Josu Mämmi

An Unlimited Instrument

Teaching Live Electronics and Creativity

Metropolia University of Applied Sciences

Master of Culture and Arts

Music

Thesis

May 30, 2023

Abstract

Author:	Josu Mämmi
Title:	An Unlimited Instrument: Teaching Live Electronics and Creativity
Number of Pages:	105 pages + 2 appendices
Date:	May 30, 2023
Degree:	Master of Culture and Arts
Degree Programme:	Music
Specialisation option:	Music Pedagogy
Supervisor:	Susanna Mesiä, DMus

This thesis explores the intricacies of teaching live electronics and the inherent creativity involved in this field. Live electronics involves the use of technology to create music in real-time performances, encompassing electronic and electroacoustic music. The study aims to enhance knowledge and understanding of live electronics within educational contexts. Despite its popularity in popular and contemporary music, the inclusion of live electronics in formal education lags behind.

This thesis first examines the definition of live electronics and its historical background. It then delves into the current technological possibilities and provides real-world examples. Lastly, it investigates the current state of live electronics education through semi-structured interviews with teachers from five western countries, focusing on teachers' backgrounds, challenges faced in teaching, and approaches to nurturing creativity.

The findings suggest that the possibilities of live electronics as an instrument are limited only by one’s resources and imagination. They also highlight the importance of creativity in both musical and technological aspects for mastering live electronics. The diverse teaching approaches arise from the fact that many teachers are self-taught in the field. Time and resource limitations pose challenges for both teachers and students, as live electronics requires dedicated learning. Teachers employ limitations and experimentation to navigate the vast array of opportunities available to electronics performers. Live electronics presents a unique platform for artistic expression across cultures, offering the potential to reshape our understanding of music and the creative process. The originality of this thesis has been checked using Turnitin OriginalityCheck service.

Keywords: music, live electronics, music technology, live performance, pedagogy, education, creativity, electronic music, music production

Tiivistelmä

Tekijä:	Josu Mämmi
Otsikko:	Rajaton instrumentti: Live elektroniikan opettaminen ja luovuus
Sivumäärä:	105 sivua + 2 liitettä
Aika:	30.5.2023
Tutkinto:	Musiikkipedagogi (ylempi AMK)
Tutkinto-ohjelma:	Musiikki
Suuntautumisvaihtoehto:	
Ohjaaja:	MuT Susanna Mesiä, lehtori

Tämä opinnäytetyö tutkii live-elektroniikan opettamista sekä siihen liittyvää luovuutta. Live-elektroniikka tarkoittaa teknologian käyttöä musiikin luomisessa reaaliaikaisesti esiintymistilanteessa, ja se soveltuu elektronisen musiikin tai elektroakustisen musiikin tuottamiseen. Tutkimuksen tavoitteena on lisätä tietämystä ja ymmärrystä live-elektroniikasta. Live-elektroniikka on ajankohtainen ilmiö, joka on suosittu sekä populaari- että nykymusiikissa. Sitä opetetaan monissa kouluissa länsimaissa kaikilla tasoilla. Sen sisällyttäminen koulutukseen jää kuitenkin jälkeen sen suosiosta populaari- ja nykymusiikissa.

Tässä opinnäytetyössä tutkitaan ensinnä, miten live-elektroniikka määritellään ja mikä on sen historiallinen tausta. Toiseksi syvennytään nykyisiin teknologisiin mahdollisuuksiin live-elektroniikassa ja esitellään joitakin käytännön esimerkkejä. Lopuksi tämä tutkimus tarkastelee, miten live-elektroniikkaa opetetaan nykypäivänä käyttäen menetelmänä kansainvälisiä puolistrukturoituja haastatteluja. Erityisesti tutkitaan opettajien taustoja, heidän kohtaamiaan haasteita opetuksessa ja heidän lähestymistapaansa luovuuden opettamiseen tällä alalla.

Tutkimustulokset viittaavat siihen, että live-elektroniikan mahdollisuuksille instrumenttina vain mielikuvitus ja resurssit ovat rajana. Live-elektroniikan hallitsemiseksi tarvitaan luovuutta sekä musiikillisesta että teknologisesta näkökulmasta. Live-elektroniikan opetuksessa on monenlaisia lähestymistapoja, sillä monet opettajat ovat oppineet alaa omatoimisesti. Aika- ja resurssirajoitukset asettavat haasteita opettajille ja opiskelijoille, sillä live-elektroniikan oppiminen vie aikaa. Opettajat hyödyntävät rajoitteita ja kokeiluja käsitellessään live-elektroniikan valtavia mahdollisuuksia. Live-elektroniikka tarjoaa ainutlaatuisia mahdollisuuksia taiteelliseen ilmaisuun eri kulttuureissa, ja sillä on potentiaalia muokata käsitystämme musiikista ja luovasta prosessista. Tämän työn alkuperäisyys on tarkistettu Turnitin OriginalityCheck -palvelussa.

Avainsanat: musiikki, live-elektroniikka, musiikkiteknologia, live-esiintyminen, pedagogiikka, koulutus, luovuus, elektroninen musiikki, musiikkituotanto, elävä musiikki

Contents

1 Introduction

Imagine stepping into a club in Berlin in 2023. The poster for the night mentions artists you have never heard of and a couple of them have the word ‘live’ added after their artist name. You step inside and hear unimaginable sounds blasting from a huge PA speaker system while a single person is sweating on stage twisting knobs and pushing buttons. Some faders get wiggled as well while some people dancing on the dance floor are not even facing the featured artist, just dancing, and enjoying the sound. What is the artist doing?

Repetitive music invokes a physical reaction (Warren 1994, 69-82) by its sheer volume, and the abstract sounds gradually detach you from reality. You have encountered ‘live electronic music’, or ‘live electronics’ as some call it (Harvey 1999, 79-82). Sounds you heard might not have had any traces of human instrumental performance at all (Warren 1994, 69-82). Where do these sounds come from and how are they made?

Electronic music is estimated to be the third most popular music genre in the world with a 32% share of all listeners of music according to IMS Business Report 2019 (Watson 2019, 5). It is also noteworthy that 26% of the people that answered the poll reported listening to hip-hop / trap, a genre that is fundamentally electronic, but listed separately in the survey. Unsurprisingly, the leading genre is pop, with its 64% listener share, which has inherited elements from the electronic music from the beginning (Cox and Warner 2017, 468), and can therefore be considered partly electronic. To verify this, I analyzed the global Spotify Top 10 list on 6 April 2022. On that date, apart from vocals, six out of ten songs could be considered completely electronic. Three of the remaining four songs contained significant electronic elements, and only one song was performed completely with electronically amplified acoustic instruments.

Yet an online search with ‘Electronic Music education in Europe’ in 2021 gave mainly degrees in music production or education in electroacoustic music. While

both are important and distinguished subjects, neither of them deals with playing popular electronic music (or popular music with electronic elements) live directly. While live performance is the largest income stream for musicians with a 28% share of all income in 2013 (DiCola 2013, 53), it is essential to incorporate the creative use of live electronics into western education on all levels. While the so-called traditional acoustic instruments still seem to rule the educational world today, many schools and institutions have started providing education in electronic music tools and live electronics such as Berklee College of Music (Berklee 2023).

I am interested in how this subject is taught on different levels of education now and what the characteristics of electronics or laptop are as an instrument. The laptop has already taken its place as one of the most popular instruments of our time, yet most of the music teachers in my working environment still seem to be unaware of its full potential. It might also be hard for traditional instrumentalists, a pianist, for example, to understand how pushing a button on a controller could be creative artistic work. Where does creativity lie in live electronics? It is hard to blame them, since the technology is advancing fast and working methods keep changing with it.

My research questions are:

1. What are the common tools live electronics performers work with today and how did they emerge?

2. How is live electronics taught in formal education today?

3. What are the most common challenges teachers face when teaching live electronics?

4. How can creative use of live electronics be taught?

To answer the first question, I did a literature review and compiled a short history of live electronics as well as a practical overview of the common

devices, programs and concepts live electronics performers use. In this thesis, I also discuss a few real-world examples. For the latter three questions, I interviewed six teachers who have taught this subject and can therefore be considered experts in the field. The interviewees bring an international aspect to the thesis as they are from Belgium, Finland, United Kingdom, and United States.

2 Live Electronics

To understand the idiosyncrasies and nuances in live electronics, we need to know the definition and background of the term. This chapter starts by defining the term and then provides a brief historical overview.

2.1 Defining Live Electronics

Defining live electronics is challenging. As a term, it is more widely used in academic contexts than within popular music or in electronic dance music (EDM). There is no singular all-encompassing term in literature to describe the phenomenon. There are terms such as 'live electronic music', 'electronic live' or even 'a hybrid set'. When live electronics acts are featured side by side with DJ acts in posters for Berlin clubs such as RSO or Berghain, the nature of the acts is indicated simply by writing 'live' after the performer's name. If not specified, one would assume the act is performing a DJ set. To keep things simple and to unify the worlds of contemporary, often academic, art music and so called EDM, I choose to use the term 'live electronics', since it describes the phenomenon clearly in two words.

To define the term, we must start with the word 'live'. 'Live' in this context means that there is a presence of a human performer, who "takes decisions and/or makes actions during a performance which change the real sounding nature of the music." (Emmerson 2007, 90)

Some former definitions referred to gestures and physicality, but in the age of Elon Musk's Neuralink and other applications that can link human brain to almost anything (Neuralink n.d.), the limits of physical interfacing and gestural input are losing their meaning. Whatever the interface is, the essential elements are real-time input and control of the music which are in the hands of the performer.

The second part of the term, 'electronics', simply refers to any sound that is made with the help of electronic means or made purely by electronic means (Emmerson 2007, xiii). However, this definition is problematic as this way everything amplified or heard through loudspeakers can be regarded as electronic music or live electronics. As almost all music since the invention of the amplifier is transmitted through a loudspeaker at some point, with the exception of fully acoustic performances, I find it necessary to set clearer boundaries. In *Audio Culture – Readings in Modern Music* (Cox & Warner 2017, 607), electronic music is defined as music made primarily by non-acoustic means such as tape manipulation, analogue synthesis, and digital synthesis. In the context of the digital age, tape manipulation has been replaced by sampling that includes playback and editing of digital sound files. We can directly apply this definition to 'electronics' as well, as all live electronics entail electronic music in some form.

To conclude, the term 'live electronics' stands for a human performer who manipulates music made primarily by non-acoustic means such as tape manipulation, sampling, analogue synthesis, and digital synthesis. The interesting question is: how is this manipulation done? Here lies one of my main interests in live electronics and the creativity it allows. There are as many approaches to the real-time manipulation of electronic sound by electronic or acoustic means as there are electronic live performers. These vast and ever-expanding possibilities are discussed in chapter three. To understand how these possibilities were created, we need to examine the beginnings of this artform, and the technologies involved.

2.2 Early History of Live Electronics

In the next chapters, I will give a brief overview of the history of live electronics. To understand the tradition and one's own position in live electronics as a performer or spectator, knowing the cultural and technological background gives a good basis to start studying the newest trends in the field. Much like when pianists play the works of Johann Sebastian Bach before delving into Phillip Glass or John Adams, live electronics performers can gain essential techniques and aesthetic views from studying the history.

Electronic music emerged in 1877 when Thomas Edison invented the cylinder phonograph (Marco 1993, xvii). The phonograph was able to record music and when combined with an electronic motor, it could be manipulated electronically. In principle all the recorded music after that became electronic music at some point. Later, the definition of electronic music had to be changed since not all recorded music could be labelled electronic or the term would have lost its meaning. The emergence of live performance of electric music or electroacoustic music happened a couple of decades later.

The earliest live experiments with electronic sounds and music were conducted by Italian futurist Luigi Russolo circa 1910. His Intona Rumore instruments were designed to imitate the noisy sounds of modern machinery and traffic. Russolo's letter *The Art of Noises: Futurist Manifesto* is one of the most important texts of the 20th century aesthetics (Cox and Warner 2017, 11). However, for such reasons as politics and world wars, his works did not start a movement right away.

Electronic instruments were used in a more traditional orchestral live context in the early 1900s as a part of the orchestra or as a soloist. Leon Theremin developed the Theremin in Russia in 1919 (Crab 2023, 31). The instrument was based on tube oscillators, a fruit of the accelerated development of radio technology during the first world war. It was considered futuristic at the time since it was controlled via manipulating an electromagnetic field while not touching the

device at all. The instrument gained popularity for its expressivity and notoriety for its challenging user interface.

Maurice Martenot developed Theremin's idea further by implementing a keyboard and a touch strip to control a single oscillator tube synthesizer. This interface was more familiar to the instrumentalists of the day than Theremin's inventive approach. (Crab 2023, 43). As a result, a device by the name of Ondes Martenot was created in 1928 and was used around central Europe as a soloist instrument with orchestras. Shortly after Friedrich Trautwein and Oskar Sala followed with their Trautonium synthesizer, which was used in film scores as well as orchestral pieces (Apple 2022, 725). During the interwar period, monophonic electronic instruments of this kind enjoyed a brief period of popularity but failed to make a lasting impact on music (Manning 2013, 5). The music made with these instruments was primarily orchestral and the electronics were a by-product. Hence the definition of live electronics in the sense specified in the previous chapter was not met yet, though it was getting close.

2.3 Electronics Take the Centre Stage

The beginning of live electronics as an artform can be dated to the year 1939 when composer John Cage gave performances with two turntables playing recordings of synthesized sine waves (Stubbs 2018, 115). This was approximately 30 years before hip-hop DJs started using turntables as a musical instrument. This also predates the invention of tape recording in the 1940s (Burgess 2014, 44), which started the live electronics and electro-acoustic movement in contemporary music.

After World War II, there were significant advancements in technology that were beneficial to the music industry. These tools enabled composers to utilize various electronic devices to produce both sonic and temporal textures that could be saved or recorded onto audiotape, data tape, punched cards, and eventually digital computer memories (Raaijmakers 2000, 14).

One of the most important inventions of the time, tape technology, was advanced significantly mostly by German engineers (Burgess 2014, 44-45). After the war, tape technology was employed in recording speeches and music which led to the creative misuse of the technology. Experimental contemporary artists such as French Pierre Schaeffer and Egyptian Halim El-Dabh (Google Arts & Culture 2023) started to create tape collages in their studios by cutting and re-recording tapes. But it was John Cage on the forefront again with the first piece to use tape recorders live called *Williams Mix* in 1952. I 1959, Argentine-German composer Mauricio Kagel composed and performed *Transición ll* (1959) with piano, percussion and two tape recorders (Manning 2013, 157-158). German composer Karlheinz Stockhausen, a pupil of Schaeffer's, soon followed with several electro-acoustic compositions for live performing, and so live electronic music became a major sphere of activity in Europe during the 1960s (Manning 2013, 65-67). Government funded electronic tape music studios started appearing all around Europe and the United States at universities and broadcast centers (Dunn 1992, 18). Most of the material created in these studios were not intended for live performance, since working with tape was a slow and tedious process.

While tape technology gained its status and gave birth to the live electronics scene, new technologies started to take form. In the mid- 1960s, a major change in live electronics happened when Robert Moog and Don Buchla released their first modular synthesizers (Dunn 1992, 22-24). This instigated a major change in popular culture as well as contemporary music culture. Early pioneers such as Daphne Oram from BBC Radiophonic Workshop had already utilizied similar technologies in their studio work before, but the commercial availability of these technologies made it possible for a wider range of musicians to start experimenting with them also in live situations. (Morgan 2017, 238–249.)

The inclusion of sequencer in addition to all the necessary sound synthesis and control tools in a single modular product enabled musicians to experiment in a completely new way (Dunn 1992, 22). The possibilities previously reserved only for a few universities and inventors were now available for a wider range of musicians. Notes could be sequenced or played real-time, sound could be

sculpted in ways never heard before and the range of tonality widened. Musicians could now decide whether they wanted to stay tuned to the chromatic scale or free themselves from it. Artists such as Keith Emerson with Moog and Morton Subotnick with Buchla took the synthesizers on stage and performed music from rock to experimental music while improvising virtuously in the late 1960s (Manning 2013, 154, 264).

Even though the possibilities of the modular synthesizers were immense and are still being explored today, maybe more than ever, the majority of potential customers did not adopt the new instrument. Early Moog Modular synthesizers cost $3000 minimum (current value would be about $20,000) and needed a considerable amount of studying before the user could become fluent in playing one (Moog 1974). The modular nature of the devices meant that to get a sound out of one, the user had to patch multiple cables carrying control voltage (Hosken 2011, 129). The Buchla modular does not even have a keyboard, which made it even more alienating for keyboard players, for example.

To overcome the steep learning curve of modular synthesis, Moog created the Minimoog in 1970 (Apple 2022, 726-727). It was a pre-patched miniature version of the cheapest Moog modular with a keyboard. This monophonic synthesizer gained popularity in popular music when such artists as Stevie Wonder and Rick Wakeman of Yes started using it on recordings and on stage (Hermes 2022, 116). Shortly after the release of the Minimoog, other manufacturers followed and the number of monophonic and polyphonic synthesizers in the market multiplied.

2.4 Musicians Find the Synthesizer

When synthesizers became widely available in the early 1970s, some bands and live acts started to build their whole style on them. Pioneering Krautrock bands such as Kraftwerk and Tangerine Dream became known for their unique live shows. While Kraftwerk performed like robots while playing melodic techno pop (Hermes 2022, 230, 254), Tangerine Dream played long versions of their psychedelic repetitive synth pieces with occasional improvisational passages

(Lozej 2016). Japanese pioneering synth band Yellow Magic Orchestra used vocoders and performed with the boyband aesthetics (Tanaka 2014). For these acts, the use of synthesizers and early drum machines were a central part of their sound, hence their performances fit well under the term live electronics.

In the 1970s, many artists experimented and thrived playing live electronics. American jazz pianist Herbie Hancock embraced the synthesizer when forming the Head Hunters. Their self-titled album was recorded live and fused jazz to funk and electronic music. It had a strong mass appeal, and it remains the biggest selling jazz album even today (Erlewine 2023). In Europe, after two internationally successful electronic albums which he made in his kitchen, Jean Michel Jarre performed a solo live electronics show in front of a million people at The Place de la Concorde, Paris in 1979 (Matos 2016). He later went on to break the record of most attendees in a concert several times in his career.

In the world of contemporary art music and tape music, the advent of computers and digital sequencing came at the turn of the 1970s. The size and the price limited the use of computers to the best funded tape music centers and universities. The same factors made it difficult to use early computers in live electronics. However, already in 1969 Salvatore Martirano managed to marry digital control and analog synthesis in his work *Sal-Mar Construction* by building custom equipment in Illinois, USA. In New York City, Gordon Mumma solved the problem by using remote datalink to computer in Boston in his composition *Conspiracy 8* (Dunn 1992, 37). These humble beginnings were the start of a phenomenon that stormed the 1980s and 90s.

2.5 (Re)Birth of Turntablism

Turntables, the simple electronic players for vinyl records, have been used in live electronics from its very beginnings. John Cage's *Imaginary Landscape No. 1* employed the creative use of test records in 1939 (Olarte 2019, 64). In 1948, Pierre Schaffer invented the 'locked grooves' technique in *Etude aux chemins de fer* where a vinyl record is manipulated so that it keeps looping the same groove until stopped manually (Cox and Warner 2017, 203, 280).

DJ is an acronym of a disc jockey (Merriam-Webster 2024). Its first known use was in 1940 and DJing developed as an artform firstly by radio DJs from 1940s onwards. Jamaican DJs used instrumental passages to make their own music thanks to the limited copyright laws at the time. American DJs played records on top of another to stand out from the rest in the highly competitive radio market at the time. When disco music took over the dance floors in the 1970s, club DJs started to beat-match extended disco records to create continuous beat that lasted throughout the night. This technique has stayed an integral part of underground and popular club culture ever since. (Smith 2016).

Turntablism took a leap as an artform in the 1970s, when the early hip-hop DJs extended drum breakdowns from the soul and funk records of the time by playing one record after another. As a response to the dance floor's reactions to the drum breaks, some of which later became the most sampled pieces of audio to date, it was achieved by spinning two identical records on two turntables and rewinding another record while the other was playing. This skill demanding technique became known as 'juggling' and was pioneered by DJ Kool Herc in Bronx, New York, circa 1975. Soon hip-hop DJs started to experiment with 'scratching', a form off resynthesis and a cultural commentary on existing material, by manipulating the speed of the record by hand while it was playing and cutting the volume in and out using customized mixers. (Manning 2013, 176-177).

These two fundamental turntablism techniques in connection with rap vocals gave birth to the first wave of hip-hop music. The scene born around hip-hop turntablism is still alive today and hip-hop DJing is one of the hardest DJ skills to learn.

2.6 Democratization of Music Technology Through Digital Revolution

> The advent of digital technology in the early 1980s marks the beginning of the most fundamental change in the history of Wester Music since the invention of music notation in the ninth century (Taylor 2001, 3)

From a music technological perspective, the 1980s are marked by the spread of digital devices for professionals and consumers, which started the democratization of music technology. First, consumer grade computers by Apple, Commodore and others were introduced to the public already in the latter half of the 1970s. The application of microchips to music technology emerged immediately with the products such as Synclavier digital additive synthesizer in 1976 and Fairlight CMI sampler in 1979 (Apple 2022, 728). However, these devices were too expensive for consumers and so large, that their relevance to the live electronics scene was minimal. In the wake of the 1980s, the cost of microprocessors plummeted (Maliniak 2002). Soon they were be found in handheld game consoles, compact disc players and affordable electronic instruments around the world. Cheaper microprocessors made increasingly powerful audio synthesis and processing resources available to institutions, individuals working from home and musicians playing live electronics (Manning 2013, 217-241).

2.6.1 Sampling and Digital Synthesis

A sampler is a device that captures, manipulates and playbacks digital sound files containing brief sound events that can be incorporated into a new piece of music (Cox and Warner, 2017, 611). Though Fairlight CMI pioneered this technology already in the late 1970s, it was just the beginning. E-mu's Emulator I was launched in 1981 and was a breakthrough. Although it was still relatively expensive, it was only about a quarter of the price of a Fairlight and was an innovative device (Manning 2013, 284). Emulator I was low fidelity in today's standards, offering only eight-bit resolution for samples and allowing only two seconds of sampling time. Nevertheless, it was revolutionary at its time and its success led to the release of enhanced Emulator II and inspired many other manufacturers such as Akai and Ensoniq to push the technology further. Samplers played a significant role in the development of hip hop and house music, and the early adopters who used samplers on stage include Kate Bush, Peter Gabriel, and Stevie Wonder (Musicradar 2014).

The formfactor of samplers varied throughout the 1980s from keyboards to rack units to Roger Linn’s and Akai's invention MPC 60 in 1988 (Manning 2013, 306). MPCs pad layout has since become ubiquitous in samplers designed for live electronics, such as Native Instruments Maschine or Ableton Push 2. When memory became increasingly cheaper during the 1990s and 2000s, hardware sampler units became redundant and were replaced by PCs in the studio and laptops on stage. In the 2010s and 2020s, hardware sampler units have made a comeback to live electronics, since their user interface suits the live situation and live sampling better than their software counterparts.

Sampling has gained significant importance among bedroom producers[1], especially in the hip hop and electronic music genres. Novice musicians typically begin by using pre-programmed loops as the foundation of their art, like how guitarists learn by playing their favorite songs. As they progress, these musicians create their own loops and incorporate samples from other songs to enhance the depth of their music. Using samples tastefully is a way of paying homage to past culture, as they serve as a tool rather than a final product (Feyre 2020, 49).

The digital synthesis took a leap when Yamaha introduced the DX7 in 1983. This revolutionary instrument is said to be the killer of analog synthesizers. Fortunately, this execution was not instant or final, since many great analog synthesizers were produced in the 1980s as well as 1970s (Roland Corporation 2023). DX7 had many advantages in comparison to previous analog synthesizers or the Synclavier. It was cheaper, stayed in tune, had velocity sensitivity and a 16-voice polyphony (Hughes et al. 2021, 532; Manning 2013, 281). The more expensive analog synthesizers from that age had 8-voice polyphony, such as Jupiter-8 from Roland. These features made the DX7 an

[1] 'A bedroom producer' refers to an artist, music producer or a composer who creates music at their home independently using their own equipment (Jonze 2010).

excellent keyboard to tour with and was used live by artists such as Genesis, U2, Kraftwerk and Kool & the Gang (Manning 2013, 282).

DX7 was based on frequency modulation synthesis, aka FM synthesis. FM was already pioneered in Yamaha's previous GS-1 synthesizer in 1980 and made a wide range of completely new sounds available to musicians. GS-1 and DX7 were notoriously hard to program though, and the majority of DX7 users ended up using the pre-programmed presets. While Yamaha had the patent for their FM synthesis algorithms, companies such as Casio developed their own versions of it, and the technology spread wide.

As samplers, FM and analog synthesizers ruled the 1980s, when the decade came to an end the increased power of microchips made a new form of synthesis possible. Peavey’s DPM-3, released in 1990, was the first commercially available synthesizer completely based on standard DSPs. (Apple 2022, 728). DSP stands for Digital Signal Processing. The DPM-3’s architecture was based on analog subtractive synthesizers, containing digital replications from basic building blocks such as oscillators, filters, and envelope generators. DSP turned out to become the leading method of sound creation later, when personal computers and digital audio workstations evolved into music production powerhouses which formed the backbone of live electronics performances.

As microprocessors evolved during the 1980s, sound synthesis became more common in personal computers also. In 1986, American mathematician Miller Puckette created the first version of Max, a graphic coding environment for media (Cox and Warner 2017, 336). It became a major software tool for computer improvisation and is still widely used at universities and in the experimental music scenes. It is included in the common DAW Ableton Live Suite. (Hermes 2022, 157; Hughes et al. 2021, 607). At first, Max was designed to send MIDI data and sequence instruments and other sound generators, but after ten years of development it became known as Max/MSP, which included also sound synthesis capabilities (Manning 2013, 440). The strength of Max lies

in the relatively easy graphical interface which makes it easy to change parameters on the fly and design how one wants to react with it. Today it is possible to program a plugin or standalone program in Max/MSP and convert it directly into C++, a more commonly supported programming language (Cycling '74 2023).

In the context of live electronics, one must mention the groovebox phenomenon that started in the 1980s and thrived in the 1990s. The groovebox lies somewhere between a synthesizer, sequencer, and a sampler, and combines different aspects of these devices. The term was originally applied to Roland’s MC-303 in 1996. The meaning of the term has extended over time to encompass a broader range of products offered by various firms, which incorporate the vital components and capabilities of grooveboxes. Also, many earlier devices of the 1980s now fall under this category such as Akai's MPC60 in 1988 and E-mu SP12 in 1987 (Réveillac 2019). The significance of grooveboxes for live electronics is their highly valued ability to enable live improvisation (Grove Music Online 2016). Some of the early users of grooveboxes live were Orbital, The Prodigy, and Daft Punk.

In the latter part of 1980s and in the 1990s, many other digital sound synthesis methods were created to meet the demands of the ever-growing popularity of electronic music. Some of the most common ones in my own experience are granular synthesis, wavetable synthesis and spectral synthesis. All of these are now cheaply or freely available for anybody with a computer and an internet connection. An essential developmental phases in the history of electronic music are MIDI and DAW, which I will discuss in the next subchapter.

2.6.2 From MIDI to DAW

An important step in music technology in the 1980s was Musical Instrument Digital Interface (MIDI). In 1981, three presidents of large synthesizer manufacturing companies (Sequential Circuits, Roland, and Oberheim) collaborated to develop a common interface to move note and expression data through wires. This made it possible for devices made by several different

manufacturers to play in sync and be sequenced from the same source. The MIDI format became quickly widely adapted throughout instrument manufacturers worldwide after its release in 1982 (Manning 2013, 263-264). This had immense impact on live electronics since artists could now build bigger setups where every instrument and sequencer could communicate with each other. MIDI is still the most used way to connect two musical devices together (Hermes 2022, 50-56). MIDI led to the invention of the now widespread Digital Audio Workstation, DAW (Manning 2013, vii)

DAW is an electronic device or application software used for recording, editing, and producing audio files. The essential functionality of a DAW is to allow for the manipulation of two main forms of information, MIDI data and digital audio. The way this takes place depends very much upon the design of the DAW interface in question - its visual structures and aesthetic connotations - which have consequences for creative decision-making and workflow (Manning 2013, 408-409).

The first DAW emerged quickly after the origination of MIDI. It came out in 1983 and was called the Multitrack Recorder. It was developed by German musicians Manfred Rüdup and Karl Steinberg for the Commodore 64 computer and its functionality was to sequence and mix MIDI and control external MIDI devices. After a few name changes, Multitrack Recorder eventually became Steinberg Cubase, a DAW still widely in use and innovative in many sectors (MusicRadar 2019). Audio functionality (recording and editing) was added to the program ten years after its initial creation in 1993 at the same time as its competitor Notator Logic released audio support. Quickly after that both rivalling DAWs started adding audio effects and virtual instruments to their feature sets (MusicRadar 2019).

In 1996, Steinberg created its own plug-in protocol called Virtual Studio Technology (VST). The following year, Steinberg introduced its first collection of VST plug-ins for the Intel PC. The protocol made it possible for third party manufacturers to create virtual instruments and audio effects for established

DAWs. The VST protocol turned into a standard in music production and when laptops evolved to be more robust and popular in live electronics situations, VSTs and the likes (e.g., AU and AAX) became more common in also live situations. (Manning, 2013, 399-400.) VSTs work inside the DAW as instruments or effects to increase its capabilities. One must have a host DAW open to run VSTs. (Tanev and Božinovski 2013, 231-234.)

The first DAW designed for live performance in exception of the previously mentioned Max/MSP was introduced in 2001. It was called Ableton Live 1 and was designed by German musicians Robert Henke and Gerhard Behles (MusicRadar 2019). Live 1's design was not completely unprecedented since Acid by Sonic Foundry already enabled musicians to manipulate time-stretched loops, and the concept of the computer serving as an instrument was solidified by Propellerhead's Rebirth. But Ableton Live's approach to classic live electronics routine looping was ground-breaking at the time. Musicians could now improvise using loops, one-shots, VST's and effects all at once using one program while customizing their control surfaces to their needs (MusicRadar 2019). Other manufacturers soon followed with their own approaches to DAWs geared towards live electronics such as Apple Mainstage and Bitwig. Others such as Apple Logic has copied parts of the Live's workflow (Apple 2022, 635).

DAWs have become the predominant technology for music creation and production over the last decade. They come in a wide variety of configurations from a single software program on a laptop, to an integrated stand-alone unit, all the way to a highly complex configuration of numerous components controlled by a central computer. DAWs are used in many areas of popular music practice such as songwriting and have supplanted even piano and guitar. (Marrington 2016, 52-63.)

2.6.3 The Internet and Global Communities

The emergence of MIDI sequencing offered the possibility to pre-produce music at home without the loss of audio fidelity. This changed the nature of the home studio and resulted in the integration of the home studio and the professional

studio. The emergence of DAWs finalized the home studios' possibility to produce music that may rival the quality of commercial studios (Auvinen 2016, 1-33).

In the last decade, the increasing affordability of music technology has enabled artists to create music within the confines of their own homes. With the help of the internet, numerous musicians now have the chance to develop their own fan base globally without relying on a record label, primarily by using music chat channels and social media platforms (Feyre 2020, 45-52).

The internet's impact on music production, consumption and performance began in the 1990s, when chat boards and the free distribution of music files slowly started to gain traction. The first internet underground music radios appeared already in 1993, and since then the streaming has overthrown all other types of music distribution (Feyre 2020, 26). I remember the early 2000s when the broadband connection became available, and music files, software, and the knowledge how to use the software was now available for me, the aspiring bedroom music producer.

The globalization effect caused by the internet had a role in the still growing burst of new electronic music genres and their evolution. Genres such as techno, house and hip hop have their roots in African American and Latin American cultures, but they spread and evolved into multiple subgenres through global communities via internet radios, chat channels and message boards (Feyre 2020, I; Fountain 2021).

Internet, globalization, chat boards, peer-to-peer file sharing and the burst of electronic music genres affected significantly in the democratization of music creation, consuming, and performing. Unfortunately, the democratization of live electronics has fallen behind because of the special needs of interfacing in live situations. In principle, one can perform live electronics with anything electronic that makes sounds but on many occasions, performers want controllers and/or external synthesizers on stage to make the performance more appealing to the

audience and themselves. Laptops, controllers, and synthesizers cost money, which increases the threshold to get into live electronics. (Van Esser 2016.)

To conclude this chapter, we can note that live electronics as a phenomenon has existed for almost 100 years in some form or another in the year of writing this. For an aspiring live electronics performer, it can be helpful and surely inspiring to look back into the diverse history of live electronics and consider one's own place in it. Today we as live electronics performers have it better than ever since manufacturers release many devices every year to innovate and optimize in interfacing humans and machines both in music technology and technology in general. However, the quickly advancing technology sets a challenge to the live electronics performer when just as one begins to master the instrument of one’s choosing or fabrication, new technologies come along with new possibilities (Van Esser 2016).

3 Idiosyncrasies in Live Electronics

3.1 Possibilities in the 21st Century

Due to the fast pace of technological advancements for example in microprocessors, AI, and battery technology, we have an abundance of options to go for today when designing a live electronics performance. In this chapter we are going to look at some of the main elements and tools musicians can use today to perform electronically or electro-acoustically. However, it is beyond the scope of this thesis to describe every possibility, or even most of the possibilities what comes to live electronics. The focus is on the methods I have found most common and easily accessible and the ones that I personally have utilized.

The changing nature of music technology as an instrument imposes a unique challenge to the live electronics artist in comparison for established instruments such as piano or harp. If we take piano for example, a peak showcase of late 1700s music technology (Parakilas 2002, 8-10). Its development has been

largely halted for over 200 years, which have given time for virtuosity to develop in pianism. Is the constant change a fundamental part of live electronics or will some static forms of interfaces and devices appear in the near future? Or have they already appeared and are being optimized by manufacturers at this moment? Will there be more virtuoso modular synthesizer -players in 20 years' time than now?

3.2 Computers and Software

In recent decades, the large hardware equipment commonly found in studios has been replaced by software that can be integrated into portable devices, such as small electronic chips. As a result, the use of laptops and other electronic equipment is no longer exclusive to music producers, but also available to musicians and performers. Consequently, new acts have emerged in the realm of electronic music that incorporate live vocals, musical instruments, laptops, and other electronic devices in their live performances (Moralis 2018, 9).

Due to the increasing efficiency of microchips, most of the task's computers are utilized for in music can now be run on laptop computers. I have found that some limiting factors remain such as storage and memory, but those aspects only come to play when handling large sample -instruments, for example. Those can be avoided in live electronics situations with some preparation. Laptops have become a standard also in music studios lately, by the virtue of their mobility.

A computers functionality would be severely limiting as an audio tool and an instrument without bespoke software for those purposes. I mentioned Digital Audio Workstations, DAWs, briefly in preceding chapter. In principle all DAWs could be used in a live setting in some manner, but Ableton Live was the first to establish a particular type of music software that serves as a link between a recording environment and a musical instrument in its own unique way (MusicRadar 2019). Ableton Live's functionalities add up to too many to be

addressed here, and due to the inclusion of Max for Live (an embedded Max/MSP) coding environment to the package, the limits of the software's usability lie in one's imagination and their computers power. It combines all the main building blocks of electronic music such as sound sources (samplers, synthesizers), effects, mixers, and control signals (MIDI or Control Voltage). It has been used live by acts like Daft Punk, Paul Kalkbrenner and Skrillex to name a few (Hermes 2022, 21). To gain a deeper understanding one can refer to Ableton's comprehensive manual, but I want to illuminate some of the most important features.

One of the main elements of Ableton Live is the Session View. It offers an alternative way to approach arranging and composing music in software in comparison to linearity. Whereas the more traditional view to arrange music since the early Cubase days in DAWs has been linear, Ableton Live is offering a clip-based grid view of the material as well as the traditional linear view. There the performer can launch clips in synchronization of the track, or completely freely. Whether the clips are loops, one shots, generative sequences, or anything in between is up to the performer. Clips can contain note information, audio, or automation (programmed control data for any parameter in the program). One can make scenes out of multiple clips and decide whether to stop the previously playing clips or not. Top that with the ability to launch clips automatically in chains or with probabilities, one can make a generative piece of music using only the Session View. This seemingly simple way of controlling an arrangement real-time can be approached in endlessly different ways.

To control these clips and scenes, the performer can go in for bespoke controllers such as Ableton's own Push or Novation Launchpad. These type of controllers come in varying sizes, feature-sets, and price-points, and can relatively easily be used to control any of Ableton Live's parameters. More about controllers and controllerism in the next chapter.

Other programs have followed Ableton Live's footstep after its release with varying success, such as Bitwig and Logic Pro. Bitwig's execution of clip based

session view is very close to its predecessor and can be utilized in very similar way, but Logic Pro is still lacking behind. The program’s ability to respond to real-time input is essential in live situations, and the real strength of Ableton Live and Bitwig lie here. For example, in comparison to its rivals Logic Pro's parameters, tempo and changes in arrangement have significant latency when performed while the DAW is playing. While being one of the main standards in music production, the inability to make real-time tempo changes takes Logic Pro out of the competition for many live performers. At present, Ableton Live is considered the prevalent DAW for live performances in the industry. As a result of its widespread use, Live has a flourishing online community which is an important asset in learning new, still developing tools (Hermes 2022, 21).

Any DAW can be utilized as a platform for live mixing and effects processing, with external instruments and vocals being directed into separate tracks for processing. Two DAWs in particular, Apple Mainstage and Gig Performer, are designed specifically for this purpose. The advantage of using bespoke DAW for this purpose is the ability switch quickly between different instruments, effects, and routings via a preset system or similar (Hermes 2022, 31). These features make these programs popular among instrumentalists such as keyboard players, who use electronic means to produce or enhance their sounds (Moralis 2018, 46). It is also possible to trigger audio clips to play backing tracks or other pre-recorded passages with these programs, but they lack the more sophisticated abilities for playing back clips in comparison to Ableton Live or Bitwig.

For artist seeking freer forms of expression in music software, there are lots of platforms for coding your own. Software like Cycling Max/MSP and Pure Data offer a visual environment for artists to create their own software from scratch or with ready-made building blocks. Max/MSP and Derivative TouchDesigner can be used as media environments to create interactive audio and video content at the same time. Max/MSP being incorporated in Ableton Live as Max for Live makes Live consequently a media environment also. I focus more on the

programming possibilities in the chapter 'Programming and Building Electronics'.

DJ software can be a good starting point not only for DJs but for also for electronic musicians that want to use DJing as their starting point and develop a so-called hybrid set. With DJ software one can play two to four audio files simultaneously while controlling, their speed, direction, loop points and sound spectrum while jumping from one point to another using cue points. Some of the most popular DJ software are Pioneer's Rekordbox, Serato and Native Instruments Traktor, but there are many other possibilities, some of them free and operational via an internet browser.

Some beat making software such as Native Instruments Maschine are well suitable for live electronics. Maschine is geared towards finger drumming, a style of instrumentalism and a music production technique deriving from hip hop -music and prime times of Akai MPCs. It also includes an idea’s view that works much like Ableton Live's session view, allowing for patterns to be organized into various scenes that match different parts of a song (Hermes 2022, 22). Other beat making software to consider are Akai MPC Beats and Serato Studio. To use a DJ or a beat making software live it is important to include the bespoke controller to the setup.

3.3 Controllers

For live electronics performance it may be advantageous to include hardware instruments or controllers to the setup. This gives the performer something physical to touch and the audience something to look at. In the time of writing this there are an abundance of electronic gear available for musicians. I will go through some of the main categories, starting from controllers.

Hardware controllers are what enable a laptop's performance to have physicality. They demonstrate to the audience that the artist is actively engaged in their work and enhance the hands-on and tangible nature of their performance. (Hermes 2022, 23). A controller is a type of control system that is

connected to a sonic source to create sound. Unlike other electronic instruments, a controller cannot produce sound on its own (de Llera Blanes 2017, 42). Most common sound source to connect controllers into in live situations is a laptop and a software, since usually hardware devices already have some sort of control interface built in. Most controllers work with MIDI, transmitting raw MIDI data to the sound source. Some more sophisticated controllers also receive MIDI data to visualize software's content.

Such controllers are Ableton's Push, Novation Launchpad, and Native Instruments Maschine. These are also examples of controllers that come pre-mapped to the parameters of the software, but also make it possible for user to create mappings of their own. They all are built around a grid of buttons Push enables triggering the session views clips as well as playing virtual instruments, controlling parameters, and recording new clips on the fly (Bell, Hein, and Ratcliffe 2015, 8). Its grid of buttons can be organized to show musical scales in two different manners that one can play instruments with, or to show drum pads for finger drumming. It can also be switched to show a simple sequencer if the performer prefers to write their patterns and not playing them live. Push is also MPE (The MIDI Association 2021) compatible, which makes it more expressive than its rivals such as Launchpad. Recently Ableton Push became available also as a standalone instrument, meaning that the Live software runs internally, making an external computer unnecessary. This level of versatility in one controller is hard to come by, but it also comes with a price. For more inexpensive way to control Ableton Live or Bitwig, one could opt in for a Launchpad.

DJ controllers are another breed of controllers that come pre-mapped and are designed from the beginning with a particular software in mind. They come in many sizes and price points and can be used in relation with other controllers. What sets DJ controllers apart is that an audio interface is often included. This means that a laptop -based live electronics setup might not need a separate audio interface at all if a DJ controller is involved. The pricier models might also

have a built-in analog mixer to plug in separate hardware or record players, so a DJ controller might conveniently work as a centerpiece of a hybrid DJ/live setup.

The most common type of a controller is a MIDI keyboard. They come in all shapes and sizes, and some include pads, sliders, or knobs in addition to the keyboard itself. Some might have built in screens or led lights to display positions of the sliders and knobs. Some have MPE capability and are made of rubber or cloth. A keyboard and its sliders can be mapped to do anything, which makes it way more diverse controller than one might think. For example, a key of C2 might not play C2 on an instrument at all but launch the next part of a song or trigger a series of effects to mutilate the sound unrecognizable. There are also controllers that don't include keys or pads at all but focus solely on sliders and knobs to control parameters. These can be very efficient for a performer who does not want to utilize traditional western musical interfaces such as keyboards or drums. A control such as slider can be also mapped to anything, which gives the performer freedom to make his own musical interface.

Using several controllers at once in relation with one another is common practice in live electronics. It rests on the performers shoulders to decide what kind and what amount of control is enough for their purposes. For example, one might use a MIDI keyboard to play virtual instruments, a launchpad to control the arrangement of the tracks, and a knob/slider -controller to control effects at the same time. Only limiting factors are budget and the amount of gear one's ready to carry.

3.4 Hardware

Most of the hardware devices designed for music studios can be used creatively in live context, but there are fair amounts of gear released yearly with live electronics performance in mind. Again, it would be unreasonable to list all devices here and therefore I'm addressing the most usual kinds of tools that are used in live electronics.

Synthesizers are some of the most inspiring and showy devices for electronic musician. It is also one of the most important sound sources in electronic music and available in countless different formfactors. A synthesizer is an electronic musical instrument that can create a wide variety of sounds by generating and manipulating audio signals. These signals can be used to mimic the sounds of traditional instruments as well as to create entirely new sounds that are not possible with acoustic instruments (Walzer 2016, 22).

Synthesizers typically consist of a keyboard or other input device that allows the user to play and control the generated sounds, as well as various electronic circuits and processors that generate and modify the audio signals. Some synthesizers also include built-in effects, such as reverb and delay, to further shape and enhance the sound (Hosken 2011, 132-133).

There are many different types of synthesizers, ranging from basic analog synthesizers with simple controls and limited capabilities, to complex digital synthesizers with advanced sound generation and processing capabilities and everything in between. Some synthesizers also include built-in sequencers and arpeggiators, which allow the user to create complex musical patterns and rhythms (Manning 2013, 201-216). In live electronics context, the importance of a synthesizers interface must be stressed. Performer needs well thought out physical controls to control the synthesizers tone and timbre in real-time.

In recent years, there has been a resurgence of interest in modular synthesizers, with many new manufacturers and users exploring the possibilities of this unique instrument. A modular synthesizer is a type of synthesizer that consists of individual modules or units that can be connected in various ways to create custom signal paths for generating and modifying sound. Each module typically performs a specific function, such as generating a waveform, filtering sound, or shaping the amplitude and timing of signals. Modular synthesizers are therefore highly versatile and customizable, allowing users to create unique sounds and signal paths that are not possible with fixed-

architecture synthesizers. (Manning 2013, 208.) Modular synthesizers allow users to be creative in technology itself and designing their own synthesizer.

Another important form of electronic instrument in addition to synthesizers is a sampler. As discussed before, a sampler is a device or software that captures and records audio or music, allowing it to be played back and manipulated in various ways. (Cox and Warner 2017, 611). Since computers are much more efficient in storing and playing back audio in comparison to standalone devices, traditional keyboard samplers have almost vanished from the market, but modern hardware samplers have made a resurgence in recent years in a groovebox format. Devices such as Elektron Octatrack, Digitakt, Roland SP404 or Akai Force can sample an audio input, process it, and sequence it real-time (Hermes 2022, 132). They can also sequence external gear using MIDI and act as centerpieces of the whole live setup making laptops somewhat useless in some cases.

Some grooveboxes also carry their own synthesis engines as well as sampling capabilities such as Roland MC-707, Akai Force or even Ableton Push, which runs a whole DAW environment internally. Other grooveboxes rely on synthesis only like Elektron Digitone and Syntakt or Roland SH-4D, but the most widespread and the earliest form of groovebox is a drum machine. Drum machines have been in existence since the 1959 when Wurlitzer released the first commercial pre-programmed drum machine The Side Man (Crab 2023, 111).

A drum machine generates percussive sounds using synthesis or sampling, and typically is used to create rhythms and beats for music production or live performances. It allows users to program and play patterns or individual drum sounds using its built-in sequencer. (Réveillac 2019, 93-112). Some of the most popular drum machines in history are Roland's TR-808 and TR-909. They still form the basis of many electronic music styles today and the sounds of them can be found in the modern Roland TR-8s for example. (Bougaieff 2013, 37.)

Many replicas, digital and analog, have been made since the original drum machines might cost thousands of euros if sold in a working condition.

For electroacoustic musicians or singers an important part of live electronics setup are microphones. Common types of microphones are dynamic, condenser, ribbon, and contact. The most used microphone for live performances is the dynamic microphone (Moralis 2018, 54). Dynamic microphones are rugged and durable, making them ideal for use on stage, where they may be subjected to rough handling and environmental factors such as temperature and humidity. They are also relatively inexpensive and have a simple design that makes them easy to use. Another good solution for live situations where feedback needs to be eliminated is contact microphones which can be utilized with acoustic instruments or used in more experimental manners to amplify pretty much anything. For live electronics performer, a microphone can be regarded as performance tools, since experimenting with shifts and motions, for example, brings about distinct alterations to the tone and loudness. (Olarte 2019, 58-60.) With the microphones signal, the performer can also control any parameter or function in their performance setup.

To process the microphones signal, or any signal, one can utilize sound processing effects. These can be found in DAWs, samplers, some grooveboxes and mixers, but they can also exist as standalone pedals or rack units. Effect pedals are often chained and used creatively to alter the sound. For many electric guitarists pedals and pedalboards have been an important part of creative process since the birth of pedals in 1970s (Wired Guitarist 2019). Effects and effect chains can transform sound beyond recognition and is therefore an important creative tool for live electronics musicians.

To bring all these instruments, microphones, loops, effects et cetera together, a live setup needs a mixer. A mixer is a device used to combine and adjust the level and tone of audio signals from multiple sources. It allows for control over the volume, equalization, and other effects applied to each input signal, enabling the creation of a well-balanced audio mix for live sound reinforcement

(Apple 2022, 65). Mixer can be its own standalone device, or one can use DAWs mixer by connecting external gear to an audio interface connected to a laptop. Some grooveboxes have inbuilt mixers, which makes them a viable option to replace laptops. Standalone mixers come in analog and digital format and can have almost any even number of inputs and tracks, so the user has many options to choose from. Analog mixers can even be utilized as instruments themselves using non-input mixer techniques such as feedback loops (Olarte 2019, 62).

The mixers interface is an important factor to consider when choosing a device for a live setup. A hardware DJ mixer might be a viable choice since they are live performance -centered by design and many times include inbuilt audio-interfaces, such as Allen & Heath Xone:96 or Pioneer DJ DJM-V10. For a hybrid DJ setup with live electronic elements, a DJ mixer with four inputs or more offers a well thought out performance mixer.

After the mixer has collected all the signals and processed them, the signals need to be amplified with loudspeakers. A loudspeaker, also known as a speaker, is an electroacoustic transducer device that converts an electrical audio signal into sound waves that can be heard by humans. It typically consists of a diaphragm or cone attached to a voice coil that vibrates in response to the electrical signal, causing the surrounding air to vibrate and produce sound (Ballou 2008). If a loudspeaker has a built-in amplifier, it is called an active speaker, if the amplification is produced with an external amplifier, it is a passive one. For more experimental live electronics performers, one can build their own speakers or prepare and modify existing ones. Artists may also use transducers to direct sonic vibrations to any objects and use anything as creative resonators. (Olarte 2019, 61.)

For an electronic musician the amplification process and loudspeakers are significantly important, even more so than for acoustic instrument performers. Electronic sound does not exist in the acoustic world without loudspeakers, hence the choosing of a suitable loudspeaker or speaker system is an

unavoidable task for live electronics performer. Many times, the venue and the budget of the performance dictates the choices of the performer. The venue might have a PA -system already set up and it is efficient to use that to perform. But if the performer has a possibility to design their speaker -setup from the beginning, the process can be, and should be a creative one.

Some basic knowledge of acoustics come in handy when designing a speaker system for a venue. One can choose to use the standard stereo -system where one or more speakers represent the left channel and other ones the right channel, or one might go for surround or ambisonic approach, where multiple speakers can be placed around the venue to create an immersive soundscape for the spectators. One could get creative with different sizes of speakers and position them towards walls, behind walls or anywhere one might think of. The way the space reacts and vibrates to the amplified sound can be an important part of the performance. To distance the performance from the characteristics of the space, headphones can be utilized. When the sound travels directly from the speakers of the headphones to the listeners ear, the venues resonances and echoes can be avoided, but at the same time the physicality of sound is somewhat lost. The physical nature of sound is an important factor to consider when designing a loudspeaker system for club music, dance music, or any music where the sound is supposed to make the listener feel the music.

3.5 Gray Line Between DJing and Live Electronics

We touched the subject of DJing and turntablism in previous chapter dealing with the history of live electronics. DJ culture is alive and well around the world since the popularity of electronic music in nightclubs is strong as ever (Watson 2019, 10). Turntables outsold electric guitars already in 1999 (Herz 2000). DJing is a viable starting point for performing live today and the cost of DJing have declined near zero thanks to the online DJ mixers such as YouTube DJ or YouDJ. Considering that the manipulation of turntables by John Cage was the beginning of live electronics as an idea in the 1930s, DJing is an integral part of live electronics (Cox and Warner, 2017, 27).

A DJ, short for "disc jockey," is a person who plays and mixes recorded music for an audience. DJs typically use specialized equipment, such as turntables or DJ controllers, to manipulate and blend different songs and sounds in real-time (Butler 2014, 3-5). The role of a DJ can vary depending on the type of event or venue they are performing at. In a club setting, a DJs main goal is to create an energetic and enjoyable atmosphere by playing music that the audience will respond to. They may use their skills to mix and transition between tracks seamlessly, using effects such as loops, cue points, filters, and EQ to manipulate the sound. At this point, the difference between a simple DJ -set and live electronics set is already blurred.

Some DJs produce and remix their own music and may also perform live sets or produce mixes for radio shows or podcasts. Overall, the role of a DJ is to create a musical experience that engages and entertains the audience, while showcasing their own unique style and skill set. Some DJs might improvise their whole 8 hour set while some DJs might mimic playing a pre-recorded one-hour EDM set at a festival. (Butler 2014). Where it gets tricky is when a DJ uses live looping, DJ tools (premade sound files to complement other tracks) or even external instruments in their performance. Are they DJing or performing live? It is hard to blame regular listeners for confusing the terms of DJ and live electronics when they are so hard to define separately even for an educator of the field like me.

To describe this sort of extended DJing, a term hybrid DJ set has surfaced (Tomorrowland 2022). A hybrid set is a musical performance style that combines elements of both DJ sets and live sets. It involves playing entire tracks as in a typical DJ set, while also incorporating additional components such as separated track parts, samples, vocals, or other elements mixed with another track. The flexibility of this style allows for endless creative combinations, making it a compelling and versatile option for performers (u/techno 2012). The distinguishing factor here in comparison to live electronics is the playing of entire tracks. One could argue that when a live performance includes playing of entire existing pieces of music, it becomes a hybrid DJ set.

Also culturally, if a live act has decks on stage, digital or analog, the concept of DJing inevitably wanders into spectators' minds, even though they wouldn't be used to play whole tracks, but just loops, effects, or other DJ tools.

Hybrid DJ sets offer several advantages over live electronics performances. Firstly, hybrid sets allow for longer performance durations, as the performer can incorporate occasional longer DJ passages to rest their mind and refocus during the set. Additionally, if something goes wrong with the live electronics equipment, the performer can seamlessly transition to playing records. Conversely, if there is an issue with the DJing equipment, which is a rarer occurrence, the performer can continue to play live. Finally, those with experience in DJing may find a hybrid DJ set to be an easy gateway to live electronics, as it incorporates elements of both styles and allows for a gradual transition to live performance without abandoning traditional DJing techniques. Some artists that have utilized hybrid DJing in their live performance are Chris Liebing, Richie Hawtin, and Carl Cox to name a few.

Respectively, live electronics offer several advantages over hybrid DJ sets. Firstly, live electronics performers can design their setup from the ground up, tailoring the performance to their specific creative vision. This allows for complete control over aspects of the music, such as arrangement, sound design, and effects. Additionally, live electronics performances often require more work and technical skill from the performer, resulting in a more engaging and captivating spectacle for the audience to enjoy. Spectators may also find it more special to witness a live electronics set, as it is a less common and more unique experience than a hybrid DJ set.

3.6 Programming and Building Electronics

I have shortly touched on the subject of Max/MSP and Pure Data which are graphic coding platforms aimed at musicians and media composers. These software make it relatively straightforward for composers and performers to go beyond the design philosophies of commercial software and hardware

companies and start making their own software designs to create and manipulate audio, midi, or even video (Hermes 2022, 157-158). One of the key benefits of max/MSP for example is the possibility to control any parameter with anything that sends any sort of data. It frees the user from using music - cantered devices and encourages experimentation in interfacing.

An example in my own work for a contemporary dance piece *Gamechanger (2022)* I utilized a PlayStation 4 controller on stage to control an Ableton Live set. I used the controller to transition between different scenes, to play pressure responsive effects and to pan the sounds around a surround loudspeaker setup. All this took was to transform the key pressings and other data from the controller to suitable MIDI messages in Max and send that MIDI to whatever parameters I wanted to control in the Ableton Live set.

It is well beyond the scope of this thesis to go into detail what Max/MSP or any of these software can do. Some artists even make the coding and designing a part of their performance in Live Coding scene where the hacker culture and live electronics meet (Simonetta 2019). A widely used software used in Live Coding of music is SuperCollider, a free open-source platform for audio synthesis and algorithmic composition. It is designed to be expressive and flexible, allowing users to create custom audio synthesis and processing algorithms, while including a powerful synthesis engine with a wide range of built-in audio processing tools, as well as support for external audio and MIDI devices (SuperCollider 2023).

What comes to music technology, there are deep holes to dig into in the physical world also. The artistry of building electronics and hacking them is significantly older than the largely digital techniques I have discussed so far. The building and designing electronic circuits are the basis of all the electronic music technology so the possibility of hacking them or making your own from scratch opens up the possibilities even wider for all devices. With a small set of tools such as a soldering iron, clippers, and wire strippers, an artist may hack a cheap radio, synthesizer, effect device or amplifier to make sounds unheard of,

way beyond the original purpose of the machine. This skill takes time to learn, and one should brace themselves to ruin a few devices before succeeding to converting one into something useful. Hence the emphasis on 'cheap'. (Collins 2006, xiii-xv, 3-5).

When an artist starts to create their own software, hardware and/or interfaces, the creativity involved goes beyond just setup design. One needs to think in the subjects of instrument and interface design in relation to their artistic practice. The design decisions become a part of their creative process and can even sometimes be the core idea behind a composition or other piece of art. The impulse to make art in general could be to design something unique and showcase these designs. It is not rare to use the self-made applications or electronics in conjunction with other commercial devices. The artist may complement their own devices with ready-made ones or vice versa.

Utilizing live streaming, installations, MIDI files, and software that is open ended, meant for coding or still being developed can provide opportunities for exploring novel methods of performing. However, currently, the effect of these approaches may come across as unfocused experimentation, similar to the music-making of the 1960s when the focus was on the process and change rather than creating music that had enduring value.

There is a noteworthy contrast between software programs like Logic Audio or Cubase, which are essentially virtual versions of traditional recording studios, and more open-ended applications such as MAX/MSP. As contemporary music continues to evolve, composers who have dedicated their careers to developing compositional methods that go beyond the conventional means of recording sound onto tape or digital tracks are becoming increasingly relevant. Technologies like generative music and its tools, such as stochastic processes (like those used by Xenakis), random values, probabilities, and AI, are challenging traditional notions of the artist, spectator, and even the instrument itself. The questions of who creates what and when inspire live electronic

performances that transcend the typical artist-on-stage structure. (Cox and Warner 2017, 338)

3.7 Practical Examples

As stated in the previous subchapter, the possibilities seem endless and expanding. Live electronics performer can choose from many different controllers, synthesizers, mixers, programs, sequencers, effects, and computers to create their own setup. One can even make their own devices or modify existing gear. I will now discuss some technical examples on how to approach a live electronics set to provide a picture of some common practices. These examples are more in the popular electronic music style since that is where my own expertise lies.

3.7.1 Reinier Zonneveld, 2019

First let's look at a hybrid DJ set which consists of a DAW and several hardware synthesizers. Dutch DJ/producer Reinier Zonneveld played a live electronics set at State Aviation Museum in Kyiv, Ukraine. The concert was streamed live to YouTube by French music channel Cercle (2019). Zonneveld plays his own music for over one and half hours. The music can be described as electronic dance music, with a subgenre of Tech House. Tech House is a mixture of techno and house music, combining the attitude and sound design of techno to the grooves and melodic phrases of house music (Bogdanov 2001,16).

At the center of Zonneveld's setup is Ableton Live software and an Allen & Heath Xone:96. Ableton Live sends audio and MIDI to an external audio/MIDI interface where the audio channels are routed to the mixer. The mixer controls the volume and equalization of audio tracks, external synthesizers, and effects. The final stereo audio for the PA -system, amplifiers, and loudspeakers. What happens between Zonneveld’s system and the loudspeakers does not come across from the video recording.

In Zonneveld’s setup Ableton Live's Session View contains backing tracks for several his productions and some pre-programmed midi clips that can be sent to the hardware synthesizers. Simply put, Ableton Live handles audio files and control signals, but any real-time synthesis is managed by hardware. Zonneveld’s analog synthesizers on this occasion are Roland's SH-101, Roland TB-303, and Moog Subsequent 37. All these synthesizers are monophonic or paraphonic at best, which is commonplace in techno -styles of electronic music. Zonneveld also uses another software in connection with the bespoke controller: Native Instrument Maschine. With Maschine he improvises drum patterns and sequences for the hardware synthesizers on the fly. Ableton and Maschine are synced via Ableton Link -system or Maschine could also be running as plugin in Ableton.

Zonneveld also has an external drum machine on stage, the classic Roland TR-909. Neither TR-909, Sh-101 nor TB-303 has MIDI in their original form. This means that either Zonneveld is syncing these devices using audio (the only way to sync devices to one-another before midi) or he has retrofitted MIDI kits to the devices. Judging by the sequences coming out of these instruments, the TB-303 has a MIDI retrofit, SH-101 does not (only one note sequences), and TR-909 does not need MIDI since it is used for improvisational purposes. A simple audio sync signal is enough to keep the machine in time with the software.

Zonneveld's synthesizer rich setup is a good example of a functional but enabling setup where the basis of the music comes from pre-made audio files which still leave enough to improvise and provide a unique experience to the audience. The live set contains passages that don't seem to have any sort of backing track, where only the hardware synthesizers and Maschine’s sequences create the music. What is curious, is the absence of a dedicated Ableton Live controller such as a launchpad. Zonneveld launches clips by using laptops trackpad and keyboard. This seems to not bother either the spectators or the performer since he has lots of other physically controllable devices and movement on stage.

3.7.2 Bonobo, 2015

To get a picture what live electronics can be like with a band, Bonobo's concert with a live band in 2014 at Alexandra Palace gives a diverse glimpse (Boiler Room 2015). Bonobo himself is centered in the middle of the stage surrounded by a drummer, guitarist, two keyboard players and an occasional singer, horn section, and string-orchestra. Bonobo can be spotted playing bass, bass synthesizer and electronic drum pads depending on the song. Some of the more electronic tracks he plays all by himself, while most tracks that have more organic instrumentation include the band in some configuration.

The core of the setup is Ableton Live, where Bonobo sends click tracks from to the whole band in relation with backing tracks to the front of the house mixer (FOH). The sound material his controllers are connected to varies with every track, which means that he has automated this process in Ableton Live utilizing its sampler, synthesis, and sound processing possibilities. One can spot two laptops on Bonobo's riser. They both seem to have same Session View on their screens, which suggest that other one is a synced backup computer, a complete copy of the other, in case the main computer falls over and stops audio playback. This is common in large live productions where the whole construction is based around one laptop and software.

Otherwise, Bonobo's live production on the tour in question utilizes commonplace live production methods such as in-ear monitoring, two mix engineers, festival grade PA system and an externally controlled light show. His two-hour live set consist of many different compositions varying from completely electronic to completely electroacoustic. The presence of live electronics is therefore adaptive and fluid, as electronics are in his studio productions also.

3.7.3 Colin Benders, 2020

For a setup without laptops or software, a good example is Colin Benders' live set at Lowlands free: united festival in 2020 (3voor12 2020). Colin Benders is

known for his completely modular synthesizer-based approach to composing and live performance. He can be referred to as a modular synthesizer artist.

The nature of a modular instrument is that it is completely customizable. One can choose almost any sort of modules and functionality to include in it, from raw oscillators to complete sound computers. To master the instrument, one must first spend years in assembling one and then more years to learn to play it. Usually both happen at the same time, making the process somewhat chaotic at times in my own experience. The fact that Benders can play a three-hour live set using only a modular synthesizer, albeit it being a large one, says a lot about his talent and devotion to the instrument.

In spectators’ perspective Benders' modular is an impressive sight. A wall of blinking light, different colored panels and hundreds of cords make a strong statement where the electronic nature of the instrument comes blatantly clear. Benders performs back towards the audience so that they can see his every action with his instrument. The style of music he plays could be described as a fusion of ambient and techno. The description of the YouTube video uses modular techno, highlighting the way the music is made.

Technically the setup is seemingly simple. All the sequences and sounds are made with modular synthesizer and performed live, and the output of the synth goes to FOH mixer and from there to stage monitors and PA-system. But what happens inside the modular synthesizer is not so simple. To achieve a performance of this scale one needs multiple different sequencers, clock dividers, oscillators, filters, envelope generators, effects, et cetera. To know what is where and what controls what one needs a very clearly laid out system. Here the subject of instrument design comes into play and is an important part of modular artists skillset. From hundreds of knobs, one needs to know exactly what to turn and when. Happy accidents happen, but a performer cannot rely on them when designing a live setup. They should be reserved mainly for studio conditions, where new sounds are searched for and refined for the live performance in mind.

Benders starts his concert with ambient pads and reverberant melodies. Slowly he introduces rhythmical sequences and finally drum like beats. In contrast to popular music, the division of drums and tonal instruments is not so clear. A sound can be both at the same time or shift from one to another. Benders uses this ear bending technique many times during his set making a melodic sequence a rhythmic transient beat and vice versa. He seems to have somewhat clearly laid out system of modules, sequencers and other control devices lying on the bottom part of the systems while most of the sound generation happens in the top part. This makes the playing visually pleasing to watch since the sound shaping happens where all spectators can see. Movement of the hand correlates directly to the sound.

The strengths of a modular synthesizer, or really any system without a computer, contrastingly lie in their limited functionality. By picking their tools carefully, an artist can simplify their workflow and therefore achieve their own sound more quickly while enjoying fluent music making process. This is why designing one’s setup and instruments is an important part of the creative process in live electronics. In Benders' way of working this is easily heard and seen.

3.8 Creativity in Live Electronics

The question of creativity in live electronics is one of the main issues in the research interviews, and therefore I will next discuss creativity in general and also shortly in the context of live electronics.

What makes live electronics interesting from the creative standpoint is the emphasis of technology. In comparison to for example piano, the live electronics instrumentalist must make much more decisions in the field of technology such as what to use and how to connect everything together. According to my experience a pianist generally does not need to spend time with operation manuals very often. So, to understand this subject better, it is

beneficiary to discuss both types of creativity, engineering, and technology, and in the context of arts.

Taylor (1988, 45-65) created six categories of definitions for creativity after conducting a thorough research on the essence of it.

1. Gestalt or perception: stresses the unique combination of ideas.

2. Product or innovation: emphasizes the process that yields a new idea or product.

3. Aesthetic or expressive: focuses on the creativity inherently present in authentic forms of self-expression.

4. Psychoanalytic or dynamic: suggests that creativity is linked to personality.

5. Solution thinking: emphasizes the value of general intellectual thought with special consideration to divergent thinking during the creative process.

6. Varia: provides a category for creativity activity not easily defined by the definitions above.

There are significant differences in creativity in technology and engineering and in arts as stated in Stricker's research in 2008. He states that the process is fundamentally different but there are some similarities. In both fields there are elements from all the categories, but the emphasis varies. Where the engineering approach generally focuses more on the second category of creativity, product or innovation, the art-creatives focus is on the third one: aesthetic or expressive. (Stricker 2008, 18-21).

Which factors are distinctively typical for musical creativity? Webster (1987) formulated a creative thinking model that was designed specifically for music. The model encompassed these components:

- Musical Extensiveness: The time in seconds that involved in a musical response.

- Musical Flexibility: The extent a person can move freely between the extremes of the parameters of high/low, soft/loud, and fast/slow.

- Musical Originality: The degree of musical manipulation a person can accomplish in a unique fashion.

- Musical Syntax: The extent a person can manipulate music in a logical and “inherently musical” manner with regard to the entire response (Webster 1987, 257-271).

For live electronics artist to find musical originality and musical syntax, one has to have a thorough understanding of their instrument, how it works, how it is set up and why. For this to be achieved, artist needs to customize the instrument to their needs or build it modularly or from scratch. For this they then need to utilize creative perspectives from the engineering and technological side as well as artistic side. Usually these go hand in hand since one affects the other: the musical aim dictates the setup construction, and the setup inspires musical and artistic choices.

To summarize, in this work I understand creativity to include musical creativity, problem-solving and problem invention. Musical creativity is the starting point since music is the material the performer is aiming for when solving problems. The musical starting point overlaps with the problem creation. How can I make that sound in my head happen with the devices at my disposal? Do I need to acquire or create a new device for this purpose? Would composing ambient textures be more inspiring with a device of my own making? With which limb I want to control this parameter with? After refining the problem starts the

problem-solving part, where the musical creativity defines the outcome and dictates the solutions. This creates a creative loop where each musical piece or performance might just be one iteration of the loop before moving on to the next one.

Traditionally, in the context of higher education, when creative processes like music and music technology were taught as part of a single discipline, the emphasis was primarily on the technical aspects, or the history and theory associated with that particular discipline. Music technology education has an engineering background, hence the wording 'studio engineer.' Since 2000s and onwards, there has been a push to include more creative challenges and tasks in music technology education. (Boehm 2009, chap. 2-4.) This thesis can be seen as a continuum of that movement.

4 The Interviews and The Specialists

In the beginning I set four research questions that this study is searching answers for. The first question about common tools for live electronics is addressed in the chapters two and three, while for the questions two to four I searched answers through interviewing individuals I consider as experts on the field of live electronics education. The research questions for the interview-part of this study are:

2. How is live electronics taught in classrooms today?

3. What are the most common challenges teachers face when teaching live electronics?

4. What are the ways in which creativity can be taught in live electronics?

4.1 Interviewees

The interviewees chosen for this research are individuals that I consider as experts in the field of live electronics and live electronics education. They all

have experience in teaching live electronics and hold a teaching position in one or more facilities. Due to the relative rarity of live electronics as a subject of education in Africa or Asia in comparison to the global west; Europe, United Kingdom, and United States of America, I focused my search of interviewees to the latter part of the world. By chance, most of the interviewees are European, with only one American who replied to the initial email I sent.

When I began my research, I wanted to explore the teaching methods and pedagogical approaches used by music educators across different genres. As such, I initially wanted to refrain from genre limitations when selecting interviewees. As I delved deeper into my research, I discovered that music educators who specialize in different genres have unique perspectives that offer valuable insights into the pedagogy of live electronics. For example, educators who specialize in EDM approach live electronics in a different way than those who teach experimental music.

I realized that in order to fully understand the pedagogical approaches to live electronics, I needed to include a diverse range of educators from different genres. By including both, three contemporary music and four popular music educators, I was able to gain a more comprehensive understanding of the various pedagogical phenomena. Here is a short biography from all the interviewees in alphabetical order.

Benjamin Van Esser is a live electronics specialist, programmer, pianist, composer, and improviser, focusing on contemporary and experimental music. Apart from artistic activities, he is professor Live Electronics and Spearhead of the research group Music and Technology at the Koninklijk Conservatorium Brussel. Benjamin currently focuses on computer-based performance and composition, working with hyper-extended instruments and using minimalist interfaces such as ‘monome grids’ to control extensive electro-acoustic setups.

Ethan Hein has a PhD in music education from New York University. He teaches music education, technology, theory and songwriting at NYU, The New School, Montclair State University, and Western Illinois University. As a

founding member of the NYU Music Experience Design Lab, Ethan has also taken a role in the development of online tools for music learning and expression, such as the Groove Pizza. He has co-written the book *Electronic Music School: A Contemporary Approach to Teaching Musical Creativity* with Will Kuhn.

Kirsten Hermes is a Senior Lecturer in Music Performance Technology at the University of Westminster in London. Her research contributes towards measuring and modelling the perceived quality of music mixes and the development of tools that enhance creativity. She has written an extensive book on the subject of live electronics called *Performing Electronic Music Live*. Kirsten is also a music producer and releases and performs music as Nyokee.

Aki Himanen is a music producer, sound designer, mixing engineer, composer, trumpet player, musician and educator based in Helsinki, Finland. In 2016 he founded Super Sound Design where he offers services such as music production, sound design, mixing and mastering. Aki is also an educator and has been teaching Ableton Live and music production at Metropolia University of Applied Sciences since 2017 and at Varsinais-Suomi Community College since 2021.

Johan van Kreij is a performer and composer of electronic music. He graduated from the Institute of Sonology in 1998 where he started developing his own electronic musical instruments. He develops both the hardware and software for his instruments. The gestural part of these instruments consists of sensors and other equipment while the sounding part consists of software that employs a wide range of sound synthesis models. Johan has been teaching at the Institute of Sonology, The Haag since 2001.

Alejandro Olarte is a lecturer of Electroacoustic Music at the Centre for Music and Technology, University of the Arts Helsinki, Finland. His interests include electroacoustic music performance, improvisation, composition, contemporary music, and art, electronic lutherie, and pedagogy. Alejandro holds a Doctorate in music and teaches courses such as Live Electronics Atelier, Electroacoustic

Improvisation, Performance with Electronic Instruments, Sound Synthesis and SuperCollider.

Merlyn Perez-Silva is a musician, producer, and educator who is situated in Aarhus, Denmark. He produces cosmic-sounding electronic music for Iboga Records, collaborates on digital content with Warp Academy, and serves as an Assistant Professor in Electronic Music at the Royal Academy of Music. Merlyn has attained a master's degree and Postgraduate Soloist-Diploma in Electronic Music, as well as a bachelor's degree in theatre. His electronic music is released under the name Merlyn Silva.

4.2 Semi Structured Expert Interviews

The study utilized professional conversations as a methodological approach for data generation. This is a form of qualitative research. My assumption was that by interviewing highly experienced teachers, valuable insights would be obtained in how live electronics is taught, who teaches it and what are the challenges the teachers face. Rather than seeking definitive truths, the focus of my study is on identifying topical phenomena.

Qualitative research is typically contextual in nature. Unlike other research methods that focus on examining phenomena independently from their surroundings (such as using standardized tests to assess intelligence or personality), qualitative researchers assert that these phenomena can only be comprehended when viewed within their contexts. (Brinkmann and Kvale 2015, 103.)

The aim of a qualitative research interview is to gain insight into the perspective of the participants, unravel the significance of their experiences, and reveal their real-life situations. This interview has two dimensions - one is the personal connection between the interviewer and interviewee, while the other focuses on the knowledge gained through this connection (Brinkmann and Kvale, 2015). My focus was on the latter dimension of the two, the knowledge gained.

Nevertheless, it must be noted that the interviewers position affects the knowledge gained.

A research interview is not a dialogue between two peers since the researcher has authority and sets the tone. The interviewer initiates the interview subject and scrutinizes the responses provided by the interviewee. Despite being a professional conversation, a research interview utilizes the same language as everyday conversations and involves the collaborative construction of knowledge between the interviewer and interviewee. (Brinkmann and Kvale 2015, 4.)

It is crucial to recognize the reflexivity of the participants and view them as valuable resources who possess expertise regarding the research question. They should be regarded as research partners and actively involved throughout the research process (Schreier 2012). To facilitate this collaborative approach, during the interviews I "led the subject toward certain themes but not to specific opinions about these themes" (Brinkmann and Steinar 2015, 150). In conducting the interviews, my aim was not to overly challenge the interviewees' views or opinions, but rather to understand their perspectives and the reasoning behind their conclusions. Occasionally, after the interviewee responded to a question, I offered my own insights on the topic to encourage deeper reflection and, in some cases, to challenge my own assumptions and biases. By utilizing a qualitative approach, I was able to become an engaged learner throughout the process (Creswell 1998).

I shared a preliminary version of the research with the participants after transcribing and organizing the answers according to themes. This allowed them to review their respective sections and provide feedback and comments as they saw fit. This ensured that that their quotes reflect their views as close as possible.

The interviews tie this work strongly to this time and age, since technology, the very center of this study, is in constant change and development. How we react and interact with technology have changed fundamentally in 2023, the year of

writing this. The rise and popularization of AI is changing our approach to internet and even knowledge itself and is already impacting our lives in many ways. How this affects our interaction with music technology and how fast it is going to happen remains to be seen.

4.2.1 Interview Themes

The themes I prepared for the interviews were intended mainly to arouse conversation. In semi-structured interviews the questions may be presented in varying form and order (Galletta 2013, 47-51). In some cases they acted more as a guides to keep the interviews on track. Some other times the questions were asked as they were written, depending how talkative the interviewee was or how well the interview focused on the intended topics. I divided the themes into three parts: the background of the interviewee, questions about teaching and creativity in live electronics, and then ended the interview with a question regarding the future of live electronics education.

I had written the themes in my notes in the following form:

Professional and artistic background:

- Which subject(s) do you teach at your facility and on which levels?
- What content is included in your subject(s)
- How many years of teaching experience do you have on this subject matter?
- Can you give me a short version of your artistic background?
- How about educational background? Any education in the field of live electronics?

Teaching and creativity:

- When a new student starts their studies on the subject matter, where do you begin? What is your starting point?

- What do you think about creativity and live electronics? How do you see it happening? Where and when it happens?

- How do you breed this creativity in your students?

- How do you think it is different to teach live electronics in comparison to so-called traditional instruments?

- What topics have you found most challenging to teach and what are the easiest?

Future:

- How do you see live electronics education evolving in the near future or how would you hope to see it evolve?

The way I presented the themes varied on the basis on how the interviewee answered the previous question. As an interviewer, in both structured inquiries and your prompts, one assists the participant in producing significant answers. The interviewer has a chance to involve the participant in seeking clarity, constructing meaning, and engaging in thoughtful analysis, especially when dealing with conceptual and theoretically influenced queries. (Galletta 2013, 50-52.) This means that most of the questions were rarely expressed the way they were written here, except for the first one. By answering the first question of the background questions most interviewees answered the second question as well, which led to me usually skipping it and going straight to the third question. Similar kind of thing happened also with the question regarding their own education background. More often than not they addressed it while reflecting the previous themes.

Some themes have several questions embedded, since I found them to be easier to discuss in connection with each other, or they were meant to lead the interviewee to think about the subject more broadly. This was nevertheless pointless in most cases since the interviewees seemed to have a philosophical approach to the questions from the beginning and the underlying themes were addressed fundamentally without me pushing them into it.

When a question seemed too inconclusive or hard, I noticed myself leading the interviewee to the similar subjects that had come up in the preceding interviews. This happened largely because I was interested in hearing their opinions and views in relation to each other. I tried to consciously to avoid this, but I caught myself doing it on couple of occasions. I also told some of my own experiences after they had answered a question, sometimes to gain more insights and opinions out of them and other times to encourage them sharing more precise anecdotes. It requires spontaneity and speculation as one encounters moments during the interview that have the potential to reveal a deeper understanding of the participant's story. (Galletta 2013, 76)

At any point my objective was not to challenge the opinions and views of the interviewee. I think it wouldn't have benefitted this research since its purpose is mainly to gather some thoughts and phenomena behind live electronics educators of today. The only challenge I consciously set for them was the difficult and broad subjects such as creativity. Creativity seems to be such a deep and fundamental subject that all interviewees had a short breath to gather their thoughts before answering the question.

4.2.2 Practical Implementation

I approached the possible interviewees via email. In the email I stated that this study will not be kept confidential, and their answers, as well as their name, may be included in the publication of this study. I also stated that their participation in this study was completely voluntary, and that they were able to withdraw their participation at any time, and proofread the parts of the study where they were involved in. The target duration of the interviews as mentioned

in the email were 45 minutes, but often the target was exceeded by 5 to 15 minutes. I sent this email to 24 recipients, from which 10 recipients replied. Seven out of those 10 led to an interview. The 24 initial recipients I picked on the basis of whether knowing some their work beforehand or by searching the internet for live electronics education programs and the teachers involved. After the first emails I sent, I had only five confirmed participants, so I decided to send a reminder email to all who had not replied to the first one. The result of the reminder email was two participants more, adding the total number to seven, which I found to be sufficient for the research. From those seven participants three of them I found purely by internet search and the four others I knew something about beforehand.

When a recipient had offered to participate to the interview, I sent a list of possible times to pick from. All of the interviews were carried out in a 19-day period from May 31st to April 19th. The interviews were carried out via Zoom video conferencing platform. Metropolia University provides professional version of Zoom for students, so it was logical for me to use that. From my own experience, Zoom also offers the best audio quality. In zoom both me and the interviewee had our cameras on, so we could see each other. The interview was recorded directly in Zoom both as audio and video, but I only used the audio part for transcription purposes.

Since the nationalities of the interviewees varied, the language spoken in the interviews was English, except for one which was carried out in Finnish. Prior to starting the actual interview, I had a few words with the interviewees off the record. First, I wanted to set an informal and relaxed mood by greeting them and asking about their day so far. Then I asked their permission to record the interview and to use their name in the thesis publicly in conjunction with their statements made in the interview. After getting their approval, I told them shortly about myself and why I'm conducting this research, and the semiformal structure of the interview. I emphasized that it was OK to deviate from the questions and to have a conversation where it was possible for them to ask something from me.

4.2.3 Analysis

The starting point of analyzing the interview data was to convert it from audio form to written form. Converting audio recordings into written text and verifying the accuracy of those written records can be a laborious process, but it is essential for establishing trust in the results of data analysis and the conclusions drawn from them. When transforming data from its original form into a more condensed format, it is crucial to ensure that the resulting product is genuine and precise. This condensed data then serves as the foundation for analysis and interpretation. (Galletta 2013, 121.)

The conversations were fully transcribed using Whisper AI by Open AI. The translations were rough with lacking punctuation and occasional mistakes in specialized words such as program names. Since my main focus was not on the way how things were said but what were the underlying ideas and thoughts of the interviewee, I took the parts I found important and topical in from these transcriptions and corrected the possible mistakes, filler words and discourse markers while compiling the quotes to themes. At times when the text produced by Whisper AI was unclear, I referred back to the audio recordings the check is some words were transcribed wrongly. In the case Aki Himanen, the interview was conducted in Finnish, the AI algorithm was not as efficient as with English, and it required more work in comparison to others. It needed to be translated as well. Since most of the participants in this research do not speak English as their native language, I took the liberty to revise many quotes to get the point across efficiently in written format.

By undertaking tasks such as reading, arranging, and transcribing, the researcher is initiating preliminary analysis, which can reveal particular themes related to your research inquiry. Some of these themes may stand out on their own. Analysis consists of identifying and categorizing these thematic patterns, which represent concepts that are evident in the data. These concepts signify a fundamental level of significance and are typically referred to as codes. It is crucial to document these codes by recording them as they emerge and then

examining their significance. (Galletta 2013, 121-122.) While correcting the translations of Whisper AI, I started to rearrange and code the quotes. I made a separate Word document where I copied the corrected and translated quotes under a suitable category, and I made new categories while going.

After the simultaneous correcting and coding -process, I proceeded to consider the connections between thematic codes by rearranging them within the document. Relating one code to another provides a deeper insight into the subject of the research. Grouping codes together under a more general theme or category frequently brings a fresh perspective to your interpretation of the data. Categories are an initial step in synthesizing the concepts that arise from the connections between codes. (Galletta 2013, 150.) I found that some codes align with the initial themes of the interview, while some, such as the topicality of live electronics or pushback towards it, rose from the data without my initiative. It felt natural to compile many codes together under bigger themes to create so-called subcodes under headline codes. While the headlines of the resulting themes align largely with the initial ones set before the interviews, there are underlying subjects which were collected from different points of the interviews. For example, the quotes which comprise the chapter dealing with invoking creativity came from all over the interviews' timelines.

After writing the first version of the results -chapter of this thesis, I sent it to the interviewees for their review. When I received their feedback, I changed their quotes according to their edits.

An issue worth mentioning, which concerns interviewing as a form of research in general, is that categories are generated by the human brain, and are both an outcome and a feature of human intellect. They are not an inherent attribute of objects, and even on a more basic level, there is ambiguity in defining them (such as when does a trickle of rain become a downpour or DJ set become a live set?). (Gillham 2000, 70-71.) The categorization and coding process is then subjective, and one might approach the same data from totally another

perspective as I have. It is therefore essential to address my own background in the next chapter to unfold some biases I have as a researcher.

4.3 The Researcher's Position

The topic of this research stems from my own experiences as an educator of live electronics. Since 2020 I have taught a subject called Music Technology and Musical Creativity at Turku Conservatory. The subject heading enables wide possibilities to approach music technology and includes studies in studio practices as well as live performance. The latter part has specifically raised questions among colleagues, and it is the area that I find the most demanding to teach. Since there are no preceding practices of this field on this educational level (vocational college) in Finland, I wanted to raise awareness of this topic and exchange experiences with fellow teachers from this field.

Since the topic has been heavily inspired by my own experiences, it is important to state my own position as a researcher. I was born to Caucasian parents in Finland in the late 1980s, making me a Caucasian millennial western male. I have lived in Finland, the happiest country in the world for third year in a row (World Population Review 2023), for all my life making me a part of one of the most privileged groups of people in the world. I have worked as full-time or part-time freelance artist for all my adult life, which is also rare and privileged on a global scale. According to Statista, in 2020, approximately 0.9 pieces of computer hardware were sold on average per capita in Europe. Compare that to the only 7.7 percent of households that are estimated to have a computer in Africa, one starts to get a picture of the different realities we live in globally (Statista 2019).

The possibilities I have had in exploring my creativity in live electronics and other artforms are not to be taken lightly. I have always had access to a relatively up to date computer as well as funds and time to explore its capabilities in audio and other fields of art. Even in Finland, this is not granted for everybody.

I hold a Bachelor of Arts degree with Music Education as a main field of study. Though my main instrument for all my instrument studies was a drum set, I started my personal journey with electronic music before delving into any established acoustic instrument. Electronics stood aside for a while when I learned about popular music and jazz first at a music institute, then at a conservatory and finally at a University of Applied Sciences. During the final years of my study career prior to master -studies, I gravitated back to electronic music, and begun experimenting in live electronics.

After graduating I worked as a freelance musician for several years while teaching myself about composing, mixing, mastering, DJing and live electronics. My main interest at the time was electronic dance music, EDM. It took me several years to get my first release out as an EDM artist, and then it took me several more to turn my interest in electronics into work opportunities and income via DJ gigs, occasional live electronics concerts, and commissioned work. From 2018 onwards I have had the opportunity to sound design and compose for several contemporary dance and circus projects. These projects have led me towards a wider palette of expression both in studio and live situations. My interest in contemporary music has presented itself in my sound design work and my experimental jazz group Josu Mämmi Trio.

Because of my background in popular music and EDM, the idiosyncrasies of contemporary electroacoustic music are still quite new to me. There is significantly longer history in teaching and conserving contemporary electroacoustic music than in popular electronic or electroacoustic music. This subject has been researched and studied in western universities since the 1950s (Dunn 1992, 15-18) while popular electronic music, having existed for over 40 years now, is just starting to get noted in music schools. The division between contemporary music and popular music is there, but fortunately it has not grown as strong as the gap between classical and popular music. Personally, I find these gaps to do more harm than good. They reflect more the teachers, editors, and academics view of the world than the students and consumers. To create new music and come together as cultures, it shouldn't

matter if the music is classical, pop, acoustic, electronic, ethnic, tonal, or atonal. I am working to bridge these gaps both as an artist and as an educator.

5 Results

As the research methodology employed was semi-structured interviews, the presentation of the results will be done in a way that empathizes with the participants. The focus will be on highlighting their views by prominently featuring their quotes, while my own comments and questions will be kept to a minimum. Since the interview questions generated diverse responses, the themes presented do not strictly correspond to the original interview structure but rather create new sub-topics where the interviews overlap and intersect.

5.1 Topicality of Live Electronics

The underlying response to this research was positive, even from the people that responded 'no' to the initial email I sent. Many interviewees, especially the ones that operate more on the popular music -territory, stressed that the field of live electronics education is still fresh and growing.

> *BENJAMIN VAN ESSER: The computer is more and more regarded as a potential instrument, or at least as a mediator, in some kind of way, or an agent, you know, a part of an instrument. So yeah, I think it's only normal that we start teaching that also.*

> *KIRSTEN HERMES: I think that is a growing field really. I suppose traditionally you can get Ableton certified training and things like that. People are having a growing interest in such training courses. But in academia, I think it's still quite new.*

The quote from Hermes shines some light in the different statuses of live electronics in popular music and contemporary music what comes to academic institutions. While some teachers from contemporary or classical music departments may have over a decade long teaching careers behind them, such as Benjamin van Esser with 14 years and Johan van Kreij with 22 years when writing this, the interviewees representing the popular music departments

reported eight or seven years of teaching experience. The division between popular and contemporary seems mainly institutional since many interviewees had strong interest in both areas of music.

> *BENJAMIN VAN ESSER: I think it is dangerous to limit oneself to a particular time period or musical genre. Therefore, what's important is that we remain open and allow for live electronics to be integrated across various genres, including pop, classical, dance, and metal. It can be applied anywhere, and it makes sense to use it in any genre. (...) The school where I teach live electronics is well-known for its tradition, and there is a tangible divide between different departments of classical, jazz, and historic music. However, my vision for the program is to connect with all of those genres. As a result, we collaborate with people from the ancient music department, the classical music department, and jazz musicians in various forms.*

Van Esser also states that he believes it is important to maintain openness in live electronics so that students from across genres can connect with each other and learn to adapt to different musical circumstances and live electronics can also serve as a hub between various domains of art. This openness nature of electronic music was also mentioned by Merlyn Perez-Silva when he extended the possibilities to comprise also different artforms.

> *MERLYN PEREZ-SILVA: When you open up Ableton Live or Max/MSP, it's a blank page and you start filling it up with ideas. Whereas if I take a guitar on stage, I already have a cultural communication and expectations happening with my audience. So, in a way, the ideas of dance and drama are very vital to electronic music because they all start from an empty space, much like Max when you load it up.*

This open-endedness of many electronic music tools such as the mentioned Max/MSP enable the live electronics musician to create diverse set of sounds, which in turn makes live electronics genre-fluid. To address the topicality of the subject, Perez-Silva also brought up the increasing focus on electronic music in Danish Universities in last 11 years he has lived in the country. The schools are trying to find their own blueprints and found their own structures two work with, so it is still a new frontier, with much left to be explored and established. He also

mentions how the growing popularity of electronics in popular music feeds the music technology industry, or other way around.

> *MERLYN PEREZ-SILVA: The market for equipment gets more and more interesting with more possibilities. Using laptop or technology on stage has become much more culturally accepted. And in fact, I can't remember the last time I saw a rock or jazz band without a laptop somewhere or a sampler or an iPad with backing tracks. There're very few purely acoustic stage situations anymore. So, in one hand, you could say that it's a great time to be involved with this and that the technology available is getting cheaper and more accessible and there is therefore more representation. It's not just white middle class men doing lab coat stuff, but it's becoming a lot more accessible. So that's a great thing.*

The increasing accessibility of music technology and technology in general works in favor of electronic music through democratization and increasing popularity. I would like to also point out the irony when he mentions "white middle class men doing lab coat stuff" since four of the interviewees plus the researcher can be included in this category. Democratisation of electronic instruments and the culture surrounding them makes the diversification of live electronics possible and is something to aim for.

5.2 Backgrounds

All of the participants in this research teach at the higher education, either in bachelor's or master's degrees. Only one participant, Aki Himanen mentioned that he teaches also in music institute, folk high school, and vocational education as well as on Bachelor -level. The reasons why this research ended up involving almost purely university level teachers can be that while searching the internet to find potential interviewees, the university teachers are easier to find online. Also, for reasons unknown to me the university teachers were more open to participate to this research. For research purposes it could have been more fruitful to have wider range of participants involved, but personally I found this rewarding since the university level of live electronics education is largely new to me, having only participated in a handful of courses myself.

It seems that I am not alone with the lack of formal training in live electronics. While many interviewees mentioned having studied music technology formally, some pointed out that the live performance -part was not included in the curriculum. In Ethan Hein's case he didn't study music as an undergraduate since most of the classes offered were classical. He only participated on one jazz class, which he liked, but there were no studies involving electronics.

> *ETHAN HEIN: They weren't doing anything with electronics at the time. I learned how to use music technology on my own in my apartment. Later, I earned a master's degree in music technology at NYU, which focused more on the technology than the music itself.*

Aki Himanen is also self-taught in live electronics, while also having formal training on music technology in general.

> *AKI HIMANEN: I did my bachelor's thesis on live electronic music. But in practice, no one really guided me on it. I learned it through the internet. I have a degree in music production/technology from a university of applied sciences, so in principle, I have received education on it, but not specifically on live performance. It has mostly been a process of self-discovery and learning through experience on how to do it.*

Again, coming back to the institutional division of electronic music into contemporary/classical and popular music, many teachers that have classical background, such as Alejandro Olarte, Benjamin van Esser and Johan van Kreij have had formal training in live electronics performance. Perez-Silva stands out from the other interviewees with a different background in education, that gives him a unique perspective to music performance. He has a bachelor in drama and theatre studies and has worked a lot on contemporary theatre and other performing arts. Music and performing arts might look different on the surface but Perez-Silva finds an underlying common factor.

> *MERLYN PEREZ-SILVA: But music was my first love and I somehow managed to convince the professors here when I applied for the master's program that that was somehow basically the same thing, stuff moving in space, I guess it all comes down to.*

Also Kirsten Hermes and Perez-Silva discovered electronic music through avenues other than education. Hermes's experience in music school as teenager was mostly about analyzing existing compositions.

> *KIRSTEN HERMES: But when I was in my late teens, I realized I wanted to produce music. I got a copy of Cubase and then just started playing around with that and then studied music technology in the UK as an undergraduate. I did the MA that I'm now teaching on at the University of Westminster. And then I did a PhD, which was more to do with sound perception and music mixes. I learned a lot around music production as an undergraduate, but when it comes to performance, I think that was mainly self-taught.*

> *MERLYN PEREZ-SILVA: I started producing with Ableton live first as a way of running theatre shows to trigger scenes, make crossfades, and communicating the music with the lighting through DMX. And then that turned into DJing which turned into production. And I did that for maybe eight years or so before I started studying it formally.*

Theatre was involved also in Ethan Hein's early experiments with live electronics. He also points out the significant growth of electronic music that has happened during his career.

> *ETHAN HEIN: I'm a guitarist and I spent many years playing rock, jazz, and country guitar. However, I was always interested in experimenting with the sound of the instrument. I did some more experimental music, such as theatre and dance, where I used delay and looping to make the guitar sound like a synthesizer. I had a band where we improvised dance music with a DJ and me on guitar. We jammed for hours, and it was great, but unfortunately, it went nowhere. I think if we did it now, it would have a good audience.*

Similar to me, Aki Himanen started his electronic music career before studying any instrument formally, getting into electronics right in the middle of the 'golden age' of house and techno in the 1990s (Lavoie 2019, 17).

> *AKI HIMANEN: Machine music, or electronic music, began for me around the mid-1990s. I started with an Atari and Cubase 1.0 during my middle school years. Making music continued as a hobby over the years, and later it also became my profession. When I*

> *started my professional studies in trumpet, I became familiar with Ableton Live.*

Himanen remembers asking someone what program he could use to make live electronic music, and they responded with Ableton Live. He started to use the program fairly quickly in his gigs. Some participants found electronics while studying a more traditional instrument formally. Alejandro Olarte studied classical guitar when he became fascinated with electroacoustic music. He quickly started building his own machines and hacking existing ones.

> *ALEJANDRO OLARTE: Eventually, I started experimenting with extending the capabilities of the guitar for improvisation using microphones, amplifiers, and pedals. I modified the guitar with sensors and actuators, and made it communicate with the computer in both directions. My performances were related to improvisation because there was no established repertoire for this type of practice.*

Van Esser studied classical piano while also attending music technology courses. Those courses triggered him to start investigating and researching the possibilities of electronic music mostly by himself.

> *BENJAMIN VAN ESSER: Apart from these lessons, I do not have any formal training in electronics. Most of my knowledge is self-taught, but the seeds were planted there. Sometime later, during rehearsals of an electroacoustic project, I became acquainted with Ableton Live through a friend. Although it seemed to be geared toward DJing, I quickly saw the possibilities in regard to live electroacoustic performance.*

These quotes and experiences reflect the fact that live electronics is still not so common in music education as acoustic or electroacoustic instruments. There is even some pushback as I will point out later. Therefore, comparisons to more traditional acoustic or electroacoustic instruments cannot be avoided.

5.3 Comparisons to Other Instruments

For people more acquainted with acoustic and electroacoustic instruments to understand live electronics better it can be beneficial to make direct

comparisons with electronics. For strictly electronic musicians it can be beneficial to understand the practices and creativity involved with acoustic instruments to get better at working with the players and programming the virtual instrument versions of them. In the themes I prepared for the interview I had a question concerning this, but the theme came up many times in connection with other questions as well. One point that rose was the open nature of live electronics and the programs used for it.

> *ALEJANDRO OLARTE: The openness in the concept of musical instrument is a pleasure that I share, for example, with percussionists. The potential for finding or making an instrument is endless, each object has a particular timbre, its own dynamic range and invites you to imagine ways of playing it; similarly, electronic instruments can be built, modified, or hacked from virtually anything. For example, customizing any object with a dedicated microphone (an egg slicer with a contact microphone), any toy or electronic device with a speaker can be bent for sonic purposes, a radio, a hand-held noise circuit, a prepared loudspeaker, and so on. Any of these can be easily integrated into the range of electroacoustic instruments.*

Hermes notes that a violin has had a clear signature sound for hundreds of years and is widely regarded to take a lot of practice and time to learn. Still it has a relatively narrow application in terms of what one might end up doing with it. Then she goes on to compare it to the electronic tools:

> *KIRSTEN HERMES: In terms of electronic performance tools, they're advertised as easy to learn, where you take them out the box and straight away you can make a beat without having to learn, which is misleading. Where the creativity main challenge comes in is really that you don't have to use them in a specific way. You can stick them together in lots of different ways and the creativity lies in what you build with them.*

Hermes continues that live electronics musicians have to build their own performance tool and not use a preset shaped instrument that is a meant to sound certain way. With live electronics one can create any sound and any functionality they can think of, so to narrow things down and create one’s own palette takes thought and creativity. Hein takes similar kind of approach but using guitar as a starting point. He emphasizes that while there are several

different ways and styles to play the instrument, most of them are established and there are teachers that have specialized in different styles. But when it comes to electronics the case in not the same.

> *ETHAN HEIN: I gave private lessons in Ableton to this guy. I told him that you're going to be inventing musical instruments for yourself to play. How do I teach you how to invent? This thing can make literally any sound that you could possibly imagine. So, what are you going to make? How are you going to lay it out on the grid? Then how do you play it?*

Perez-Silva points out that a piano has a locked systems with many possibilities that we know about and has a lot of both history and culture involved in it. Then he goes on to compare it to electronics highlighting an important note on the creativity involved.

> *MERLYN PEREZ-SILVA: When you give somebody Max/MSP or a wavetable synthesizer or something that's infinitely complex, then it can be a struggle for people to feel professionally creative, but it's maybe easier for them to feel naively creative.*

Aki Himanen brought up some of the practical differences that surface during the lessons in comparison to more established instruments. He stated that major chunk of the lessons is spent while discussing creativity, demonstrating how things can be done, and then focusing on technical knowledge.

> *AKI HIMANEN: It's less about practicing playing and having the student playing other composers' music. This means that the proportion of speaking is higher than playing. This is perhaps the biggest difference, but I still like to think that philosophically it's similar to other instruments.*

Aki goes on to point out the difference in practicing mentality that can sometimes become a problem with students, and that some more tradition could help with this.

> *AKI HIMANEN: Practice mentality don't seem to go quite the same way. This is considered a little different from learning a traditional instrument. Maybe at home, the mother hasn't told to practice Ableton. Something interesting daily task to learn should be*

> *invented to give as homework. As there isn't so much tradition in this.*

This lack of practicing mentality might have something to do with the underestimated difficulty and depth of electronics as an instrument. The steep learning curve was discussed at several different points in the interviews. Ethan Hein specified the difference in difficulty between studio work and live performance. He pointed out that the tools for the live performance are more demanding of skill and technique than producing and recording.

> *ETHAN HEIN: You can produce a recording with any computer, any DAW. You don't need a controller; you can just draw stuff with the mouse pointer and the midi piano roll. But with live performance, you either have to be able to play the keyboard or you got to be able to operate something like Ableton Push or a sampler, synthesizer, vocoder, or turntables. It's like teaching somebody how to play the violin, like it's a long and complex process.*

Kirsten Hermes, a violinist herself, indicated one of the possible reasons behind the common underestimation of the skill needed to perform live electronics.

> *KIRSTEN HERMES: The problem is because they're advertised as so easy to learn. It's therefore harder for people to get over that hurdle. When you buy a tuba, you're going to spend a lot of money. You're prepared for the fact that when you buy it, you won't know how to play it yet. You spend effort on that, and you know what your goal is and fairly aware of what's required. With electronic tools, people will get them for very cheap. They're seeing someone whack it out box, press some buttons, sounds great. But actually, there's this additional challenge that maybe they weren't aware of.*

Merlyn Perez-Silva addresses this topic by referring to how people mainly see performances that are ready-made and look easy at the first glance.

> *MERLYN PEREZ-SILVA: I notice a lot of students are very inspired by what they see on YouTube, where of course there's many interesting performers, but it's very rare you get to see the journey towards being this good at what they do. A lot of students want to immediately be Rachel Collier or Blink Beats or people that are very good and rehearsed at what they're doing. And often they don't get to see the steps that got there and all the failures and mistakes that*

> *led to this kind of system that these artists have built. It's important for me to show them that you can't just flip this switch and be a loop artist.*

Perez-Silva mentions the systems and setups that artist build. The interface of the live electronics as an instrument is one thing that sets it apart from other more established instruments. The interface can be changed or built from scratch, and it becomes a big part of the artists creativity. Hein points out a problem that sometimes occurs when live electronics performance utilizes a computer as an interface:

> *ETHAN HEIN: The challenge with using a computer on stage is that the audience doesn't know what you're doing. You could just be hitting play and not doing anything else, which is unsatisfying for them. Although you can make the sound great, there's always the question of whether you're just playing video games or doing something else.*

Hein also pinpoints that the expectations involved with the performance affect this challenge. For DJs it is not necessarily expedient to be clear on what happens on stage as long as people are dancing. The result matters more. But when live electronics happen in concert situations and the audience is sitting on chairs facing the stage, it is important that you understand what the person is doing.

In the context expectations and DJing versus live performance, Perez-Silva reflected the cultural status of a DJ:

> *MERLYN PEREZ-SILVA: I wonder if the DJ question is a bit like a three-piece rock band? If you walk into an arena and you see drums, big Ampeg and Marshall stacks, some pedals and one mic, we know exactly what's going to happen. We're safe, this is a three-piece rock band and there's bass, guitars, drums, and a singer. I know where we're going with this. Maybe the DJ booth and set up says, you're in good hands. This isn't going to be weird; you don't have to use your brain. You can drink your beer and we're going to give you something rather than ask you to be part of it.*

Expectations of the audience can therefore play a big part when creating and designing a live electronics set. One aspect that makes it challenging for

spectators to know what happens in stage is that there is no need for direct physicality in live electronics. Olarte addresses this underlying fundamental difference that electricity makes:

> *ALEJANDRO OLARTE: When you play the guitar, you are crafting the sound with your nails and your muscles. We have this one-to-one relationship, and the volume of the sound depends on the energy of your muscles and the resonant properties of your instrument. With electronics, we relay to electronic amplification. So now the electricity takes over and you can play loud sounds without being engaged in that physical movement and energy.*

This lack of physical motion can be alienating for spectators or instrumentalists that are used to the presence of physical instruments and physical action on stage. There are some performers such as Autechre that embrace the computer as an interface and make the immobility a core concept in the performance, but this is conscious and personal choice of the artist.

The interface defines the physicality of the performance at least to the extent on how much it changes the sound we hear coming from the speakers. To make physical movements matter an interface is needed. Benjamin van Esser considers the performance setup, or interface, one of the main features of live electronics. He notes that often the performers on this field also create the music they play and continues:

> *BENJAMIN VAN ESSER: If you would decide on using a specific performance setup, you're compositionally bound to the affordances and constraints of that setup. Of course, if you would choose to open up the possibilities of the setup through programming, you would have a different set affordances and constraints in composition as well. We always see a triangle between the programming, the performance setup, and the music you compose for it. These three agents are always working together in some type of constellation. That's why you would have to learn all three of these disciplines and find your own balance with them.*

So for live electronics performer to free themselves from compositional restraints, or to choose their own, they must address the interface at some point

on their creative path. Olarte warns us from some of the dangers with interface first kind of approach:

> *ALEJANDRO OLARTE: I think the personal solutions tend to be the most effective ones. The underlying idea behind this conversation is that if you have a musical need or discover one, it will lead you to the technology that best suits your needs. Choosing ready-made solutions often leads to frustration and lack of progress. For example, consider a new midi controller. It takes a lot of time and effort to map gestural parameters to sound synthesis parameters, exhausting the music creation itself, so expecting to achieve a transcendental musical moment becomes a lofty hope and an almost insurmountable task.*

Olarte urges the performers to build their practice from the bottom up and explore from there. One needs to consider if they are active physical performer or static one, or anything in between. That way the interface one chooses or builds reflects their needs better and that leads to better experience in music making and better music as well.

> *ALEJANDRO OLARTE: If you're someone who has a lot of kinetic energy and who likes to engage bodily with the music, then you might end up having big structures to move and turn, big faders or knobs with strong haptic feedback, something that requires your commitment because you're already into that kind of energy. So you might end up building or finding or buying or asking someone to build something to channel that energy. And I think that will bring more musical strength to your playing and performance than choosing a generic controller or gestural interface.*

The presence of technology on stage can also have its downsides. Perez-Silva opens up how it feels to perform with live electronics in comparison to more physical instruments:

> *MERLYN PEREZ-SILVA: Part of your brain is scanning for technical issues, which is not ideal as a performer. It's not something you do when you're a drummer. You are never really getting into that flow that you're hoping you get to, and you often leave feeling that it was bad, or it could have been better. That's because you're very analytic while you're performing, whereas if you sing or play an amazing clarinet, then you can easily get lost in the in it in front of an audience.*

To summarize, interfaces enable and limit the creative output of the musician. Limitations and affordances are what make an instrument in the first place, and in the context of live electronics both of these can be changed to suit the artist's needs. That being the case then choosing, designing, or building the interface becomes fundamental creative practice for electronic musician, and the starting point for that should be the artists themself; what they want to present and say in their art. The design of the interface and the system in general has to be also robust on stage, since less possibilities for technical failures, more secure it feels to perform. The performer has to be able to focus on the music and the performance instead of the technology itself.

5.4 Starting Points

I was interested in different teaching methods and pedagogical approaches of the interviewees. I approached this theme by asking them how they start with their students, ranging from students with near zero experience in music technology to experienced music technologists. With any starting point or educational content in general the context and the course in question matter significantly. Here I have divided the contexts coarsely into two settings: situations with less experienced students and more experienced students.

5.4.1 Teaching Less Experienced Students

From all the participants in this study, Aki Himanen possibly has the most experience in teaching beginners. He often starts out with his own approaches to live electronics using his own live sets as examples. He also uses Ableton Live to teach the principles of using hardware devices since the program apply the same principles.

> *AKI HIMANEN: Mainly it's about presenting and demonstrating my own live sets because there are many different kinds. We start with something simple, playing multitrack DJ style, or later some ultimate Max for Live generative chaos perhaps. We can start simple and also demonstrate how far it can be taken.*

In context of teaching beginners, Himanen also states that live performance is rarely taught in basic education and the emphasis there is on composing songs and music production. The reasoning behind this is that one cannot perform live before they are able to make music.

Sometimes in my own teaching I question the method of imposing your own starting points. I have been worried that those would guide the actions of the students too much and they would end up imitating my approach instead of developing their own. But many interviewees encouraged me to worry less about that and use my own starting points to ignite the student's creativity.

> *BENJAMIN VAN ESSER: You can impose your own stuff, and at some point, they will let go of that as well.*
>
> *AKI HIMANEN: One has to go through a lot of theoretical and technical issues and build things before they actually get to play, compared to an imitation style where one plays first and then tries to play in a similar way afterwards. By presenting one's own project and playing it, students get tips for their own work. (...) It's a must on a case-by-case basis, such as for children or young people. When something isn't working for them, it has to be really clear: do this like this, exactly the same way.*
>
> *KIRSTEN HERMES: I felt like in my classical music education that there wasn't that much room for exploring my own ideas. I was actively discouraged from trying to write my own music because it was like, no, you need to practice. You need to play this piece or whatever. But then on the other side of the scale if it's so open and unstructured and you have absolutely no starting point, then it becomes really difficult to judge quality or to teach it in a way that doesn't feel entirely subjective.*

This subjective feeling what comes to teaching electronics circles back to the Himanen's wish that there would be more tradition to the artform. It would make it easier to assess different situations. But when I compare the viewpoints of popular music electronics teachers to their contemporary colleagues' statements, it seems that the need for tradition and structure has something to do with the cultural differences between the two styles. On the contemporary and classical music side of live electronics, there does not seem to be a lack of

historical points of reference. Johan van Kreij points out the importance of them what comes to live electronics and improvisation:

> *JOHAN VAN KREIJ: Sharing experiences and existing works is an essential part of the beginning in improvisation. As a teacher, I believe it's crucial to inform students about the origins of this field and how it started. Going back to the 1950s and 1960s, when musicians faced challenges to prove the validity of free and open improvisation, is crucial to understanding the evolution of improvised music-making. In those times, making music without written scores was not considered natural and many traditional musicians viewed it with suspicion. Therefore, it's important to create an awareness of the history and roots of improvisation.*

In context of improvisation, Hermes and Perez-Silva also emphasized the importance of experimentation to demonstrate some of the possibilities in live electronics early on and hopefully get them exited to learn more. For Hermes, the starting point revolves usually around using Ableton Live. Then she proceeds to build a range of different kinds of performance setups, demonstrate what they do, and lets students experiment with them. More often than not her students haven't tried any live electronics setups before that, even though having used Ableton Live or similar software to produce music.

> *KIRSTEN HERMES: I just set some stuff up and see what happens. Then some of them naturally become interested in it and want to learn more, and some say it's not for me. I think because there's so much information online where you can teach yourself and explore things, that the most important first step is usually to just get them inspired and then if they are inspired, they'll build on that. They'll ask questions and it can develop from there.*

> *MERLYN PEREZ-SILVA: I find that students need to try different setups with their hands and their bodies. They should try to DJ or make a soundscape from a granular synthesizer. They should get hands on because I find a lot of students have ideas of what they want to do but haven't absorbed the compromises you need to make on stage.*

Perez-Silva continues to make an example where a student might want to improvise freely, but by experimentation they quickly find out how much preparation it takes and how stressful it can be. After that they might reconsider

and change their minds which is healthy growth. Hein also uses experimentation in the beginning. He often starts with a vocoder to lure students to the realm of electronic sounds. At first, most of his students are unfamiliar with it by name but have heard it before. Once Hein mentions Daft Punk, students usually recognize it and become more interested.

> *ETHAN HEIN: Introducing the vocoder to someone who has never heard of it can be challenging. It takes a lot of effort to get them to see the potential in it and think about how they could use it in their music. Guitarists are often interested in electronics because the guitar is already an electronic instrument with pedals like the Wah Wah and distortion. Connecting it to a computer is the next logical step... It's not that they can't learn, but it may take some convincing.*

Hermes brought up another way of using examples to arouse interest in live electronics among beginning students:

> *KIRSTEN HERMES: I think sometimes the trick is to show them artists that they like doing stuff like that. Ariana Grande has played with controller-gloves and effects pedals. That was the thing that converted some of the students to try this because there is someone that they can relate to who does this. It's not just old dusty lecturers playing with these obscure tools.*

5.4.2 Teaching More Experienced Students

When students have more experience, it is possible to dive straight to the technical, conceptual, or performative side of things. Van Esser usually starts with technical content and then moves on to improvisational and musically creative practices.

> *BENJAMIN VAN ESSER: We start out with some tutorials in Ableton Live and Max/MSP. Quite early I try to give the students some assignments on composing or improvising with some simple tools. (...) Maybe not at the very beginning but at some point, the students have to try to improvise a piece, but they are only allowed to use one audio sample as input source, for instance a bell sound or a gong type of sound. They are allowed to trigger that sound only once, and from that starting point they have to create a soundscape. For instance, what you could use is the freezing*

> *function in the reverb and similar effects to create layers, which in their turn can be altered with effects.*

Van Esser also described another exercise where he would improvise with the students' using piano. Student has to create a Live set that can capture his playing by looping and/or manipulating the recorded material. This way the students' have to find a way to play together with van Esser and provide musical layers to improvise to. Both of the exercises described require knowledge of Ableton or Max/MSP, as well as skills in improvisation and experimentation. The student needs to come out of their shell in the very beginning of the class and be brave enough to perform with tools that might not be thoroughly familiar yet. Perez-Silva on likes to dive straight into the playing and interaction among the students themselves, while acting more as a facilitator and mediator himself.

> *MERLYN PEREZ-SILVA: In a group situation and I definitely find getting them to play to each other and maybe becoming more of like a walking talking library rather than so much of as a facilitator is a very good way to start. That they can teach each other and show each other their solutions to things, and you can kind of chime in with like technical corrections or options.*

Olarte also emphasizes creativity while talking from the context of his course Live Electronics Atelier which consists of learning electroacoustic music tools, electronic instruments, theories, and concepts.

> *ALEJANDRO OLARTE: Live Electronics is a group tuition, so we follow a program that has been gradually trimmed over the years to provide more opportunities for people to create. Instead of having weekly sessions on different compositions, artists, or topics, we now have one topic every two weeks. During the other week, people present their works, findings, questions, and ideas related to the topic. I focus more on creativity and production than on personal input or exploring big topics, as there are many aspects to cover, including performance, technology, and music.*

In continuation, I asked from Olarte how he approaches the situations when a student has no background in contemporary music.

> *ALEJANDRO OLARTE: My approach is contextual, so we look at different contexts. For example, if we are exploring an idea in live*

> *electronics, say the "Japanoise" movement, we can examine performances, we can look at some examples of different performers, and then we can analyze their settings: what do they use to perform? However, I like to focus mainly on the performative ideas that surround them: what are the motivations, goals, and reasons that these performances convey?*

Olarte points out that in many of the practices he teaches there are no written documents. The oral tradition has been built up over time, and that is why it is important to understand the context surrounding the phenomena.

The context of live electronics in general is something that can be unfamiliar to many. Add to that the fact that there are several different contexts in history and in present within live electronics, it sets a challenge in unfolding this matter to those interested and even more so to those not interested, who possibly are in decision-making positions in school boards.

5.5 Invoking Creativity

The distinctive nature of creativity in live electronics have been mentioned several times in this thesis before. I asked the interviewees how they approach teaching this creativity in all its forms. Many times, they found the subject demanding, but important to address.

> *BENJAMIN VAN ESSER: There are different levels of creativity, right? It's not only about musical creativity, but also about sound design, programming, conceptualization in general, and so on. Many other things come in to play compared to the performative and interpretative creativity of a pianist for instance.*

> *KIRSTEN HERMES: I feel like hacking your own creative process is a really difficult and important thing. (...) You've got to sort of build a system for yourself to be a creative in.*

The different levels of creativity and the need for one's own system to be creative in might feel like a daunting task for a student. And important tool to tackle this is restricting. The system one chooses, or builds can help students to get creative in the beginning. Perez-Silva starts by stating out that when a student starts with a modular synthesizer for example, they might access

certain creativity they wouldn't have with an instrument they are familiar with. They might not be so worried about making music and enjoy the exploration. But it this creativity might not be so useful when the purpose is to complete songs.

> *MERLYN PEREZ-SILVA: There's definitely a creative liberation in that, but if we're going to recreate that creativity and create music or songs or structures from it, then all of a sudden, it's very limiting because they don't have any restrictions within which to play, and it can be quite overwhelming how many options they have.*

Hein proposes that limiting a system on a single device and a simplified interface can be beneficial for the performance also.

> *ETHAN HEIN: One of the guys who I interviewed for my dissertation is really into live (Roland) SP 404. And he was just like, yeah, it's just the physical design of it that, there isn't a screen, you don't look like you're up there doing your taxes. And there's so few buttons, people can see what you're doing. It's not the easiest thing to learn how to use, but it is more instrument -like.*

When van Esser was discussing the triangle of live electronics as mentioned before containing the programming, the performance setup, and the composition, he also pointed out the importance of limitations when considering the possibilities in all of these fields.

> *BENJAMIN VAN ESSER: It is very important to be able to limit yourself when creating the playground for live electronics. There are so many things that we can do. There are so many paths we can take, so I think it is really important to create these constraints for yourself because if you don't, and I see this very often with my students as well, then you get lost easily.*

Johan van Kreij opens up his personal journey in discovering the importance of restrictions in improvisation.

> *JOHAN VAN KREIJ: I started approaching the whole subject in terms of problem-solving, to the extent that the more I have control over how sensors connect to parameters in my software, the more versatile I can make sound, or I can produce sound. But I concluded that that was a kind of a wrong thought, because at*

> *some point there were so many knobs and sliders in front of me, and everything a specific function that it became impossible to manage the situation. There was so much information I had to deal with, there were so many parameters.*

Van Kreij then took an opposite direction to his controller setup and started to dramatically reduce the amount of parameters for real-time situations. He aimed for a specific instrument behaviour where there would be no need to deal with all the possible parameters. He continues that it can be beneficial to limit the options available in live situation to help exploration. Rather than having complete control in every parameter, it is more rewarding to stumble upon something one has not heard before. He tries to pass this to his students also.

> *JOHAN VAN KREJ: Rather than thinking in terms of the ultimate control, or the best possible control situation, it is better to introduce unknowns so that you can start exploring. (...) So, this idea that rather than trying to come up with the best possible control scheme, I suggest trying to make it a bit unstable, like a bit unknown, so that it allows for exploration.*

In the context of improvisation van Esser notes that while it is a common practice in live electronics at the contemporary and classical music context it sets it apart from the more traditional instruments in those surroundings.

> *BENJAMIN VAN ESSER: If I were to play for instance a piece by Rachmaninov, I can be creative in my interpretation but I'm not creating a new piece. If I were to improvise, then I'm creating something that didn't exist before, at the moment.*

Van Kreij also points out that the individual backgrounds of the students are important to consider while teaching improvisation with live electronics. Everyone approaches it differently. Some might have natural inclination to go on stage and perform improvising while some feel more reserved towards it and take more time to prepare.

> *JOHAN VAN KREIJ: I try to be aware of each person's background, taking that as a starting point in their own development. Making clear that it doesn't matter where they are or where they stand, that it is much more about developing the skill of picking up anything and bring that on stage rather than thinking in terms of that it should*

> *be of a certain level. Because I believe that then something unique may come out. So, I try to make space for that uniqueness.*

Perez-Silva adds his own approach to this theme:

> *MERLYN PEREZ-SILVA: It gets quite hard to really draw the lines in the sand when you have a group of 10 students that will kind of do very different things. It's nice to be able to have conversations about the performing self or the performing body alongside talking about compressors and limiters. (...) I definitely try and make it silly, gamified, much more like a drama class than a music class and get them kind of on their feet because if they get those skills down, they can easily fill in the music with their own sounds and learn that way.*

For an instrumentalist to be able to improvise and create in the moment, one of the most important skills to develop is active listening. It can be considered as the basis of all musical training that has anything to do with creativity, and live electronics is no exception. Both Olarte and van Kreij believe that when working with electronics, becoming good in it involves becoming a good listener.

> *ALEJANDRO OLARTE: You have to appreciate the sounds and acoustic phenomena of surrounding objects and their environment, and then interact with an instrument. That's how you build your musicality and identity as a musician, by listening, perceiving, analyzing, exploring, experimenting, failing, discarding, succeeding. It's not just a matter of the medium, you can have a room full of electronic gadgets and instruments and make something interesting, or you can have a crackle box and still create something interesting and meaningful.*

> *JOHAN VAN KREIJ: The art of listening is something that I always emphasize and consider to be of great importance. It's not just about producing sound, but also the ability to actively listen. In fact, listening is a crucial aspect of live improvisation. (...) The first thing is listening to nothing that is just being silent and listening to the space and hear what is there, what happens. (...) It is something that I would do as a sort of group activity. Like let's be silent for five or even 10 minutes, it needs to be quite long because then something starts to happen.*

The listening exercises can be a good starting point for live electronics improvisation workshops and courses. The listening exercise van Kreij introduced reminds me of electronic music pioneer John Cage's composition

4'33, where the performer is meant to make no sounds whatsoever and the surrounding unintentional sounds form the music (Cox and Warner 2017, 27). To circle back to starting points, many interviewees shared some of practical methods on how to get student's creativity flowing.

> *BENJAMIN VAN ESSER: One way I approach this problem is by giving the students some sort of starting point; a musical idea, but it can also be a visual idea or a mathematical principle for instance. Throughout the first creative processes, I shape and sculpt their work together with them. After several projects the students get a better understanding of their creative possibilities and start to discover their own set of preferred tools and tricks.*

> *KIRSTEN HERMES: I'm almost forensically trying to find out what is it that they want to do live? Is the main idea that it just looks better than singing to a backing track, given the audience that they perform for, in which case it's maybe not useful to make it overly complicated. Or do they want to improvise live? What is the aim and why and then I can make some suggestions of things to try. If they are interested, then they start to organically ask questions as well. They kind of become self-directed in that sense.*

In contrast to the earlier statements about giving your own starting points with beginners, Himanen often also uses a different kind of approach where he demonstrates different tools on a technical level without the aim to make music with them, but to introduce some of the possibilities they offer.

> *AKI HIMANEN: Hopefully, they start thinking about how they can apply them in their own work as they follow along. So, I provide them with the technical tools and say, "Here's what you can do," but how to use them has to be figured out by themselves. (...) I usually tell new students that the examples I'm doing here may not necessarily stand the test of time. I'm not focused on whether this is the final sound for a song, but rather showing how the tool works.*

Hein highlights the idea of starting small with the tools and growing from there. One can start with recording oneself playing, then take next step by programming some beats, and then adding a bassline. All of a sudden, the student might use mainly electronics in their work.

> *ETHAN HEIN: And then that takes on the life of its own. I don't even need the guitar. Actually, I should just do everything in within Ableton. Maybe I should just record my playing and use it as a sample library? Or forget about my playing, I'm just going to sample Jimi Hendrix and use him. It definitely started with trying to solve a problem in my guitar playing life before it took on a life of its own.*

Perez-Silva has come up with a surprisingly strict exercise to teach fundamental skills of staying in time and thinking ahead.

> *MERLYN PEREZ-SILVA: I'll often do things, for example, choreograph a series of follow-actions in life where they know the piano is going to loop for eight bars and then the guitar gets switched on, so they have to run around and go through a choreography, and not really have a musical idea, but just know they have to kind of win this game. Like start with a tambourine and then go on to a new thing. And it kind of gamifies it, and they're not allowed to make good music. They can't do their own songs or anything. It has to be playful and fast and silly. I definitely use that a lot to train them to be on the beat when they do stuff and to think ahead and get ready to change instruments and things. This is a lot easier to do before you start trying to be an artist.*

This sort of exercise is done using loopers or a software capable of similar action. One has to pre-program the looper to loop certain things that happen at certain stages of the performance. The choreography then happens when the performer goes around the stage and plays all the parts for the looper. Perez-Silva also mentions another method that has more to do with the creative part of performance and get into a right mindset:

> *MERLYN PEREZ-SILVA: I make them play other people's songs, getting them to do a Kraftwerk song in a group or get them to kind of do a bad remix live and take their seriousness and their own needs out.*

Both for Himanen and Perez-Silva when teaching the creative use of the technological tools, the target is not necessarily to make good music from the start. Important is to explore the possibilities and let them inspire the student. It helps to lower the expectations and give room to the creativity.

5.6 Challenges

Even though I had included a specific question in the interview for different challenges in teaching live electronics, the theme emerged also while discussing other topics. It was as if many of the interviewees had a need to talk and reflect on the topics, and therefore various challenges arose in relation to many of the questions. This was not a surprise for me since that was one of the main reasons I started this research in the first place.

Some interviewees mentioned that one thing they are struggling with is the broad range of students attending to their classes. Perez-Silva states that it is challenging to teach live performance to people with varying backgrounds in music. When some are drummers, some singers, some techno artists etc. it is hard to include them all. He suggests that making them share ideas and inspire each other is a good approach in those situations.

> *MERLYN PEREZ-SILVA: All of a sudden, we have some people that can code Java and some people that purely work with found objects and microphones. And we're supposed to somehow kind of create programs that will include them all. And it's very challenging.*

Ethan Hein is facing similar challenges when he teaches music tech class. The skillsets of the students there range from complete beginners to professional DJs and everything in between.

> *ETHAN HEIN: Part of the challenge of doing music tech is that even in introductory classes, I get people who have been producing house music at a professional level for years without any formal training, or someone who has been a classical violinist since they were five years old but have never made music with electronics, or a DJ, or a singer-songwriter, or someone who has no prior experience whatsoever. And they're all in the same room for an introduction to music technology.*

To add to the different skillset and artistic ambitions, Hermes also pointed out the different neuropsychological starting points of her students:

> *KIRSTEN HERMES: I guess another challenge is catering to different learning styles. A lot of musicians are neurodivergent, or they're learning in a different way or are inspired by different things, and they have different needs. There isn't one best strategy. That's what's tricky about it.*

Another challenging topic for teachers to address was the pressure and anxiety some students feel. Big expectations and fear of judgement cause unease in students and might disrupt their creativity.

> *ETHAN HEIN: Creativity can be challenging, similar to anxiety. People may fear judgment, struggle to generate new ideas, find it difficult to evaluate their own concepts without becoming discouraged, or struggle to critique others' ideas constructively. However, I enjoy these challenges because they offer opportunities for growth and development. (...)*

Hein emphasizes that the students he teaches affects his teaching approach. In music schools many of his students have already developed a high level of skill in their instruments before going into electronics. With these students specifically anxiety can cause problems.

> *ETHAN HEIN: They often struggle with anxiety and fear being judged harshly. This psychological hurdle can make it difficult for them to explore new ideas and play around with their music. They don't have trouble learning complex information, but they just have anxiety.*

Perez-Silva shares this experience noting that when a student is very good at what they do but do not have a lot of performance experience, teaching performance and creativity can be very challenging due to their expectations of themselves. Also the increased importance of live performance in music business sets more pressure to the students’ shoulders.

> *MERLYN PEREZ-SILVA: They know that if they really want to do music sustainably, they need to perform it. And now they're trying to compete with all these people in their genre or their niche. So, they're walking in and saying, can we get from zero to hero in five hours or 10 hours over a semester. And they also are very busy. They have other subjects and things. I feel for them, because it is something that takes time and trying a lot of stuff out and a lot of*

> *people feel very pressured to come out with something extraordinary.*

Perez-Silva continues that the challenge is not a bad thing per se, but the short amount of time some students expect to put into their live performance project sets an extra level of difficulty. It is easier to introduce ideas and let the students find their way to it, but it takes time. Hein points out that to help with the creative side bridging the gaps between genres might help, but it also takes time and effort to do so.

> *ETHAN HEIN: In the classical music or jazz world, there are distinct boundaries between different types of music such as music concrete and playing the saxophone. This lack of overlap makes it difficult to spark their creativity. It takes time and effort to bridge these gaps, which is more challenging than teaching someone how to use the vocoder. It's about helping them combine their existing knowledge with new electronic tools.*

Himanen highlights the psychological skills needed to deal with different students.

> *AKI HIMANEN: When students have a strong desire to create personal material, it can fuel creativity. However, it can also be challenging because each student is so different, and it would be necessary to act like a psychologist in dealing with that. (...) Sometimes difficult students come along who expect some kind of ready-made system where they are told what to do and given a list to follow to independently create a song or a project. It has been challenging for some to realize that they have to figure it out themselves.*

To comment on Himanen's statement from my own standpoint, usually the need for ready-made system is more common with students with less experience in arts. When a student starts any endeavor with arts, they will inevitably realize at some point that the purpose of art is not to replicate something completely. Hermes draws parallels with art world when discussing what is important in live electronics in general.

> *KIRSTEN HERMES: It's not about very specific technical skills, but sometimes it's about Artist identity, having a sonic signature or*

> *having a visual identity, knowing target audiences. So, it's not necessarily required to be technically excellent at any one given thing but more about how you bring these things together. I suppose it's similar to when you had modern art movements over the past hundred years where people invented things like minimalism where it's not difficult to draw a square onto a white sheet of paper in terms of comparing that to what Classic painters had to do but it's more about what does it say? What's the meaning of this?*

Olarte has an angle how to tackle the source of anxiety in his own classes, and points out that it takes time to overcome these issues:

> *ALEJANDRO OLARTE: In the realm of creativity, the influence of popular music can create a heavy burden on young individuals' thinking. There is a belief that if you don't sound like this or that, you are not successful. It takes time to unravel this belief and discover that there are many other aesthetic practices that can be explored. Even glitches or small speakers can convey an artistic voice that goes beyond the norm of being quantized on the beat and pitch with full range loudspeakers. It is important to realize that a software might have a button selection that allows for non-quantized timeline patterns and non-linear structures*

As with everything, the subjects any teacher finds easy or hard varies by what courses they teach and on which levels. In the dialogue between technical knowledge and creativity, some teachers found the technical part easier to teach, but for van Esser it is another way around:

> *BENJAMIN VAN ESSER: For me, programming is more difficult to teach than the artistic part. Since the technical background knowledge of each student is different, we have to bring them all up to the same level before we wander into the artistic realm. But some students are faster in their understanding of this often-abstract matter than others. It is hard to place yourself back in this 'noob' state to make sure you explain the matter in an understandable way.*

In van Esser's classes the students start their artistic exercises after the first batch of programming lessons, so they are already aware of the environment they are working in. Van Esser continues that they usually start to show their own technical and musical preferences after the first creative exercises and states that it is a great deal of fun to dive into the worlds of students and support

them to find viable musical outcomes. For Hein and Himanen, from the technical standpoint the case is usually opposite to van Esser's:

> *ETHAN HEIN: Technical stuff is easy, creativity is hard. Technical stuff is just time and repetition. At first, people always have a hard time with how does the compressor work? At first, what does the attack do? What does the release do? You just do it, just fiddle with it, play and experiment with it. Eventually, you will get it. Go through the presets, see what the presets sound like.*

> *AKI HIMANEN: I think the easiest way to teach is technically, like on an Ableton course. It's like the easiest thing in the world because it almost always goes in the same way.*

As Himanen teaches also younger students as well as Bachelor level, he has a clear view on the differences between those situations, and the steep learning curve.

> *AKI HIMANEN: Quite young students, underage ones, are quite challenging. There is surprisingly much to understand about technology and music production. If we move a bit towards the production side, music production is not as simple as, say, learning the basics of an instrument, because suddenly one has to grasp the big picture with all the instruments, not just the one that is being focused on. In my opinion, it has been more difficult to make progress with it, depending on the student.*

In addition to these more general topics, there were also couple of interesting points that came up in the interviews that I would like to point out as separate comments. Hermes pointed out something that I have myself struggled with from time to time, which is teaching someone to teach themselves. This imposes a bigger problem in schools that cost money to students, in comparison to the government funded schools where tuition is free, such as the school I'm teaching in currently.

> *KIRSTEN HERMES: Ultimately, they have to learn how to learn and teach themselves, which is hard to explain when people pay large fees to come to university to learn something you don't know. You don't want to feel like someone's telling you OK now, you've paid all this money and you'll teach yourself some stuff. I think some areas especially around creativity where you have to find a*

> *balance between giving them a 10-step approach of how to do a thing versus having them find their own unique path can be more difficult.*

Olarte ties live electronics to the bigger picture and global challenges of our society, pointing out ecological footprint our artform creates. The race to create or use the most interesting and forward-thinking new gadget around sets a challenge to sustainability of our artform.

> *ALEJANDRO OLARTE: How do we talk about sustainability in the ecological sense if we are constantly preoccupied with the latest mixer or gadget? I believe the challenge now is to initiate and engage in a conversation that addresses this issue. It is not just a conversation to be had with students, but as a society as a whole. We need to consider how we consume and use technology, not just for aesthetic purposes, but also for everyday life. Engaging in this conversation can be difficult, but it is necessary.*

He also states that our society faces more pressing ecological concerns today than we did 20 years ago. There are also very difficult sociological issues regarding equality, peace, and social justice. How live electronics and electronic music in general positions itself in relation to these issues needs an ongoing conversation.

> *ALEJANDRO OLARTE: I think electronics tends to be driven by an industry that is solely focused on profitability. We receive offers for hundreds of products every day, which are essentially the same things again and again. It takes time to sift through all of that and to come back to the principles of what is actually meaningful amidst all the commercial hype. There is a constant push to have the latest plug-in or synthesizer, and this creates a barrier within the pedagogical context. It becomes difficult to address the real issues, such as sustainability.*

Sustainability surely lies in the future for live electronics as well as any other aspect of our lives. The conversation on how we should address this is possibly more important than any other topic since it largely dictates the future of live electronics as well.

5.7 Future of Live Electronics Education

When asking the participants about the future of live electronics education I added that they could address the things they think are likely to happens as well as things they would like to happen. Many times, the answer brought up themes addressed earlier in the interviews and one common theme was that the teaching of live electronics would gain acceptance and become more widespread.

> *BENJAMIN VAN ESSER: Well, I only I hope there will be more schools, in lower as well as higher education, to offer this kind of study to future students, and that it can only continue to grow.*

> *ETHAN HEIN: The field of electronic music production is growing rapidly, although it is currently a relatively small part of formal music education in the US. However, this is changing quickly, and innovative institutions like Berklee College of Music are leading the way. They recently announced that the laptop can now be a primary instrument. Berklee is always way ahead of all the other music schools, like they were way ahead with jazz and rock. While it may take many years for other music schools to follow suit, I am optimistic about the future.*

Himanen stressed that in addition of hoping that live electronics education would exist in the first place, that the live electronics should be included more in the popular music band education to reflect the zeitgeist.

> *AKI HIMANEN: I hope that it would integrate more into basic band education. Then, as you know, in the professional line, in large parts of bands, there are backing tracks and things like that. Could it be diversified so that it's not just pressing play on a backing track, but that a machine musician could clearly bring an improvisational perspective to it? In the same way that players bring something different, like a drummer playing a different fill than usual, why couldn't a machine musician do something different?*

He also continued that there is a lot of work to be done in the early education in the field. We need more teachers specializing in electronics in early childhood education. Olarte also underlined the importance of teaching young students the fundamental nature of how electronics and nature work.

> *ALEJANDRO OLARTE: If we were to teach music with an app in a tablet to a kindergarten, I hope we could deconstruct it to understand what it is, what's really going on. How is it that if I move my fingers like this, these sounds come out? What do the hardware and software do, what are they made of? How are they made? What components, materials and resources are involved? We have to go deeper with the kids. But I also believe that practitioners and professionals have to help us deconstruct the practice and the given to understand the nature of our tools. So my hope is that we can use the affordability of the electroacoustic medium to deepen our contact and understanding of nature.*

5.7.1 Pushback

Some interviewees brought up the slow application and integration of live electronics into the education system. This was more evident in the popular music schools what comes to dance music for example.

> *ETHAN HEIN: In the US, universities have historically been resistant to dance music culture. For example, jazz was not taught in universities until the 1980s, long after it had ceased to be popular and was no longer danced to. Similarly, rock music is only now starting to become accepted as a subject of study, but only now that it is no longer considered a youth music, and nobody dances to it anymore. The focus has shifted to more "artistic" rock music, like Tame Impala, and away from music like Chuck Berry or Buddy Holly that people actually dance to. I predict that universities will start embracing hip hop only after it is no longer popular and considered fun by young people.*

> *AKI HIMANEN: So maybe, if electronic music has reached the point in the 2010s where it can be improvised with or it's more prevalent - it has existed before, of course - but now we can expect to see it more in Finland in the 2030s. That's just how it goes, the schools react slowly here.*

The barriers between different styles and cultures create extra work for teachers when sometimes they have to justify the existence of live electronics education in some styles or even at all.

> *ETHAN HEIN: After my master's, I pursued a PhD in music education, questioning why universities only taught art music and not dance or black music. I took an electronic music composition class with a professor who discouraged beats. This was 10 years*

> *ago, and since then, the professor retired, and the new person is more accepting of beats. However, many US schools that embrace music technology still don't prioritize dance or hip hop.*
>
> *AKI HIMANEN: It would be a dream situation if it was integrated more seamlessly, and especially if we could remove this kind of barrier between us, the electronic musicians, and the "real" musicians, because it can be so tiring to deal with.*

Himanen is thinking back to some encounters he has had even with younger colleagues that have brought up the similar viewpoint where electronic music is not real music. At some point the prejudices have been instilled in their minds by somebody.

> *AKI HIMANEN: Even on teacher meetings I have encountered ignorance towards live electronics and electronics in general. When I mention the Berklee (Electronics Digital Instrument, EDI) thing about it, even then the response doesn't really change. That creates a certain battle position, and one has to defend the obvious. Does one have the energy to do all of this?*

It came as a surprise to me that in the US electronic musicians have to tackle somewhat similar problems as we do in Finland. Luckily in comparison to Himanen's experiences, my encounters with colleagues and leadership have been mostly positive, and I have been largely answering questions from genuinely interested but unknowing people. For many the culture surrounding electronic music is so foreign it has been hard to explain what happens in a three-hour DJ set and why it is not as easy as pushing play on a mp3 player. From my experience the days of unified Finnish culture where everyone is dancing to Kari Tapio are over. Different ways of consuming arts and culture are thriving side-by-side, but sometimes the other culture is not appreciated because of the lack of understanding.

5.7.2 New Technologies

The advancements of technology surely impact on the education in the future, and since live electronics predominantly revolves around technology, it is no

exception. The speed of the change is nevertheless not so fast as one might think.

> *KIRSTEN HERMES: You could say if you're teaching a DAW, you can go over parts of the functionality, but there's the question of how useful is that if in 10 years someone makes a completely new tool? (...) I think things do change, but they don't change that fast or that drastically because a lot of new performance tools are similar to ones that have come out before.*

> *ALEJANDRO OLARTE: Many times, I don't need to hear or touch a product to understand what it is. The field of sound synthesis hasn't seen much progress since physical modelling. There are a lot of experimental ideas out there, but not many people seem to be committed to taking them any further. As a result, we've gone back to analog and cassette recorders. It feels like we're going in circles technologically. We have yet to build a sustainable instrument or at least explore that possibility.*

Even though the technology is going in circles around itself, van Kreij has noticed a change in his own approach during his teaching years:

> *JOHAN VAN KREIJ: And there's a lot of things to say, also more detailed things like how I have changed in terms of ideas of thinking or working with electronics in live situation. I think that's quite different now than what I did 20 years ago.*

Van Kreij continues reflecting on how new technology might and could create new possibilities in performance. We might start looking differently at the building blocks of live performance, where the stage, a good sound system and a sitting audience are not necessary. Live performance can become more mobile and fluid.

> *JOHAN VAN KREIJ: Live electronic music can even be without, say, a loudspeaker system, as we typically know, but could indeed include mobile phones, or it could be across multiple spaces. It could take place in a whole building rather than in one single room. These subjects I find very interesting and also try to introduce them in my class.*

Perez-Silva suggests that the increasing popularity and the fusion of old and new could bring new performative elements into the forefront.

> *MERLYN PEREZ-SILVA: I'd like to hope that the performative element will emerge from this. One default that we all kind of have lent on a bit the last 10, 20 years is a clock. Everything is on the grid; everything is synced and there's a feeling of you can't really improve what you do with other people without Ableton Link or midi clock happening. And I really hope that the different technologies coming out around this idea of timing and the re-emergence of ambient music and tape music can take that apart and create an interesting space where people can just improvise with patches or live electronics. We could kind of lose the studio a little bit and reinvent what it is.*

Perez-Silva continues that with the expansion of electronic music beyond clubs and into jazz cafes, venues, and festivals, there is now an opportunity for the performative aspect of electronic music to evolve into a more refined and expressive form, moving away from the compromise between live performance and pre-produced elements. This shift opens up space for experimentation, risk-taking, and the revival of musicality. He also shortly mentions that maybe ChatGPT, a current popular AI -tool by OpenAI, will not interfere the more creative performance part of their curriculum in the foreseeable future and that is why it would be useful to focus on it more. Hermes comments on how AI is going to change our approach to arts that utilize technology. She also mentions the possibility of incorporating electronics into musical cultures outside our western sphere of 12 tones.

> *KIRSTEN HERMES: I think there's more of AI and therefore probably an even greater push for ideas over technicalities and innovating and doing something somehow unique as opposed to doing something that requires traditional craft. (...) I guess a push towards teaching online, flip classroom approaches and more diverse international students, which is going to have some sort of impact on it, which I don't know what that impact will be. (...) Electronics is such a thing that it can be adapted pretty easily to different kind of approaches to sound and music. If you compare it to a piano, which has 12 tones, it's hard to play a traditional Indian piece on it. With electronics you could do that.*

Olarte also mentioned that electronics is a great vehicle to incorporate different musical cultures into. When discussing the future of live electronics, he circles back to the sustainability issue:

> *ALEJANDRO OLARTE: There are places where sustainability is being discussed, and alternative energies that could power our devices have been pointed out. These alternatives could be the core of sustainable technologies, but progress in this area in our field is slow. It seems that few people are actively engaged in exploring these issues, although some individuals are. Unfortunately, they are not able to compete with big industry and machinery, which tend to slow progress. Perhaps the key is to de-escalate production and go local.*

Olarte also talks about how live electronics as an artform could help us understand as a society what science is already telling us:

> *ALEJANDRO OLARTE: Maybe we're arriving at that point with the nanotechnologies and the electromagnetic radiation. Maybe we'll start to understand that things are actually connected, and everything belongs to the same. We share the space with plants, animals, and other human beings in the same space. So somehow, I hope the technology or the performing with technologies will open up that conversation for real, deeper.*

6 Conclusions

In the beginning, I set four research questions. The first one was 1) What are the common tools live electronics performers work with today and how did they emerge? I answered the question through a literature review in chapters two and three. The most important finding was that – contrary to what one might think –live electronics has a rich history of over a hundred years. After the first four experimental decades, electronic music started to mature into an established contemporary music method in the form of tape music, and live electronics grew with it. After the first commercial synthesizers appeared in the 1960s, the influence of electronic music started its slow growth also in popular music as well as contemporary art music. Turntablism brought live electronics to new audiences in the wake of hip-hop music while the democratization of digital technologies made it possible for a wider range of artists to experiment with live electronics from year 1980s onwards. The falling costs of microprocessors made it possible to produce and perform music using only a computer and

software in the 1990s/2000s. The internet created global communities where information and music changed hands faster than ever, and it has notably brought down the barriers for artists to go into electronic music and live electronics.

The possibilities for live electronics musicians in the 2020s range from utilizing computers and software to using only hardware devices, or even only analog devices. Artists can make use of practically anything in their setups to make music with. One can process acoustic sources electronically, make electronic sounds purely by electronics means, or even control acoustic sound sources by electronic means. An artist might use sections of entire existing tracks or create everything on the spot from the ground up. If the affordances of existing electronic devices do not fulfill the artist's needs, they can assemble or program their own devices by using modules, electronics, or coding environments. The vast possibilities for live electronics musicians make choosing and making their performance system an important part of the creative process.

To answer the second question, 2) How is live electronics taught in formal education today? I reviewed the interview results. Many of the teachers are self-taught in live electronics despite having formal training in music technology. However, contemporary music teachers often have more formal live electronics training than their counterparts in popular music. Hence the teachers have to autonomously discover many of the methods used in teaching. This leads to many different approaches on the matter.

The interface is a crucial component in live electronics and building it from the ground up is essential to achieve the best musical results. The system needs to be robust to ensure the optimal fluidity of the performance. Teaching students to develop a setup and a system where their creativity can thrive comprises a significant part of the live electronics lessons. It is crucial to focus on the students' needs and artistic voice when considering different interface and setup options, so that the interface does not come in the way of the music but acts as an enabling factor in the process. The need for an interface suitable for

live performance sets an additional challenge for music schools. If the students do not have any equipment themselves, the school should offer a starting point for them to start experimenting with. This sets financial demands to start teaching the subject successfully.

Another key aspect of live electronics is that performers almost always make their own music. This is a significant distinguishing factor when compared to more traditional instruments, as it allows for greater creativity and freedom in the performance. When comparing live electronics studies to more traditional instrument studies, the share of music creation, composing and improvisation is higher. For a student to be able to produce their own music, they need to study music as a whole. This can take a significant amount of time and requires rigorous practice in listening.

To answer the third research question 3) What are the most common challenges teachers face when teaching live electronics? one has to consider the different levels of education and different backgrounds of the students. Still, there are some common factors which appeared among teachers.

Live electronics as an instrument presents a unique set of challenges for students who seek to master it. Unlike traditional instruments, students must learn not only the technical aspects of the equipment but also the musical principles that govern live electronics performance. It is common for beginners to have unrealistic expectations about the ease of performing with live electronics. However, becoming proficient in this field takes time, practice, and experimentation, and this is something teachers have to stress for students at early stages.

Limited resources within the educational system and the busy schedules of students can make it difficult to devote adequate time to exploring the full range of options available in live electronics. Moreover, the current state of live electronics education in schools does not reflect the growing popularity of electronic music, particularly live electronics. To address this issue, more resources need to be allocated to live electronics education, and schools should

seek out teachers with expertise in this field, even at the early education levels. Only then can we ensure that the next generation of musicians is equipped with the skills and knowledge necessary to take full advantage of the exciting possibilities that live electronics has to offer.

It is also worth noting the differences between contemporary/classical live electronics and live electronics in popular music. These differences can be partially explained by the longer history of classical live electronics in education. It is somewhat paradoxical that the classical side of education has been more active and accepting in incorporating live electronics, a relatively new instrument, into their curriculum. Nevertheless, it is important to recognize that both contemporary/classical and popular music offer unique opportunities for artistic expression and experimentation in electronics. By encouraging greater access to live electronics education and promoting cross-genre collaboration, we can foster a more vibrant and dynamic music culture.

The final research question was 4) How can creative use of live electronics be taught? Live electronics has two distinct levels of creativity at play. Performers must not only think creatively about musical composition, but also about interface and instrument design. Another example of an instrument that has similar possibilities is percussion since any object can be used as part of a percussion setup. Similarly, any object can be included in an electroacoustic setup, whether it is electronic in nature or not.

The vast array of possibilities available within live electronics can be both exhilarating and overwhelming, and limitations can serve as useful tools for sparking creativity. These limitations can take the form of a limited set of tools or sound sources, for example. Experimentation is also a key starting point for live electronics performers, whether they are just beginning their work or seeking inspiration for new musical creations. Limitations and experimentation often go hand in hand when exploring the potentialities of electronic music.

One of the most exciting aspects of live electronics is its openness to incorporating musical styles outside of the Western tradition, or even

incorporating live electronics into traditional Western styles. Unlike some more traditional instruments, live electronics is not constrained by the 12-tone system, making it an ideal vehicle for introducing novel ways of composing and creating sounds. Ultimately, live electronics represents a powerful tool for musical innovation and experimentation, with the potential to transform the way we think about music and the creative process.

7 Discussion

I began this research to gain insight into how live electronics is taught today. I wanted to discover what kind of perspectives teachers have and what challenges they face in their work. These questions arose from my own desire to share thoughts and ideas with other teachers in the field and to find solutions to some of my own challenges in teaching. Secondly, I wanted to raise awareness and collect knowledge. For many of my colleagues, the idea of live electronics is still vague, and I strove to form a clear presentation of what live electronics is and what it can be today. My initial idea of collecting practical teaching methods in a coherent written form proved to be a task too demanding for this master's thesis, but it can be seen as laying groundwork for such endeavor.

The cultural context was limited to the western hemisphere, with all participants and the researcher representing western world[2]. Western contemporary electronic music has a solid educational foundation in classical and music technology departments at western universities. It has a long written tradition while the surrounding unwritten tradition is being addressed in the universities as well. This sets the classical and contemporary live electronics education apart from popular music and jazz music education, where the tuition of electronic music and live electronics has just started this decade. Nevertheless, there seems to be a wish among the live electronics educators on both sides

[2] The phrase "Western world" denotes a collection of nations that have common cultural and historical backgrounds and are mainly located in Europe and North America (Wise Voter 2023).

that it can be beneficial to blur the already faint lines between genres, and use the genre-free nature of electronic music to bridge the gaps between any musical genres such as classical, contemporary, folk, jazz, pop, techno etc.

This study discusses current topics that live electronics teachers are tackling in their work. There seemed to be a strong need for discussion and reflection among the interviewees and after reading the preliminary version of the results Benjamin van Esser wrote in an email that while many of the teachers worked in different circumstances, there seemed to be a mutual understanding of many topics.

> *BENJAMIN VAN ESSER: Funny to see so many opinions complementing each other. It seems that, although we work in a different context, we all seem to comment toward similar goals.*

Live electronics is a field of music that involves the use of electronic instruments, interfaces, and tools in a live performance context. It presents a unique set of challenges for students who seek to master it, requiring not only technical proficiency but also musical creativity and understanding. Many live electronics teachers are self-taught, and there is a wide range of approaches to teaching the subject. One common challenge is the need to develop robust and suitable interfaces for live performance, which can be expensive and time-consuming. Moreover, limited resources and busy schedules can make it difficult to explore the full range of possibilities available in live electronics. Despite these challenges, live electronics offers unique opportunities across different cultures for artistic expression and experimentation, with the potential to transform the way we think about music and the creative process. By promoting cross-genre collaboration and encouraging greater access to live electronics education, we can foster a more vibrant and dynamic music culture.

Implications for this study are manifold. Firstly, it is meant to increase the awareness of the topic in general as well as clarify the idiosyncrasies involved in it. For many of my colleagues, live electronics is still full of mystery, and this thesis can act as material to educate them, or anybody interested in the topic. This study also lays groundwork for further studies on the topic. For example,

one can dive further into practical utilizations of specific technologies and the creative possibilities they offer or focus on early education of live electronics.

An illustrative example of the scarcity of teachers in live electronics or electronic music in general, was when I was asked to give a talk at the Pirkanmaa Music Institute this spring in 2023. The facilitator told me that they found dozens of potential teachers in Finland that could have given a presentation on songwriting or music technology, but specifically electronic music experts with any teaching experience or pedagogical education were hard to find. The facilitator's ability to respond to the demands of the students was difficult to meet. If we want the curricula in music education to reflect the popularity of electronic and electroacoustic music even remotely, the amount of content on electronic music and live electronics needs to increase. The possibilities of live electronics as an instrument and performance practice are still to be explored, and they offer great opportunities for teachers to experiment artistically and pedagogically. The evolving nature of live electronics makes it suitable to explore and comment on themes such as sustainability and socio-economic challenges. The democratization of technology in general offers many possibilities as almost every citizen of the western world carries a modern microprocessor in their pocket.

The working title of this thesis was 'Fast and Gray'. It was meant to point out how this field of live performing and education is growing and evolving fast. While conducting this research, delving into the history of live electronics, and interviewing many experts I hold in high regard, I noticed my perspective on the topic changed. Maybe my impressions of fast growth and perplexity were mostly due to my own experiences and high expectations. There is a long history of live electronics where to draw from and the fundamental phenomenon of live performance is as old as human civilization, or maybe even older. The quickly evolving technology might not be evolving so quickly after all. Maybe the music technology industry just wants us to believe so to sell more gear. Instead of emphasizing how to use certain devices, live electronics education should focus on what students want to say with their art. How do we encourage and help the

next generation of live electronics performers that constantly grows in numbers and give them tools to learn for themselves? Should technology be regarded as a mediator of an idea, and not the central point of a performance? New technologies might disrupt many things, but the fundamental human interaction that happens in live performance situations is something that transcends barriers in cultures and technologies.

> *MERLYN PEREZ-SILVA: Hey AI make me a routine for four loopers and a tin can.*

References

3voor12. 2020. " Colin Benders - Live at Lowlands free: united 2020." YouTube video posted August 26th, 2020. https://youtu.be/ORBgzuPNDKA

Andertons Music Co. 2022. “What Is a Drum Machine?”, https://blog.andertons.co.uk/learn/what-is-a-drum-machine

Apple Inc. 2022. *Logic Pro X User Guide*. Cupertino, CA: Apple Inc.

Auvinen, Tuomas. 2016. "A New Breed of Home Studio Producer: Agency and Cultural Space in Contemporary Studio Music Production". *Etnomusikologian vuosikirja vol 28*. Helsinki: Suomen Etnomusikologinen Seura ry.

Ballou, Glen. 2008. *Handbook for Sound Engineers*. London: Focal Press. Loudspeakers, ch. 41.4.2.

Bell, Adam, Ethain Hein and Jarrod Ratcliffe. 2015. "Beyond Skeuomorphism: The Evolution of Music Production Software User Interface Metaphors" *Journal on the Art of Record Production*. Issue 6. 1-18. Association for the Studio of the Art of Record Production.

Bennett, Joe. 2018. *Oxford Handbook of Creative Process in Music*. New York: Oxford University Press.

Berklee College of Music. 2023. “Electronic Digital Instrument Principal.” Berklee College of Music. Accessed June 30, 2023. https://college.berklee.edu/electronic-production-design/electronic-digital-instrument-principal

Bogdanov, Vladimir. 2001 All Music Guide to Electronica: The Definitive Guide to Electronic Music. San Francisco: Backbeat Books.

Boehm, Carola. 2009. "Brave Creative World: Creativity in the Computer Music Curriculum." The International Computer Music Association San Francisco, CA

Boiler Room. 2015. "Bonobo Boiler Room London — Live at Alexandra Palace" YouTube video, posted July 2nd, 2015. https://youtu.be/Ca93bp-jpn8

Bougaieff, Nicolas. 2013. "An Approach to Composition on a Minimal Techno Case Study". Doctoral thesis in Department of Music, Humanities and Media, University of Huddersfield, Huddersfield.

Boutard, Guillaume. 2016. "Co-construction of meaning, creative processes and digital curation - The transmission of music with live electronics." *Journal of Documentation*, Vol. 72 No 4, 755-779. Bingley: Emerald Group Publishing.

Brinkmann, Svend and Steinar Kvale. 2015. *InterViews: Learning the Craft of Qualitative Interviewing*. London: SAGE Publications, Inc.

Burgess, Richard James. 2014. *The History of Music Production*. New York: Oxford University Press.

Butler, Mark J. 2014. *Playing with Something That Runs: Technology: Improvisation, and composition in DJ and laptop performance.* New York: Oxford University Press.

Cercle. 2019. “Reinier Zonneveld at the State Aviation Museum in Kyiv, Ukraine for Cercle" YouTube video, Posted July 4th, 2019. https://youtu.be/xRgntIyd4h0

Collins, Nick. 2003. "Generative Music and Laptop Performance." *Contemporary Music Review* 22: 4, 67-79.

Collins, Nicolas. 2006. *Handmade Electronic Music: The Art of Hardware Hacking.* New York: Routledge.

Cox, Christoph, and Daniel Warner. 2017. *Audio Culture: Readings in Modern Music.* Dublin: Bloomsbury Publishing Inc.

Crab, Simon. 2023. *120 Years of Electronic Music (update v3.0).* Self-published, accessed May 15, 2023. https://120years.net/wordpress/

Creswell, J. W. 2009. *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications Inc.

Cycling '74. 2023. “RNBO resources.” accessed May 12, 2023, https://docs.cycling74.com/max8/vignettes/rnbo_resources.

Denk, Felix and Sven von Thülen. 2014. *Der Klang Der Familie: Berlin, Techno, and the Fall of the Wall.* Norderstedt: BoD – Books on Demand.

DeSantis, Dennis. 2015. *Making Music: 74 Creative Strategies for Electronic Music Producers*. Berlin: Ableton AG.

DiCola, Peter C. 2013. “Money from Music: Survey Evidence on Musicians’ Revenue and Lessons About Copyright Incentives.” 55 Arizona Law Review 301. Tucson: University of Arizona James E. Rogers College of Law.

SuperCollider. 2023 "Documentation." Accessed April 19, 2023. https://doc.sccode.org/

Dunn, David. 1992. *A History of Electronic Music Pioneers*. Linz: Ars Electronica.

Emmerson, Simon. 2007. *Living Electronic Music.* Hampshire: Ashgate Publishing Limited.

Erlewine, Stephen Thomas. “Head Hunters - Herbie Hancock.” AllMusic, accessed April 6, 2023, https://www.allmusic.com/album/head-hunters-mw0000649551

Van Esser, Benjamin. 2016. “Invisible.” Accessed April 8, 2023. http://www.benjaminvanesser.be/invisible/

Feyre, Ryan. 2020. "How the Democratization of Music Changed the Industry." Honors Thesis, Department of Media & Communication at Salem State University, Massachusetts.

Fountain, Tony M. 2021. “The Evolution of The Music Industry — And What It Means For Marketing Yourself As A Musician.” Forbes. September 13, 2021. https://www.forbes.com/sites/forbesbusinesscouncil/2021/09/13/the-evolution-of-the-music-industry---and-what-it-means-for-marketing-yourself-as-a-musician/

Galletta, Anne. 2013. *Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication*. New York, New York University Press

Gillham, Bill. 2000. *Research Interview*. London, Bloomsbury Publishing Plc

Glennon, Mike. 2019. "Consumer, Producer, Creator: The Mixtape as creative form." *Organized Sound* 24(2): 164-173. Cambridge University Press.

Gómez-Sánchez, Daniel. 2021. "Rosalia, much more than just a topline music composer: a change of paradigm in the songwriting process". *Academia Letters,* Article 1766. Universidad Complutense de Madrid.

Google and Musikinstrumenten-Museum. n.d. "Electronic Music: Live!". Google Arts & Culture. Accessed October 1, 2021. https://artsandculture.google.com/story/electronic-music-live/qALy8HXmaFR9IA

Google Arts & Culture. “Early Pioneers of Electronic Music.” Accessed April 6, 2023. https://artsandculture.google.com/story/early-pioneers-of-electronic-music/OwWRWQUJpScspQ?hl=en

Grove Music Online. 2016. "Groovebox". Oxford University Press, accessed April 8, 2023, https://doi-org.ezproxy.metropolia.fi/10.1093/gmo/9781561592630.article.L2294223

Harvey, Jonathan. 1999. "The Metaphysics of Live Electronics" *Contemporary Music Review*. 18:3.

Hermes, Kirsten. 2022. *Performing Electronic Music Live.* New York: Routledge.

Herz, J. C. 2000. “GAME THEORY; Making Music Without the Instruments.” The New York Times, January 20, 2000, sec. Technology. https://www.nytimes.com/2000/01/20/technology/game-theory-making-music-without-the-instruments.html

Himanen, Aki. 2015. "From Studio to Stage - Live Electronic Performance." Bachelor program in Music, Metropolia University of Applied Sciences, Helsinki.

Hosken, Dan. 2011. *An Introduction to Music Technology*. New York: Routledge.

Hughes, Michelle, Dennis DeSantis, Timothy Beutler, Ian Gallagher, Kevin Haywood, Rose Knudsen, Gerhard Behles, et al. *Ableton Reference Manual Version 11.* Berlin: Ableton AG, 2021.

Jonze, Tim. 2010. “The Bedroom Artists Who Prefer Creative Solitude." The Guardian, Guardian News and Media, 4 Apr. 2010, visited 4 Apr 2023, www.theguardian.com/music/2010/apr/04/tim-jonze-indie-music.

Klein, Eve. 2016. "Feigning Humanity: Virtual Instruments, Simulation and Performativity." *IASPM@Journal,* Vol. 6, No. 2.

Kuhn, William, and Ethan Hein. 2021. *Electronic Music School: A Contemporary Approach to Teaching Musical Creativity.* New York: Oxford University Press.

Lavoie, Sébastien. 2019. "My Practice of Lie Performance of Spatial Electronics." Doctor of Philosophy, Department of Music, Humanities and Media, University of Huddersfield, Huddersfield.

Leino, Joni. 2017. "Music Production at Home - Muusikon tuotanto kotistudiossa." Master of Music Pedagogy, Metropolia University of Applied Sciences, Helsinki.

de Llera Blanes, Guillermo. 2017. "Controllers as Musical Instruments, Controllerism as Musical Practice." Dissertation in Musical Sciences in the Ethnomusicology specialty. Nova University Lisbon.

Lozej, Martino. 2016. "The Arpeggiator: A Compositional Tool for Performance and Production." Graduate Program in Music, York University, Toronto Ontario.

Maliniak, Lisa. 2002 “1970s: Microprocessors: The Little Engines That Could.” Electronic Design accessed May 14, 2023. https://www.electronicdesign.com/archive/article/21757398/1970s-microprocessors-the-little-engines-that-could.

Manning, Peter. 2013. *Electronic and Computer Music.* New York: Oxford University Press.

Marco, Guy A. 1993. *Encyclopedia of Recorded Sound in the United States.* New York: Garland Publishing, Inc.

Marrington, Mark. 2016. "Paradigms of Music Software Interface Design and Musical Creativity." In R. Hepworth-Sawyer, J. Hodgson, J. L. Paterson, and R. Toulson: *Innovation in Music II*. Shoreham-by-sea: Future Technology Press.

Matos, Michelangelo. 2016. “A Guide to Jean-Michel Jarre’s Biggest Live Performances" *Red Bull Music Academy Daily.* Accessed May 14, 2023. https://daily.redbullmusicacademy.com/2016/01/jean-michel-jarre-live-feature.

Mazierska, Ewa. 2018. "Improvisation in Electronic Music - The Case of Vienna Electronica." Open Access, De Gruyter.

Meikle, George. 2016. "Examining the Effects of Experimental/Academic Electroacoustic and Popular Electronic Music on the Evolution and Development of Human-Computer Interaction in Music." *Contemporary Music Review.* 35:2. 224-241. New York: Routledge.

Merriam-Webster. 2023. “Disc Jockey.” Merriam-Webster.com Dictionary. Accessed May 30, 2023. https://www.merriam-webster.com/dictionary/disc%20jockey#h1

The MIDI Association. 2021. “MIDI Polyphonic Expression (MPE) Specification Adopted!” MIDI.org, MIDI Manufacturers Association, accessed May 14, 2023. https://www.midi.org/midi-articles/midi-polyphonic-expression-mpe

Moog Synthesizers. 1974. *Moog Modular Price List.* Asheville: Moog Music.

Moralis, Christos. 2018. "Live Popular Electronic Music: Performable Recordings" London College of Music, University of West London, London.

Morgan, Frances. 2017. "Pioneer Spirits: New media representations of women in electronic music history" *Organised Sound.* 22(2). Cambridge: Cambridge University Press.

MusicRadar. 2014. “A brief history of sampling.” MusicRadar, Future Publishing Limited Quay House, The Ambury, Bath BA1 1UA United Kingdom. Accessed April 8, 2023. https://www.musicradar.com/tuition/tech/a-brief-history-of-sampling-604868

MusicRadar. 2019. “20 years of Ableton Live: a history told by the founders and developers.” MusicRadar, Future Publishing Limited Quay House, The Ambury, Bath BA1 1UA United Kingdom. Accessed May 14, 2023. https://www.musicradar.com/news/story-of-ableton-live-at-2

MusicRadar. 2019. “Early DAWs: the software that changed music production forever.” MusicRadar, Future Publishing Limited Quay House, The Ambury, Bath BA1 1UA United Kingdom. Accessed May 14, 2023. https://www.musicradar.com/news/early-daws-the-software-that-changed-music-production-forever

Neuralink. “Our Approach,” Neuralink, accessed May 25, 2023, https://neuralink.com/approach/

Olarte, Luis Alejandro. 2019. "Elements of Electroacoustic Music Improvisation and Performance: A Pedagogical Toolkit." Sibelius Academy, University of the Arts Helsinki, Helsinki.

Parakilas, James. 2002. *Piano Roles: A New History of the Piano.* New Haven: Yale Nota Bene.

Raaijmakers, Dick. 2000. *A Brief Morphology of Electronic Sound: Collected Writings of the Orpheus Institute.* 14. Leuven: Leuven University Press.

Réveillac, Jean-Michel. 2019. *Electronic Music Machines: The New Musical Instruments*. New Jersey: John Wiley & Sons, Incorporated.

Roland Corporation. “Company History.” Accessed April 8, 2023. https://www.roland.com/global/company/history/

Schreier, M. 2012. *Qualitative content analysis in practice*. Thousand Oaks, CA: Sage Publications Inc.

Simonetta, Federico. 2019. “Live Coding.” Accessed April 19, 2023. https://federicosimonetta.eu.org/post/live_coding/

Smith, Sophy. 2016. “A Brief History of Turntablism.” The Vinyl Factory. Accessed May 14, 2023. https://thevinylfactory.com/features/a-brief-history-of-turntablism/

Statista. 2021. "Share of households with a computer in Africa 2005-2019.” Statista, November 26, 2021. Accessed May 14, 2023. https://www.statista.com/statistics/748549/africa-households-with-computer/

Stricker, David Russell. 2008. "Perceptions of Creativity in Art, Music and Technology Education" Doctoral Dissertation, University of Minnesota, Minnesota.

Stubbs, David. 2018. *Future Sounds: The Story of Electronic Music from Stockhausen to Skrillex.* London: Bloomsbury House.

Tanaka, Yuji. 2014. "Yellow Magic Orchestra: The Pre-MIDI Technology Behind Their Anthems" Red Bull Music Academy, Accessed May 12, 2023. https://daily.redbullmusicacademy.com/2014/11/yellow-magic-orchestra-gear

Tanev, George, and Adrijan Božinovski. 2013. "Virtual Studio Technology inside Music Production." In The ICT Innovations: ICT Innovations and Education,

edited by Vladimir Trackovik and Anastas Mishev, 231-241. Heidelberg: Springer International Publishing.

Taylor, C. W. 1988. "Various approaches to and definitions of creativity." In The Nature of Creativity: Contemporary Psychological Perspectives, edited by Robert J. Sternberg, 45-65. Cambridge: Cambridge University Press

Taylor, T. D. 2001. *Strange sounds: music, technology & culture.* New York, Routledge.

Tomorrowland, "WhoMadeWho (Hybrid DJ Set)," YouTube, August 1. 2022, concert recording. Accessed May 14, 2023. https://www.youtube.com/watch?v=OVItXkpb2_U

van Tonder, Cobi. 2004. "Music Composition and Performance in Interactive Computer/Human Systems." Research Essay, Music in History and Society in the Wits School of Art, Faculty of Humanities, University of the Witwatersrand, Johannesburg.

u/techno. 2012, September 21. What is a hybrid live DJ set? [Online forum post]. Reddit. Accessed May 14, 2023. https://www.reddit.com/r/Techno/comments/10ays9g/what_is_a_hybrid_live_dj_set/

Waisvisz, Michel. 1999. "Riding the Sphinx - Lines about 'Live'." *Contemporary Music Review.* 18:3, 119-126. New York: Routledge.

Walzer, Daniel A. 2016. Software-Based Scoring and Sound Design: An Introductory Guide for Music Technology Instruction, National Association for Music Education, DOI: 10.1177/0027432116653449

Warren, Burt. 1994. Thoughts on physicality and interaction in current electronic music, Continuum, 8:1, DOI: 10.1080/10304319409365627

Watson, Kevin. 2019. *IMS Business Report 2019*. International Music Summit Ibiza.

Webster, Peter R. 1987. "Refinement of a measure of creative thinking in music." In Applications of Research in Music Behavior, edited by Clifford K. Madsen and Craig A. Prickett, 257–271. Tuscaloosa, AL: The University of Alabama Press.

Wiederkehr, George A. 2015. "The Role of Music Theory in Music Production and Engineering." Thesis, Master of Arts, School of Music and Dance and the Graduate School of the University of Oregon, Oregon.

Wired Guitarist. 2019. “What Was the First Guitar Pedal Ever?” Wired Guitarist, 6 June 2019. Accessed May 14, 2023. http://www.wiredguitarist.com/2019/06/06/what-was-the-first-guitar-pedal-ever/

Wise Voter. 2023. “Western World Country Rankings.” Accessed April 5, 2023. https://wisevoter.com/country-rankings/western-world/

World Population Review. “Happiest Countries in the World 2022.” Accessed April 13, 2023. https://worldpopulationreview.com/country-rankings/happiest-countries-in-the-world

Appendix

Appendix 1: Information Form

Information about the thesis

Good Recipient,

I am Josu Mämmi, and I am studying for a master's degree in music at Metropolia University of Applied Sciences. In my thesis, which is part of my studies, I am researching the teaching of live electronics and the associated creativity through interview-based research.

In the thesis, information is collected through interviews conducted using the Zoom video calling software. The interviews are recorded for transcription purposes. The interviews are conducted with selected experts.

The participants in the study will be identified by their real names, and they will have the opportunity to review and provide input on the quotations and related content before the completion of the thesis. I commit to handling the data carefully. After the completion of the thesis, the data will be disposed of in an appropriate manner.

Please confirm your consent by signing a separate form. If you have any further questions, feel free to contact me via email or phone.

Thank you!

Appendix 2: Research Consent Form

Research title: Fast and Gray: About Teaching Live Electronics and Creativity

Research implementer: Metropolia University of Applied Sciences Ltd., Josu Mämmi, +358407786979, josu.mammi@mertropolia.fi Supervisor: Susanna Mesiä +358503405353 susanna.mesia@metropolia.fi

I, Recipient, have been asked to participate in the aforementioned thesis, which aims to investigate the teaching of live electronics and associated creativity through interview-based research.

I have received the research information about the thesis and understood it. The information provided has given me sufficient clarification about the purpose and implementation of the thesis, my rights, as well as the potential benefits and risks associated with participating in the thesis. I have had the opportunity to ask questions, and I have received satisfactory answers to all my participation-related inquiries.

I have not been pressured or coerced to participate in the thesis. I have had enough time to consider my participation.

I understand that my participation is voluntary and that I can withdraw my consent at any time without providing a reason. I am aware that if I discontinue my participation or withdraw my consent, the data and samples collected up until the discontinuation or withdrawal may still be used as part of the research data.

With my signature, I confirm my participation in this research.

_____, ____ . ____. _____

Signature: _____ Name clarification: _____

The original signed consent form, along with its attachments, will be retained in the researcher's archive. The research information sheet, along with its attachments, and a copy of the signed consent form will be provided to the participant.