen, but that his frustration and rage required an outlet nonetheless. Eventually Julian programmed beats, wrote lyrics, until Covid-19 put a stop to our creation together.

Most of the students that we teach eventually compose a track or two that they will share with their community. We are there to help them make a statement, and to help them put a sound or voice to their immediate concerns, and to learn from them. We can never know what will inspire their creation, but we can attempt to be ready to enrich ourselves in order to learn or make sense of an instrument or genre that we may not have any comprehension or connection with.

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TECHNOLOGICAL RESOURCES

Appendix 1: Handheld Recording Devices [Dan Tapper]

I am attaching a review of handheld audio recorders compiled in 2015 as part of a publication I made on field recording and recording electromagnetic sounds from space. Based on this review and my ongoing engagement with music technology hardware I would recommend the RPSM consider the **Zoom H4N recorder** as a low budget, robust and effective tool for creating field recordings and as an accompaniment for a digital studio which can act as a two channel recording interface.

TOOLS OF THE TRADE:

In this section I'm going to look at one of the simplest ways of listening to VLF signals by directly plugging the output of a receiver into an audio recorder. There are a number of cheaply available devices that allow us to quickly listen to and record VLF signals. There are several things to consider when looking at audio recording equipment.

Inputs – Make sure your receiver's output jack is compatible with the recorder. Many low-end recorders have limited inputs, which only accept 1/8" jacks. If this is the case tailor your receiver's output to the recorder.

It is also important to think about how many inputs you need. One is fine if you are content recording a single receiver but if you wish to expand your setup, a single input recorder may limit you. Other considerations should be about if you wish to use the recorder to record sounds outside of VLF. If this is the case you should think about what sorts of sounds you wish to record, the quality of the inbuilt mics and if you are able to connect and power microphones with XLR outputs.

Pre-amplification – The VLF signals coming straight from your inductor loop will often be very quiet. It is important to amplify these signals in the cleanest possible way, retaining a high quality recording with no distortion. Audio recording devices amplify the signals to some extent; this varies from recorder to recorder depending on the quality of the pre-amp. VLF enthusiasts often build their own pre-amplification devices to amplify signals whilst also filtering out unwanted areas of the spectrum so as to be more attuned to natural radio. From my experience I have found that building a successful pre-amp is quite a difficult task. It resulted with a louder overall signal but noise and distortion were also introduced resulting in dirtier recordings. From a process of trial and error I have found that twinning an audio recorder with a FiiO E06 headphone amplifier made it easier to cleanly monitor my recordings. I later digitally amplify recordings on a computer.

Zoom H1 – £70, €98, $110
The Zoom H1 is a small pocket device available for under £100. It is compact and powered from one AA battery. It features two inbuilt microphones placed in an XY pattern. The device has a single 1/8" mic/line in input. The device is often used as a microphone preamp

LISTENING TO VLF SIGNALS

for video cameras by budget filmmakers to increase audio quality. For the size and price this recorder is a great buy, allowing you to get started with listening to VLF signals as well as having a pocket-sized multipurpose audio recorder.

Olympus LS-11 – £141, €198, $221

The Olympus LS-11 is a popular low budget handheld recorder. It is larger than the Zoom H1 and powered from two AA batteries. It features two inbuilt microphones, a 1/8" microphone input and a 1/8" line in input. The device has quite low mic/line in input sensitivity and also has a built-in bass roll off, reducing low end frequencies. This feature is not ideal for recording VLF signals; the device's preamps can be boosted by using an external preamp but this adds extra cost and increases the bulk of what essentially is meant to be a handy pocket device.

Zoom H4N – £177, €248, $277

The Zoom H4N is a larger device than the H1 and LS-11. It is powered from two AA batteries. It features two built in adjustable microphones and two XLR and 1/4" jack inputs. It has a number of features not available in the previous two recorders including the ability to record four channels of simultaneous sound – two channels from the XLR and 1/4" jack inputs and two from the inbuilt microphones. This is not especially useful for recording VLF signals but could be used for recording a pair of inductors alongside the acoustic ambience.

Other useful features include the ability to take a mono input and monitor/record in two channels by doubling the signal. The Zoom H4N has a very high input and output gain, meaning that you can record and monitor your signals at high level. This is useful for VLF signals which can often come into the recorder at quite low level. This high level of amplification can result in some noise added to the recording from the preamps. I find the best way is to record at a

mid range level and later amplify digitally. The Zoom H4N is a really great way to get started listening to VLF. The slightly noisy preamps are a bit of a downside but overall the device allows you to pick up lots of clear sound from a variety of sources – I've found it to be specifically good at picking up snatches of radio transmission.

Olympus LS-100 – £246, €344, $385

The Olympus LS-100 is a slightly higher end recorder than the previous models mentioned. It is similar in size to the Zoom H4N. Unlike the other three recorders the LS-100 is powered by a lithium ion battery. This gives a longer battery life and is rechargeable. It features two built in high quality microphones, two XLR and 1/4" jack inputs and 1/8" mic/line in input. Like the H4N the LS-100 has a number of extra features, including a built in multi-track recorder, metronome and tuner. None of these are especially useful but expand the recorder's uses outside of VLF and field recording. The device has very high quality preamps for the price and size, resulting in clean recordings; however, the volume of low-level signals can sometimes be quite quiet. The built in headphone amplifier does not allow for signals to be monitored at a particularly high level so when recording VLF signals I often attach a FiiO E06 headphone amplifier to boost my monitoring signal. I later amplify the recordings digitally.

The LS-100 is a really great recorder for general field recording but I don't feel it is particularly effective for recording VLF signals. The device also has some annoying factory settings such as beeping buttons and a speaking menu. These can be turned off but it takes a little bit of time to tailor the device to your method of recording.

My Reccomendation

My recommendation for a budget recorder to listen to VLF would be the Zoom H1 as it is portable, requires only a single AA battery and is very affordable with a decent preamp.

My recommendation for a slightly more advanced recorder with more mileage in terms of listening to VLF and field recording in general would be the Zoom H4N. It is well priced, allows a lot of gain on recording and monitoring signals and has a simple and fairly intuitive menu interface.

Appendix 2: Software Tools/Games/Online Resources for Music Education and Sound Creation

[Chris Taeyoung Kim, Michaela Pnacekova, Natasha Walsh & Marko Djurdjic]

Name & Link	Type / $	Description/Usage	Evaluation
Soundtrap & Soundtrap for Education https://www.soundtrap.com/	DAW / music creation tool / Freemium	Soundtrap is a browser-based digital audio workstation (DAW) designed for collaborative music recording. Features include recording live audio, video chat and advanced collaboration (across all devices), which can be well suited for both creators and educators.	**Can teach music and audio recording in K-12 schools on a computer lab (only requires an internet browser with access to sound).** Soundtrap for Education (premium version with up to 50 users) allows a safer environment with walled garden and COPPA compliance to ensure student protection. Syncing abilities with Google Classroom for ease to create assignments, keep organized with admin panel, and foster creative, remote music making in collaboration with students.
Flat.io https://flat.io/	Online notation software / Freemium	Flat.io is a browser-based online collaborative music notation software that allows for real-time music notation and editing across multiple users, devices, and platforms. Users can use Flat.io to collaboratively write music together, or share original music with one another.	As a notation software, **students should have basic knowledge of western music notation and instrumentation**. Hence, **recommended for older grades (grade 6 and up).** Can be useful for students to create or arrange music collaboratively, or for teachers to share original/edited ensemble scores to be shared across multiple devices. Its syncing ability on multiple school-related technologies can be useful (Google Drive, Google Classroom, Moodle, Microsoft Account, etc.) Interface is simple, accessible (browser-based) and user-friendly, which would allow students with zero experience of digital notation software to use.

Flat for Education https://flat.io/edu	Online notation software / $	An extension of Flat.io, Flat for Education is a cloud-based collaborative music notation software that teachers can create musical compositions or music education activities to share with their students. The students are able to view, work-on, and turn-in assignments in real-time on the shared sheet music across locations, devices, and platforms.	Similar to above, simple interface to allow **use for students who have a working knowledge of western music notation (grade 6 and up).** Accessible on all devices, and can sync to google classroom and teachers can create separate 'assignments' and 'classes' to better organize the musical activities. Paid program - allows up to 51 users at once.
Chrome Music Lab https://musiclab.chromeexperiments.com/ **For workshop ideas on Chrome Music Lab, see **pages 32-34** of the Educational Workshops document*	Music creation tool/website / FREE	Chrome Music Lab (CML) is a free music creation website/tool that students can experiment with music in creative, hands-on, and interactive formats. All the technology on CML has been built with freely accessible web technology (i.e. Web Audio API, WebMIDI, Tone.js), allowing coders to easily build new interactive music experiences. CML is accessible across all devices on a web browser, and can be used in classrooms to explore music and its curricular connections to science, math, art, and more.	Due to its accessible and interactive format, CML can be entertaining and engaging for students as well as a source of learning for **students across ALL ages and musical proficiency.** CML does not assume traditional notation methods, easily reaching students without prior knowledge in reading and writing music. Although presented in a fun, user-friendly manner, the musical aspects of CML can formulate and foster complex ideas that will appeal to more advanced music students. CML can be an effective tool with its intuitive nature that encourages experimentation. The pre-formatted sounds on CML will allow instant success in students' compositions, thereby providing beginning musicians confidence and immediate gratification in their improvisation and composition abilities. Moreover, CML fosters collaboration skills. As CML can be accessed across devices and settings, students will be able to use the technology to practice and enjoy music-making outside of the classroom.

Acappella from PicPlayPost by Mixcord Inc. https://www.mixcord.co/pages/acapella	Collaborative music maker/app for iOs & Google Play / Freemium	Acappella is a collaborative music maker/multitrack tool available as an app for iOs and Android devices. Acappella can record multiple users' audio and video tracks, which can be synced to a single, simultaneous track. Users can record a track (sing, play instruments, etc.) and collaborate with up to 9 other users. Each user can record, edit, and share the music from their mobile devices. Audio editing features include optimizing sound with EQ, audio panning, noise gate and processor. Intended for an online musical community of sharing and collaborating on original songs - has an online community of millions of users that share musical creations; social media platform.	**Efficient for individual or group collaboration across devices and locations.** Not real-time, so each collaborator will have to send work to another user, and so forth. Students need to be able to listen to track and layer harmony or their music on top, and also **will require working knowledge in audio/video recording on a mobile device.** Can be a fun way to collaborate across any level/age but having skills previously mentioned will allow users to use app to full capacity. **Teachers need to be aware of privacy issues as the app is a social media app and can be shared to the public if the setting is not changed to private.**
Solfeg.io https://solfeg.io/	Music education platform / FREE for schools	Solfeg.io is an interactive app for practicing music instruments, focusing on teaching and learning through popular and well-known songs (i.e. Ariana Grande, Imagine Dragons). Designed to use in-school in a music classroom, teachers can display the lyrics, melody, chords, and rhythm with a projector or screencast, for a more interactive and hands-on learning experience. Learners can also download the app as a self-learning/guiding tool for learning guitar, piano, ukulele, and singing.	Since it is connected to a specific instrument, it **can be used for choir (voice ensemble) and small group piano, guitar, and ukulele.** The interface uses traditional western notation, so musical level and knowledge of students needs to be taken into consideration **(i.e. for grades 5-6 and higher)**. Might be more effective to use the app for a smaller group setting in order to ensure that all the students are on track and following the guidance of the app on the projector screen, or a personal device. For self-'learning, it offers an interactive chat-bot that tailors learning - advertised like a private online music teacher, which guides the learners to pre-made tutorial videos. Students might be more motivated to learn because of the popular tunes in the app.

MatchMySound https://matchmysound.com/	Music education plug-in/technology / FREE (*limited time)	MatchMySound is an interactive play technology to support remote music learning. Features include guided practice and performance assessment capabilities, secure platform for live video lessons (through Zoom), work assignment and providing progress reports. Teachers and students can access an app (iOs and Android) called achievemusic.com. Also supports ensemble settings (My Choral Coach) for guided practice, uploading repertoire, submit performance, etc.	For achievemusic.com, it is a currently free software (during COVID) for teaching for three months. **Best suited for private studios so teachers can organize and keep track, assign repertoire, etc.** Is linked to specific music instrument learning **(sources available are typically for piano, guitar, or voice).** This means that students will need access to some kind of instrument to be able to maximize this resource and actively communicate with their teacher. **More suitable for the private instrumental student rather than a full class/ensemble.**
Noteflight https://www.noteflight.com/	Notation software / Freemium	Noteflight is an online music notation software that allows users to write, view, and share music from any browser. It has an online community of over 2 million users, with user-created scores searchable for view in public scores, and professional scores available for purchase in the marketplace. Noteflight Premium: web-based audio recording feature - can record live audio directly into musical score; can be sent to collaborate with other users. Track and mier panel for panning audio. Recording features can allow teachers to share demo tracks so students can record their own version for collaborative products or for performance assessments. To practice improvisation skills over a pre-recorded section.	Similar to flat.io, but not real-time collaborative work. Simple interface, accessibility and user-friendly. **Suited for students that have basic knowledge of western music notation and instrumentation (recommended for grades 6 and up);** can be useful for students to create or arrange music or for teachers to share original/edited ensemble scores to be accessed across multiple devices. Noteflight Learn: for music education. Same as premium features plus organizing classes and creating assignments. Full library access of musical scores and lessons. Integration with Learning Management Systems like Google Classroom, Moodle, Blackboard.

Bandimal by Yatatoy https://www.yatatoy.com/bandimal	iOs app for music creation / $	Electronic music creation app for children on iPad devices as introduction to creation music; exploring beats, high and low sounds, clapping rhythms, adding movement to music. Creating music by adding effects, changing speeds, adding beat to melody. Uses 9 cartoon animals to represent band members or 'instruments'; can create collaborative composition by students making the musical decision on the elements of music.	The makers designed the app to 'sound great' (using a Kalimba (thumb piano from Africa) interface based on pentatonic scales - limited to five notes, which make it easier to compose something that sounds tonal. No musical notation or text - focus is on experimenting, play, and sound. **(recommended age for kids 5 and under)** No need for formal musical training or knowledge of musical notation. Kids will intuitively practice and build knowledge of musical elements through experimentation. Students get instant feedback of sounds created with immediate playback. Effective initial tool for learning to layer and compose music; students need to experiment with it for some time as they develop more 'quality' work and listen to what sounds more balanced etc. Since it is designed for younger kids/beginners, teachers might want to expand into learning musical elements/concepts afterwards to make the most out of students' playing.
Loopimal by Yatatoy https://www.yatatoy.com/loopimal	iOs app for music creation / $	Extension to Bandimal by Yatatoy, for slightly higher grades (K-5). Loopimal is a music creation app to build sequences and loops - hence, 'loop'imal. Again, with the concept of nine animals that represent different sounds (each animal has a different base beat), layer the sounds to create a looping melody.	Similar efficiency as Bandimal: simple interface, intuitive design can allow an easy entrance into experimenting with sounds, composing, while also indirectly learning about musical elements (beat, rhythm, melody, tempo). More explicit experience of visual and auditory loops compared to Bandimal. **Can be used for students K-5** as an introduction to more advanced loop mixers/DJ apps

Mussila Music School https://mussila.com/	iOs and android app for music education (music theory and piano) / Freemium	Game-based music learning app for young learners to teach basics of music theory, tutorials to play songs on the keyboard. Designed for self-learning with parental support - app can send musical progress report to parents.	**Best suited for a younger audience (ages 5-8) and beginners at learning music.** App has an interactive interface that is game-based with 'levels'. It shows direct progress for students which can be a motivating factor. Students can learn to read notes, count beats, and eventually play the piano (app is geared towards learning piano - so might not be suitable for children wanting to learn other instruments). Might be best suited for a supplemental tool in individual learning spaces rather than a collaborated learning as a class.
Melody Jams ($) https://melodyjams.com/	iOs app for music creation / $	iPad game/music-making app where you combine characters who each play various instruments (drum, guitar, flute, conga, bass, violin, trumpet, xylophone, keytar, tambourine) and each have distinct personality and animations to create a rock band. Drag the band members on stage, and the user can also 'join' the band on an instrument (piano, drums, or xylophone).	App is tuned to sound harmonious and tonal, so there is no 'wrong note'. It is **intended for toddlers (ages 3-5);** the musical learning is through experimentation, and learning the different kinds of instruments in a rock band, and which instruments go well with each other, etc. Can be used in an individual setting or small group to experiment with instrumental sounds.
Kapu Bloom Tunes ($) https://www.kapu toys.com/en/	iOs and android app for music creation / $	Make melodies through 'painting' by decorating a seed with colours on a palette. Intuitive (text-free) interface with lower tones on the left and higher tones on the right, which creates a flower with the pattern that was designed on the seed. When you spin the flower, the music/sound painted on the seed is played.	Can be a **fun starter app for children in creation and sound experiment (ages 3-5).** Can develop children's fine-motor skills (scribbling) and app provides a no-fail, immediate visual and tactile feedback as they scribble on the screen. Can make use of discussing the connections of sound to touch and colours.

Sketch-a-Song Kids https://www.sketchasong.com/#/	iOs and android app for music creation / FREE	Music creation app that uses 'sketching' as the basis for creation. Users can drag the instruments represented by colour onto the sketchpad. Explore sounds of 40+ instruments (keyboards, guitars, woodwinds, brass, voice, percussion); sketchpad system. Sounds are also divided into different styles or 'grooves' - house, punk rock, calypso, digital, etc.	Each 'sketchpad' has a pre-written chord progression. The notes that are sketched follows the chord progression, which also will allow the final sounds to sound harmonious. Can add sketchpads to create longer songs/loops. The inclusion of the chord progression makes it more complex than other similar apps for music creation while also incorporating colour, and drawing. Very interactive and intuitive. **Can be used for students in the primary grades (K-5) to look at composing,** which can be extended to a lesson on chord progressions, creating harmonies, etc.
PlayGround https://getplayground.com/ **For workshop ideas on PlayGround, see **pages 34-35** of the Educational Workshops document*	iOs app for remixing beats / FREE	Create music beats by swiping and tapping fingers on musical shapes; play, remix, and share. Created in collaboration with DJs, producers and beatmakers.	DJ experience on unique audio-visual experience with interactive and fascinating interface. **No musical knowledge is required to play.** Game-like, visual interface with mind-blowing sounds is **appealing to audiences across all ages and levels.** Can be used to initiate a 2-player mode 'jamming' to create collaborations. Sounds can be recorded and shared via social media. While the music and sounds are 'pre-recorded', an excellent app to allow students to visualize combining and layering sounds to show the relationship between aural and tactile.

Beepbox.co https://beepbox.co	Online, browser-based music/loop creator / FREE	BeepBox is an online tool for sketching and sharing instrumental melodies. All the song data is contained in the URL at the top of your browser. When you make changes to the song, the URL is updated to reflect your changes. When you are satisfied with your song, just copy and paste the URL to save and share your song.	Vast array of instruments and options available to make beats, loops. Sharing tool allows for collaborations. Does not require knowledge of formal notation, but terminology used in the tool (i.e. scale, key, tempo, rhythm, reverb, panning) might be **suited to a more older audience (middle/high school)**. Meant to be an exploratory tool but also has some instructions of which buttons do what, etc. social media component of created songs posted on twitter - also for song sharing, online musical community out there! but the beats and loops are considered original work and belong to their authors. Can encourage students to not only explore the sounds available on the tool, but create their own music compositions and share on a class cloud. Offline version also available to download.
Breezin' thru Theory & Breezin' thru Composing https://breezinthrutheory.com/	Music education website/ theory tool / FREE (*limited time)	Breezin' thru Theory is a music education website that contains 24 chapters of basic music theory content. Each chapter includes a lesson, drills, games, and tunes (where students can play their instrument - from band). Also comes with Breezin' thru Composing, where students learn to compose with 15 chapters that also aligns with the Breezin' Thru Theory materials. Uses Noteflight as a notation tool and composition activities through GarageBand or Soundtrap. Students can upload audio files of their compositions on the dashboard where teachers can keep track of all the students' work.	**Suitable for school music; western music notation and theory, as a remote teaching option that allows to keep track of students' progress.** All chapters are progressive, designed to go from chapter 1-24 (for composing app, 1-15). Teachers can see students progress organized by the different classes, download student results that can be shared with students and parents. Starts with music staff - **more suitable to grades 6 and up who have a basic understanding of music notation and how to apply it (in band).** An organized and effective resource for music classrooms

Musictheory.net https://www.musictheory.net/	Music education website/ theory tool / FREE	Free online music theory/resource tool that students can have theory lessons about basics of music notation, rhythm and meter, scales and key signatures, intervals, ear training skills and more. Exercises available for students to practice music theory and ear training skills, including customizable exercises to send students; assign exercises as homework. Students can practice/drill and also submit results to the teacher through a 'code checker', which is a feature available for the teachers.	Exercises and tools might be **more suited/effective to older students (high school);** can be used to teach music theory remotely and can be delivered to a larger classroom - each student can work at their own pace, and monitor their own progress. Results are immediate (you get the exercise right or wrong), so instant feedback would help students to improve.
Loopseque 8 - beat performer https://loopseque.com/	iOs/iPad-only app for creating music / $	Sequencer, sampler, effects; a wheel-based performer for rhythm improvisation; 32 tracks and 32 steps sequencer, can modify samples or upload own; compose patterns, mix projects, record, edit and share, can sync with Ableton live. Has more than 400 samples of bass, percussion, effects, chords, synths or upload your own. Can design your own project by adding the cover art, artist name and share it with your friends. Can record your live sessions performance and open it in your own DAW later. For at-home, studio, and live-gig use.	More complex interface that might be **more suitable for older students who might have experience with mixing and looping sounds, and who can edit with DAWs** in order to take full advantage of the program. Only compatible with iPads - would need access to individual devices if all students in the classroom want to work on an individual project.

LoopsequeKids https://apps.apple.com/us/app/looseque-kids/id473718143	iOs/iPad-only app for music creation / FREE	**Colourful music/sound-making tool for very young children (Pre-K+).** Children's version of Loopseque 8.	Can learn the basics of rhythm; symmetry of music patterns through audio-visual and tactile ways. Immersive tool with gentle sounds. **Great interactive experience for kids to experiment; elements of improvisation**. Only compatible with iPads - access to individual devices required for individual projects.
Singing Fingers http://singingfingers.com/	iOs app for music creation / $	Drawing and music creation tool - finger painting with sound for beginners. While you drag your finger across the screen, your voice or other sounds nearby turn into colors on the musical canvas. The pitch of the sound is translated into a color, while the loudness of the sound determines the size. Blank white space: you are recording. Colored space: you are replaying. Use up to five fingers to play back many sounds at the same time, forwards, backwards or sideways.	Exploratory tool to turn sounds into concrete, visual - 'seeing music', 'hearing colours'. 'Sound-drawing': sound can move forward, backward, sideways, or any way. No complex interfaces but only with touch. Also where real sounds/instruments become virtual, remixed like a DJ - can extend into soundscape composition projects. **While such a simple interface might be appealing to younger children, anyone at any level will be intrigued at the app; can use it to extend onto other projects for older students.**
Artsmesh https://www.artsmesh.com/	Real-time network music performance platform / FREE	Telematic music improvised performance - professional use to allow real time, distributed performances that musicians can remix, stream live multichannel uncompressed audio. 'Artsmesh is aimed to empower users who are serious global networkers: musicians and new-media performers, telecommuters and netcasters. TV production is going the way of the home recording studio and both are now able to network multiple nodes into one production unit for one concert/jam or permanent collaboration.'	**Can allow for remote musical collaborations across distances. Software seems less of an 'educational tool' but a professional application.** This would need required technologies to set up for efficient synchronous recording, mixing or streaming. If delivering to students, can collaborate with others and broadcast live globally via Twitch, YouTube Live, FB, Instagram, other social media live.

JamKazam https://www.jamkazam.com/	Online platform/app that supports live, synchronous music	Free website/online platform with user profiles and match-making options to share and connect with peers with a zero-latency, online music space (for collaborative, telematic music performances). “Play music live and in sync with others from different locations Rehearse without travel or space Co-write and produce music live Join open sessions to jam with others Record and live broadcast sessions Connect with other musicians and bands”	Can play instruments/music live, in sync with students in remote settings. Communicate through audio/video and also text chat. Audio setup can be difficult; hardware requirements might exclude many students. Options for ‘private’ sessions instead of public for privacy issues for students. However if all works out, **would be most beneficial for ensembles (choirs, bands) who want to rehearse or perform together in remote settings**
Musyc http://fingerlab.net/portfolio/musyc	iOs app/game for music creation / FREE	Create music soundscapes with a combination of geometry and physics, by choosing shapes from the menu, dragging it on the screen and hear the playback as the shapes bounce. “Musyc is a fun and innovative music application where touch turns into music. No use of piano keyboard or partitions, draw shapes and listen to your piece of music while viewing sounds bouncing on the screen. Enjoy the 88 instruments (organized into 22 groups) exclusively created and produced at Fingerlab music studio as well as all the exciting and new physical and music tools provided in Musyc.”	Starting with exploration of sounds by combining different shapes and lines, this app can also be cross-curricular for core math fundamentals/geometry/physics. **Can be used across ages and levels, but potential for older (more advanced) students to expand exploration into a music-creation project into real-time audio recording.**

SoundRebound https://www.exploratorium.edu/explore/apps/sound-rebound	iOs app/game for music creation / FREE	Sound Rebound is a creative digital toy to explore colour and sound for the iPad and iPhone. You can create music by adding shapes and balls to the screen, and sounds occur when the balls hit the shapes.	Similar to Musyc, can be a cross-curricular project with physics/geometry/mathematical concepts. Great explorative tool for soundscapes. **Can be used across ages and levels, and potential for older (more advanced) students to expand into a soundscapes project.**
Groove Pizza https://apps.musedlab.org/groovepizza/?museid=aWx0Swdup&	Online, browser-based tool for sound creation / FREE	"Groove Pizza is a circular rhythm app for creative music making and learning! It's also a playful tool for creating grooves using math concepts like shapes, angles and patterns."	Experiment with rhythm. Different 'grooves' (hip-hop, jazz, rock, techno, Afro-Latin) to teach students about different patterns and styles. **Can be used for younger grades, however, might be best for an individual or collaborative music creation project for older students.** (i.e. Finished sounds can be downloaded as audio or midi to rework groove patterns on DAWs and music notation software (i.e. SoundTrap, Flat.io, etc.)
Isle of Tune http://www.isleoftune.com/ **For workshop ideas on Isle of Tune, see **page 36** of the Educational Workshops document*	iOs game for music creation (also available for free on web browser) / $	Isle of Tune is a street/road construction simulation game for the iPad (also available on web browser) that creates unique compositions by building a musical city. You can build roads and add street elements (trees, houses, lampposts, bushes), and when you drive the car down the street, each object the car passes makes rhythmic or melodic sounds. Students can create original music or recreate familiar melodies.	Highly engaging music app that can **appeal to all audiences across age and level.** Can be used for individual experimentation, and can build into a bigger project. Sharing and collaborating is possible, and can upload finished sound to share with others.

Incredibox https://www.incredibox.com/ **For workshop ideas on Incredibox, see **pages 34-35** of the Educational Workshops document*	iOs game for music creation (also available for free on web browser) / $	"Incredibox is a music app for creating your own music with the help of a merry crew of beatboxers. Part game, part tool, Incredibox is above all an audio and visual experience that introduces kids and adults to notions of rhythm and melody - in double-quick time!"	**Suitable for all ages. Excellent tool for the classroom to teach rhythm and various music mechanisms to children**. "The app has been rewarded by the AASL (American Association of School Librarians) in the category of the Best Apps 2018 for Teaching & Learning. Also, Incredibox got the PEGI 3 certification and the Family Friendly label from the Google Play Store. Plus, as a parent, you can enable the Safe mode option (no internet interactions)."
Mazetools https://www.mazetools.com/	iOS and Android / Tablets and iPads / $	MUTANT: Your space to experiment – with Mutant you create "crazy different" music intuitively. Turn the Hypercube, and you can hear your sound from new perspectives again and again. SONIFACE: Music is a maze of the senses – Soniface is an exploratory and audiovisual composition environment to develop and perform unique music and soundscapes	Fit for creation of electronic music and its visualization. The app creates music through touch - fit also for beginners and students interested in DJing. Students will learn to connect their motoric senses with the sound.

Intone https://www.wearvr.com/apps/intone	Oculus Rift /$	You start off floating in deep space with a cluster of blocks in front you. You select blocks through the gaze-based reticle. Also, depending on the noises you make, the blocks will move and change colour. look at a cube and tap the "A" button on the xbox one controller to select it. Sing into the microphone and other cubes will move towards the selected one. The other cubes will push on the selected one. Try and "sing" the cubes into the colored spheres of influence. When most of the cubes are "changed" by the colored spheres of influence a bell will sound and a new sphere will be available to sing the cubes into. The last sphere of influence will make the cubes go very fast There are two other small spheres that change the shape of the cube. One will change it to a stick and the other will change sticks back to cubes.	It looks like an interesting experiment in interactive VR audio-visualizers. Instead of using existing music to visualize material, Intone uses voice. For students who aim to practice singing, this is an exciting game. **For all ages.**
Musical VR Playground http://playthingsvr.com/	HTC Vive / $	Playthings was made to welcome anyone to the world of virtual reality. Built for the HTC Vive, Playthings puts virtual drumsticks in your hands and sets you loose on a musical playground from another world. There's no complicated buttons or tutorials—everyone knows how to use drumsticks. But drums are for real life…	**Suitable for children as an introduction to music creation through play.**

Amplify VR https://www.youtube.com/watch?time_continue=2&v=hjJzcMFJSZs&feature=emb_logo	Oculus Rift, Htc Vive /$	The software analyses music videos for their rhythmic and color content. It allows the user to watch the videos in 360 environments that pulse, change and animate to the music enveloping the user in an immersive tactile experience. We have currently have nine customisable environments but new ones can be added and built to spec. Allowing artists to create if required a completely new and bespoke experience. Artist branding and logos can also be incorporated throughout the experience and UI to provide a completely white-label experience.	VR music video making tool. **Suitable for musicians who'd like to create their own VR videos and possibly release them. Might be interesting for students who'd like to connect visuals and music.** The software is primarily designed for Oculus Rift and HTC Vive headsets. However Playstation VR and even mobile units such as Samsung Gear or Google Cardboard can be supported with some modification on request.
Audioshield VR https://store.steampowered.com/app/412740/Audioshield/	HTC Vive, Valve Index, Oculus Rift, Windows MR / $	In the game, notes fly at you and you need to hit them with the correct remote control. One interesting side effect that Jeff Grubb writes is that you create new memories of your favourite songs. So if you're playing that song, because you were listening to that using your whole body, it subsequently creates a deeper memory. Similar to how, if you see a band at a concert, when you hear their music later you'll be reminded of the concert you attended.	It engages you to actively participate in the song and find the rhythm. **For beginners of music learning - all ages.**
Harmonix Music VR https://www.harmonixmusic.com/games/harmonix-music-vr/	Playstation / $	VR Visualizer - upload your music and create visualizations in VR	**All ages -** connecting music and VR - however you can't create music within, it needs to be ready. Agency also not big.

Music Room VR https://store.steampowered.com/app/431030/The_Music_Room/	HTC Vive , Valve Index / $	Unlike keyboard MIDI controllers, The Music Room allows you to strum, slide, bend and drum naturally and expressively. With 8 dimensions of expressive control per note The Music Room is the most expressive MIDI controller available and supports the future of MIDI, MPE. Play carefully scanned drums and cymbals from Pearl, Ludwig, Sabian, Zildjian, DW, and Gretsch. Play drums and our 3 unique melodic instruments. All these are integrated with Bitwig 8-Track, the leading expressive audio workstation. Easily loop and record instruments from VR, select presets and launch clips.	**Good for learning drums and acquiring rhythm.**
Music Maker https://store.steampowered.com/app/906810/Music_Maker_Steam_Edition/	Windows 7 | 8 | 10 (64-bit) FREE	Make music the quick and easy way – with the free Music Maker 2020 Steam Edition.Drag & drop sounds and loops to easily compose tracks in no time at all – no previous experience required.Record vocals, play your own melodies using virtual instruments and the mouse, keyboard or MIDI keyboard and edit the resulting sound with cool effects. With new features such as the customizable user interface and an arranger, Music Maker Steam Edition 2020 offers everything you need to make your own music.	**For beginners who'd like to compose their own music electronically. It's free and easy to use.** If you want to go more advanced, it might be too restrictive. Simple drag & drop controls; Combine sounds & loops; MIDI editing function & audio recording; In-app Store with thousands of new sounds, features and instruments

Odesi https://store.steampowered.com/app/260990/Odesi_Music_Composition/	Windows 7, 8 or 10 / $	An electronic music sketch tool that also represents chords. **The software is designed for pro musicians, but you can learn how to use it even if you don't have much experience with music production.** It'll teach you a lot of techniques used by professional producers and composers to make memorable music. Odesi gives you 138 bassline rhythms that you can use in your own compositions. Some of them have resulted in #1 hits for other artists. Dig through basslines and see what sounds good to you, then customize. The goal of the software is to give you starting points and help you generate ideas.	Can be used also as a tool to practice chords and to learn how composition works through simple visualization effects. You can: Create music for your band, produce your own tracks in any genre - House, Trap, Hip Hop, Cinematic, Rock, Pop and everything else, Create music for your games if you're a game developer, Create blueprints for your vocalists to follow, Create backing tracks to play guitar and sing to - it's like having studio musicians follow your every move Save both the audio files and the MIDI file so you can take your composition and share it with people.
Soundhunters https://www.a-bahn.com/projects/soundhunters	mobile app (android, iOs) Interactive doc FREE	*The Soundhunters Experience* is an interactive documentary experience which aims to capture the world in samples and transform it into music. It's a playful tribute to a cultural remix that lays foundations for a proper language - a musical one. Four interactive web documentaries follow four soundhunters as they work. For this project, the professional musicians visited an unknown city. Their mission was to compose a song out of sounds and voices heard in the place. As you watch these films on the website, sounds from the city are released one at a time. Once all the sounds have been released, you can access the finished composition, the "song of the city".	RECORD: If you feel inspired then you can become a soundhunter. As you hunt down sounds, use the mobile app to record, process and share them. CREATE: In this social network for soundhunters around the world, you can compose your first tracks, even if you know nothing about music. You can draw on the sounds from the films, your own sounds, and those captured by other soundhunters.

A Musical Tutorial 2.1 http://appspalette.com/program.php?id=26852	Windows Software / $	"Treble / bass note & chord sight reading. Associate notes to piano keys. Chord dictionary and musical games. Play, view and print scales, chords and triads. User log. Play classics. Print sight reading test papers. Intervals, ear tests, key signatures, rhythm and more"	Can be used as an additional tool to private/applied music lessons involving **western music notation.** Might be **more useful for more advanced students.** Considering the price ($24.95), however, there may be cheaper alternatives/more accessible apps (this software is only accessible on Windows OS) currently available that will achieve similar results.
AthTek DigiBand http://www.athtek.com/digiband.html#.Xxy6afhKiS4	Windows Software / $	"AthTek DigiBand is a piece of **automatic music composition software for Windows.** It can automatically compose music with flexible instruments and melodies. It can also improvise an accompaniment to imported audio files, live computer keyboard playing or humming. Rich instruments and music styles are integrated to this brilliant music software. With AthTek DigiBand, you will enjoy the fun of having a versatile music group on the computer."	Unique feature of 'auto-composition' or a click of 'I Feel Lucky' - advertised for **beginner-friendly software** that encourage musical improvisations. Free trial and free tutorial available prior to purchase.
Better Ears https://www.mamp.info/better-ears/en/	macOS Software + iOs/Android app/ $ (**Free version called 'Better Ears Beginner' available with limited features)*	"Better Ears is an educational Music Theory and Ear Training app, which helps you grow your musical skills and enhance your hearing capabilities. There are 13 different exercises included, starting from interval recognition all the way down to chord progressions - perfect for beginners and music-masters alike!"	Includes four preset levels: **beginner, easy, normal and professional. App can be utilized for musicians at various levels and skills.** Useful ear-training tool that can be assigned as individual work for large class, ensemble, and private/applied lessons.

Bloom http://www.generativemusic.com/bloom.html	Android/iOS app / $	“Part instrument, part composition and part artwork, Bloom's innovative controls allow anyone to create elaborate patterns and unique melodies by simply tapping the screen. A generative music player takes over when Bloom is left idle, creating an infinite selection of compositions and their accompanying visualisations.”	A soothing, multi-sensory sound/music creation tool that **can be used for musicians at all levels/ages/interests.** Can be used for creating ambient, relaxing sounds. Unique feature where if the screen is untouched, the software will generate its own music.
Classics for Kids https://www.classicsforkids.com/	Music Education website / FREE	Interactive music education website dedicated to help children learn about classical music.	Offers weekly updated material (quiz, activity/info sheets), podcasts/radios for kids, interactive games for kids (learning musical terms, composing, matching rhythm, note names, music history/composers, etc.), and other music education material (activity sheets and lesson plans). Helpful supplemental tool for **younger children** in classical music appreciation, guided by parent(s) or teachers.
Creative Kids Central http://creativekidseducationfoundation.org/kids/index.htm	Music Education website / FREE	“Creative Kids Central is a free public service web based introduction to classical music sponsored by KUSC Classical Radio and produced by the Creative Kids Education Foundation. Our audience is **children under 12 and their interested parents and teachers.”**	“The home page of Creative Kids Central is a music appreciation and listening experience that introduces kids to the varieties of classical music with sound and animation. Four separate music education modules exist on the site, with four more in development.” Similar interactive nature as above web-page. Includes many links to various music resources for both teachers and students.
Crayola DJ https://legacygames.com/?product=crayola-dj/	Android/iOS app / $	In Crayola DJ, kids can mix loops, add sound effects, and explore tracks in various genres. Kids can be a DJ by layering loops, scratching, and adding sound effects. You can	Colourful and flashy app with funky sounds. **Best for kids ages 6 and up** as an introduction to music-mixing and being a DJ.

		also ‘perform’ for a ‘virtual crowd, and has features that include ‘battle of the DJs’ between two players in 2-player mode.	
Do Re Mi https://apps.apple.com/us/app/doremi-1-2-3-music-for-kids/id479692413	Android/iOS app / FREEmium on iTunes; $ Play Store	“Fun music exploration app helps kids learn to play by ear. This educational app brings to life childhood melodies, allowing your child to make music with cute characters while learning how to play them.” Features include learning major scales, pitch recognition, game-like level feature (45 levels), familiar children’s melodies/tunes, creating recordings, etc.	**Suitable for very young children (ages 4-10).** “Kids can choose from music-related activities, such as creating their own music or learning to play popular kids' songs, such as Mary Had a Little Lamb. Parents can create an account to receive details about which apps in the network their kids are playing and what they're learning in those apps. Kids can connect with friends online in a social network designed for younger kids, where they can play games together and post to a wall. Kids have to choose nonpersonal usernames from the lists, and no personal information is collected from kids.” (link)
Drum Kit https://apps.apple.com/ca/app/drum-kit/id306474530	iOS app / FREE	“It's the closest thing to becoming a drummer without actually having a real kit. You can just tap to create your own beats, or you can play along to dozens of popular songs. It's super easy to use. The kit is a classic 4-piece kit with bass drum, snare, floor tom, hi-hat, crash cymbal, and ride cymbal. The hi-hat plays open, closed, and pedal sounds depending on where you tap. The drums animate and the bass drum pedal moves when touched. Drum Kit simulates the most realistic drum playing experience on the App Store.”	**Suitable for beginners with no experience with drumming** - can play along to favourite songs immediately.

Easy Music https://montessori.edokiacademy.com/en/our-games/creativity/easy-music	Android/iOS app / $	“Easy Music is the perfect initiation into the world of music, no theory required! It is a beautifully animated app to introduce kids aged 5+ to musicality. Children learn to recognize notes, pitch, rhythm, and melody in a nature-inspired game environment. An interactive sand castle serves as a musical playground where curious kids can experiment with various instruments, genres of music and objects freely to compose their first music piece.”	**Recommended for students pre-K to grade 2.** Good sound quality and fun/colourful/interesting visuals to help engagement. Accessible tool for kids to build musical foundations.
Hit’n’Mix Infinity https://hitnmix.com/	Audio editing computer software (macOs and Windows) / $	“The only true source separation, unmixing tracks down to the core components of audio – notes, harmonics, frequency, phase & amplitude.” Remix, repair and redesign mixed music.	**Advanced software for professionals or amateurs** well-versed in mixing and editing music. **Can be used as a teaching tool** to show students interested in audio-mixing the core components of mixed audio files.
Let’s Go to the Opera! https://www.amazon.com/Lets-go-to-the-Opera/dp/B00UTZBHF8	Android/iOS app / $	“Join a group of schoolchildren visiting the Opera House and be greeted by a friendly tour guide who will show all the nooks and most intimate secrets about the theater’s inner workings including orchestras, singers, choirs, dancers, lights, and scenery; discover how the show and the professionals who make it possible work; explained in a playful and didactic manner.” (link)	Can be used as educational support for teachers when discussing opera as a genre in classrooms or small groups. **Recommended for children aged 5-12.**
My First Step Sequencer https://www.kvraudio.com/product/my_first_step_s	Windows or macOS program / FREE	“My First Step Sequencer is a simple 16-(or 8-)step sequencer aimed at children. It comes with a shuffle mode and a note randomize button, as well as a scale-forcing control,	**Simple-to-use 16 step sequencer for children to experiment,** made accessible through use of animals, flowers, and colours. **Age 4+**

equencer_by_ndc_plugs		to make it so that you can only select notes within a particular scale. The notes are represented by animal heads in the carriage windows, with the velocities being represented by flowers on the carriage doors. The octave can be changed by clicking the body of the engine.”	
MusiQuest https://app.musiquest.com/	iOS app for iPad / FREEmium (paid subscription)	“MusiQuest is a creative new way to learn music that helps ensure all kids can access the benefits of musical learning and expression. It's an inventive experience intended to turn "device time" into a musical adventure loved equally by children and adults. With MusiQuest, you can: Write songs with 75+ real instruments (using block or standard notation); Explore over 300 guided lessons on subjects from Waltzes to Whales; Play with more than 500 pre-built song grooves.”	**Interactive music creation/exploration app designed for kids (K-6).** Students can build a song from scratch, learn grooves, go on quests/learning adventures etc.
Piano Dustbusters https://www.joytunes.com/apps#pdb	iOS app / FREE	“Piano Dust Buster is an ultimate introduction to piano, no previous piano experience needed. Students have the option to begin practicing reading notation, compete against other players or challenge themselves to 100s of songs ranging from Beethoven to Adele. Students help granny dust off her piano while collecting points and bonuses. Piano Dust Buster is a great tool to get your students excited about playing and practicing their piano.”	Ranges in levels. **Fun, interactive, and engaging app for kids (K-5).** Best suited to be played on the iPad. Works with an acoustic piano/keyboard to use a real musical instrument to play the game. There is also a special mode for practice reading music notation (staff mode).

Sago Mini Sound Box https://sagomini.com/apps/sound-box/	Android/iOS app / $	“This musical box of sound surprises is perfect for **toddlers**! Introduce children to sound and music with this magical app – just shake, rattle and tap! Listen for cheerful chimes, horns, drums, animals and more. Your little one is sure to laugh and giggle as they play.”	Recommended for **toddlers and very young children** to explore sounds on a colourful and interactive app with animal characters.
Sago Mini Music Box https://sagomini.com/apps/music-box/	Android/iOS app / $	Same characters as the Sago Mini Sound Box - this app takes young children and toddlers on a ‘sweet and soothing music adventure’ including familiar tunes like Twinkle Twinkle Little Star and Jingle Bells.	Recommended for **toddlers and very young children** to explore sounds on a colourful and interactive app with animal characters.
Sesame Street Makes Music https://apps.apple.com/us/app/sesame-street-makes-music/id1046694770	iOS app / $	Explore musical instruments, tempo and musical creativity with Sesame Street characters.	**Recommended for ages 3+.** Basic introduction to music genres and instruments. Can explore tempo and beat-keeping.
Theta Music Trainer https://trainer.thetamusic.com/	Music education web-page / also available as iOs and android app / FREE	“Theta Music Trainer is a complete system of online courses and games for ear training and music theory.”	“Ideal for classrooms and studios, it will help students get up to speed quickly with key music skills.” Divided into several ‘courses’ for the beginner, basic, intermediate and advanced levels. Guide is more **suitable for older students - grades 5 and up.**
Toc and Roll https://apps.apple.com/us/app/toc-and-roll-music-for-kids/id792034886	Android/iOS app / $	“Toc and Roll is a platform where kids can create songs by choosing instruments and dragging sounds onto a virtual multitrack. The app offers 10 instruments for kids to choose from. Upon choosing an instrument, a list of different sound clips appears on the	**Recommended for ages 4 and up.** Easy interface designed for young children to write, mix, and produce music. Has real instrument sound over midi.

		right side of the screen. Kids simply scroll to see the options and then drag the sound clips to the track to begin composing their song. They can compose songs with one instrument at a time or they can compose songs with multiple instruments. The voice option allows kids to record their own voice and add it to their musical creation. This requires that users grant the app access to the microphone and tap and hold the recording button. Kids have the option to name and save their songs and then share them." (link)	
Tune Train https://apps.apple.com/us/app/tunetrain/id702713073	Android/iOS app for iPad/tablet / FREE	"TuneTrain is a music creation app, where kids can quickly create and edit melodies through a fun line-drawing mechanic. In the world of TuneTrain, people live at various heights in colorful vertical buildings. To help these people get around, the user can draw a train line to connect them to each other. The magic is that the people represent musical notes and the train line represents a musical melody that kids can create and hear."	**Recommended for kids and elementary music.** Includes a teacher's guide.
Vibrafun http://apploudable.com/apps/	Android app / FREE	This app shows you how to play several popular songs on the vibraphone, marimba or xylophone (digital instrument).	Similar to other virtual/digital instrument apps. However, this app allows one to actually learn popular songs/tunes on the virtual instruments. Uses western standard note names. **Recommended for grade 1 and higher.**

WeVu for Music & Theatre https://wevu.video/wevu-for-music/	Web tool for music education/ organization / FREEmium	A Vancouver-based project. "WeVu just lets you add to your teaching toolbox. Video submissions from students so they do more, and more focussed, practice. You can subtract some of the challenges of in-person feedback or Skype and Zoom meetings. Phone cameras plus the cloud enable more practice, more feedback, and better feedback. Plus, WeVu is for applications and video auditions too!"	Designed to aid with remote and asynchronous learning. Can use for regular classrooms to keep student practice and assignments organized, to upload recordings, etc. **Suitable for both large class and private studio - any age.** Accessible through web browsers and information saved on cloud. Teachers essentially create their own 'site' for their classroom.
Yousician https://yousician.com/	Android/iOS app / FREEmium	Interactive music app to learn and play a musical instrument - **supports guitar, piano, ukulele, bass and voice.**	Can receive real-time feedback and instructions through songs, exercises, and lessons. A self-directed app, for specific instruments - **may be more suitable for older students who can self-guide their learning**.

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