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The Laptop as an Academic Instrument in Music and Digital Arts

by

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Abstract

In the last few decades of music technology, computers have transitioned from being musical tools exclusively used for studio-oriented work, to being artistic platforms, interfaces, and ideal tools for completely new styles of performance, creative expression and collaboration. Hardware improvements have helped professional and aspiring artists benefit from powerful and portable equipment. Furthermore, laptops and mobile devices have enabled them to engage in creative processes without being tied to a fixed studio or workstation. Subsequently, composition has evolved into a different artistic process altogether, which deals with functional and aesthetic challenges through the application of essential 21st century skills. It is critical for music education to address these emerging tendencies to avoid fostering students with outdated skill sets. Laptops and computer music could enhance contemporary music programs by providing an environment in which students will develop real-life knowledge and skills through artistic exploration and growth.

This thesis investigates the benefits that could be gained from combining these new methods of artistic practice with certain teaching philosophies centered around active learning, such as constructivism and connectivism. This is demonstrated by developing a system around computer music performance and laptop orchestra models in which students learn by composing, rehearsing, and playing. These dynamic settings encourage them to employ critical thinking, teamwork, and problem solving skills. A brief music technology module was used to model a Backward Design process, which allowed students to actively participate and perform collaboratively in an unfamiliar creative scenario. The learning outcomes were promising, and students felt confident and accomplished, which makes a compelling argument for pursuing authentic music education through laptop ensembles.

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Introduction

1.1 Contemporary Music Curriculums

Many things have been said about art and why it is important in our everyday lives. Some say it gives mankind a meaning and a purpose, or that it makes life worth living; some go as far as to say that it is just what makes us human. Tolstoy wanted to get away from a subjective definition such as “art is beauty”, and in his essay on “What is Art?”, he considered it to be a means of union among people through our capacity of expression of human experience (Tolstoy 1896).

In the end, the weight it carries is unquestionable, and the various benefits and the sense of accomplishment that come with learning and practicing an art form have not gone unnoticed. Though traditional educational models have largely focused on STEM (science, technology, engineering and mathematics) learning, art is being reconsidered as a core part of a well-rounded educational model that values applied knowledge as a means to engage students in deeper learning (Jolly 2014).

Music education has gained significant popularity as one of these initiatives to integrate art into formal studies at all levels. With benefits that go well beyond musical skills exclusively, schools are exploring ways to integrate music programs to strengthen their core instruction. At a basic level, it can help children cultivate auditory, visual and motor skills. Moreover, considering that this includes challenging elements such as score reading, collaboration, and creation, it is not a surprise to see students who are actively involved in music practice displaying substantial development in areas such as mathematics, reading, critical thinking and social skills (Kokotsaki and Hallam 2007).

In Ancient Greece, music was considered divine and a gift from the gods. It was admired as a highly complex form of art and an instrument of cultural expression. It was also a fundamental subject in education because it taught discipline and order, and due to its strong connections with religion, science, theatre and poetry. Pythagorean instruction placed music in the same category as arithmetic, geometry, and astronomy; and it was contemplated as the science of sound and harmony (Centre of Greek Musical Tradition - Lyravlos, n.d.; Cartwright 2013; Beer 2005).

Finally, music making is commonly associated with good health and mental well-being. Young choir singers have shown improvements in well-being and relaxation; proper breathing and posture; social, spiritual and emotional benefits; and heart and immune conditions. Similarly, adults displayed benefits in physical relaxation; stress management; positive mood; overall well-being; increased energy; attention, concentration, memory, and learning; self-esteem; a sense of physical exercise; and feelings of accomplishment and motivation (Hallam 2010).

In order to make music education meaningful and long lasting, it is essential to understand how music programs operate and the difficulties they face on an everyday basis.

1.1.1 Standards-based Education in Music

Quality arts education is not something that occurs simply by implementing teaching strategies alone. High efficacy can only be achieved by applying effective pedagogic strategies in a program with proper resources and support, and take place in an environment that encourages growth and a sense of community. (Israel 2015) highlights the importance of teaching students to become aware of art around them and support local artists by bringing them to dedicated spaces and performances. It also states that successful arts programs create this type of environment by continuously displaying their student work. For example, this is common in music curriculums in which students constantly create and perform their pieces outside the classroom, which encourages them to bring their art to their community, work across disciplines, and build important partnerships with their peers.

Qualified teachers and challenging syllabi are an important part of the formula within a program that should be built around standards and benchmarks. This is the only way to plan towards specific student outcomes and to implement real teaching strategies in the classroom. The Three Artistic Processes model builds upon standards-based music education, and it organizes learning activities into three specific categories: (1) creating; (2) performing; (3) and responding. The National Association for Music Education (NAfME) and the National

Assessment of Education Progress (NAEP) have adopted this model as a means for comprehensive, practical and authentic education (Shuler 2011; NAfME 2014).

The nine content standards for music education in the United States are the following:

1) Singing, alone and with others, a varied repertoire of music.
2) Performing on instruments, alone and with others, a varied repertoire of music.
3) Improvising melodies, variations, and accompaniments.
4) Composing and arranging music within specific guidelines.
5) Reading and notating music.
6) Listening to, analyzing, and describing music.
7) Evaluating music and music performances.
8) Understanding relationships between music, other arts, and disciplines outside the arts.
9) Understanding music in relation to history and culture.

These standards point towards what it means to be educated in music, and they can be used as guidelines for practical curriculum design. Having a model of what students should know and the skills they should master is necessary to develop a strong program and to find the best teaching approaches (Kertz-Welzel 2008). The traditional ensemble model is an example of such approach.

1.1.1.1 The Value of Ensemble Performance in Music Education

Various schools have adopted music programs with a focus in ensemble performance because it makes it possible to offer music education to large groups of students, while fitting standards-based education models. Among the selected formats are chamber orchestras, jazz bands, guitar or piano ensembles, marching bands, and larger groups leaning towards a symphonic line-up. This is where students have the opportunity to prepare challenging music in a structured and organized collective to stimulate growth in many areas:

- Essential music skills like instrumental technique, reading, and listening through the study of standard repertoire and etudes
- Music appreciation by engaging in critical listening and discussion

- Leadership, teamwork, and social skills through collective work, problem solving and communication
- Advanced music concepts like following a conductor, blending, balance, intonation, tempo, arranging
- Immediate application of theory and ear training
- Rehearsal and performance etiquette

These areas can be related directly with the standards mentioned previously, which makes a compelling argument for ensemble-based education as a means to provide a complete music education experience. Standards make the difference between simply training students for recitals or competitions, and teaching towards comprehensive musicianship (Kertz-Welzel 2008).

1.1.1.2 The Learning Experience in an Ensemble

Understanding the student experience is fundamental in order to fully understand the true importance of band and orchestra programs. Knowledge and skills are only a part of what the student gets from a class, but the way he or she feels when they walk into the classroom is just as important. Stephanie McCorkell's (University of Minnesota) research illustrates how this learning experience as a whole goes beyond course content.

Whenever students work towards a particular goal with their peers, they begin to understand the need for teamwork, and the importance of responsibility, hard work, and discipline. They realize that they are a single piece of a whole, capable of accomplishing what they could not do on their own. Students are empowered as they realize that who they are makes the group stronger, and their culture, strengths, interests and aspirations are their main contribution. They also start to be appreciated by their peers for talents that might not have been in plain sight.

Successful ensembles provide a safe, comfortable and fun learning environment where students can feel like they belong. These classes are regarded as important because they feel like their choices have a purpose, and they are where they will find trust and support from their team. There is also intrinsic gratification in authentic learning as they feel like they are working towards meaningful performances, rather than mere completion of credits or grades.

Furthermore, students feel a sense of success and accomplishment as they learn how to follow and how to lead. They start as apprentices, and later on they move up the ranks to become the tutors as new students join the team. Music class becomes meaningful to them because it is the time of their day when they are not sitting in class and they are actually doing something that matters.

In (McCorkell 2012), qualitative research through student, teacher, and administrator interviews revealed three central themes about student experience in band and orchestra: (1) accomplishment while learning; (2) teamwork; and (3) engagement with peers. When asked about what they liked about being in an ensemble class, every student mentioned the sense of gratification and personal accomplishment when they participated in band or orchestra. Many of them acknowledged that they were responsible for their performance as part of the ensemble, and they commented on how confident they felt when they had a chance to demonstrate their knowledge, and to help their classmates.

Teachers and administrators were impressed by how these classes brought out the best in the students. They had a chance to become leaders and perform every day, and their involvement gave them a sense of realization. Additionally, students who struggle in subjects like math or science also had a chance to prove that their intelligence lies elsewhere.

Finally, students also shared how exciting it was to notice their group's improvement over time, and how this was evidence of their talent and hard work.

1.1.2 Quality Art Programs at Risk

There is an increasing awareness about the importance of all types of art. Schools have realized that parents and their children are now also looking for institutions that can offer a complete educational experience. This is the main reason why art, music and theatre programs have become more common nowadays.

However, quality arts education is not just a matter of offering a few new courses. Real education in any type of art should be a core part of the general curriculum offered by schools, and integrated into other subject areas. Art classes need to be as structured as traditional subjects, and they should also be taught by highly qualified and certified professionals. Students need to be surrounded by creativity in order to practice art. It is essential to let them visit art spaces around them and participate in events nearby. This means that art programs will only be successful as long as they have proper support and funding (Israel 2015). Unfortunately, it is commonplace to find art programs in less than ideal situations, which results in lower education quality.

In the United States, heavy focus on standardized testing that became evident with the implementation of the *No Child Left Behind Act* (NCLB) in 2001 has been one of the causes for art programs to be at risk. This act was very unpopular due to the emphasis on testing results in reading, math and science. Cutting instruction time and instating ineffective reassessing techniques caused the education bar to be lowered, and a lot of teachers felt the need to teach strictly for the test. Ever since *Every Student Succeeds Act* (ESSA) in 2015, many adjustments have been made, but excessive efforts towards standardized testing have not gone away (Klein 2015).

These problems quickly spread around whole programs, and many subjects were affected, including art and music. Decreased funding and the need to meet the expected results in standard tests interfered with instruction even more. Even if art and music are now considered core subjects, students often have to sacrifice these classes to reinforce their math or reading skills. There have also been reduced options due to art classes being scheduled at the same time, which results in students being unable to take more of these courses (Spohn 2008).

Even though art programs have been at constant risk, parent and community support has been significant, and schools have found ways to preserve them. Nevertheless, many struggling schools have been hit by these difficulties and art education continues to be poorly distributed across high school and colleges (Ashby 2009).

In the last two decades, public funding for the arts has increased nominally, but it has been unable to keep up with inflation, as seen in Figure 1. In fact, the result is a decrease in public funding of over 30 percent. With the increasing cost of working with artists and organizations, and reduced grant budgets, this is definitely something to be concerned about (Stubbs 2014).

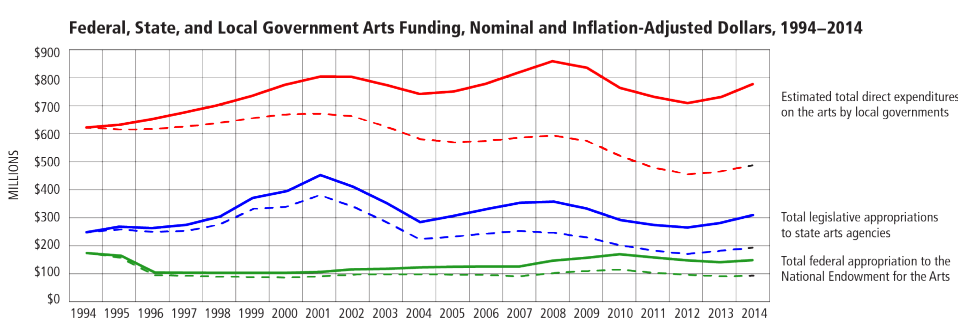

Figure 1: Public Funding for Arts Education, 1994–2014

Without proper funding, music programs cannot purchase and maintain instruments, acquire educational materials, and hire high quality instructors. As a consequence, music education is only available to a limited number of students, or it is cut completely from school curriculums.

These issues are not exclusive to the United States, since many countries do not take subjects outside STEM areas seriously, making matters worse. Rather than waiting for support, it is important to explore the options that are currently available, and to try and find a way to reengineer contemporary music programs.

1.2 Electronic Ensembles

Electronic music is at a very exciting stage today. Software is powerful enough that it is possible to generate interesting and expressive sounds that can be turned into art, while portable hardware can be carried by electronic musicians like any other musical instrument. This not only brings a lot of variety and originality to music production and performance, but it also makes it easier to collaborate with other artists. In fact, this can be done even if the musicians are not in the same place thanks to efficient recording and network technology.

Composers and performers have begun to integrate electronic sounds and instruments into traditional instrument formats like chamber ensembles, contemporary bands and larger ensembles. Others have felt the need to stray away from the usual line-ups, toward ensembles that are made completely of electronic instruments. Consequently, electronic ensembles and laptop orchestras have been created as musicians and students explore new music making techniques.

1.2.1 Structure and the Creative Process

To the average person, electronic ensembles are still somewhat of a mystery. Having groups of people making music together outside popular styles of music, and without the everyday musical instruments is still hard to comprehend for people who are not familiar with the concept. In fact, even listeners who have been exposed to these types of music can find it hard to identify what each performer is doing, particularly in the case of experimental music.

However, collaborative work in electronic music can be a great opportunity because the role of the ensemble changes completely, with the freedom to explore unique soundscapes or to include games in their pieces. Early pioneers like the League of Automatic Composers (Figure

2), which eventually became The Hub, explored the new networked ensemble as an ideal scenario for experimentation and innovation. During their performance, they interacted with each other and with the emergent algorithmic behavior of the music, which created a surprise and unpredictability that they valued highly. Ironically, this meant that their music could never be reproduced exactly after it had been played. They also believed that the composer was now responsible for designing and building the instrument to be used in each piece (Gresham-Lancaster 1998).

Figure 2: The League of Automatic Composers

The volatile nature of this music makes it necessary to embrace human and technological imperfection. At the same time, the potential for art and expression through computers is so great, that it opens the door for more people to be involved. It is possible for amateur musicians to produce a convincing performance without requiring years of practice and experience.

Laptop orchestras have become stimulating environments for art creation and intellectual exchange, but only higher education programs have implemented them for the most part. They are available to musicians of all levels, engineers, computer scientists, and digital artists; and they challenge proficient computer users to interact with their machine artistically. This adds interest to the format because ensemble members are encouraged to incorporate Human Interface Device (HIDs), sensors, controllers and hyper-instruments[1] to their station (Smallwood et al. 2008). Electronic ensembles have become hubs of creativity and music making, and there are considerable benefits that could come from bringing them to a larger number of people.

[1] Musical instruments whose output is processed and transformed by a computer.

1.2.2 A Gap in the Music Technology Education

Having examined the clear benefits of making music in an electronic ensemble, it is important to consider how easy it is for someone with no previous experience to acquire the necessary knowledge and skills to be successful in one.

At an informal level, whenever someone wants to learn something new, one of their first instincts is to browse the internet. After all, it offers free resources, tools, and previous knowledge from other users with similar interests. It is also a gateway to all sorts of documentation, publications and tutorials available to people who have a deeper interest in a certain topic. However, after doing some investigation, the first impressions were somewhat disappointing.

Simple internet searches regarding electronic music, making music with a computer, and learning music technology did not paint a clear picture of what a beginner needs to do to get involved in computer music. If anything, it would be fairly easy to get lost as someone with no previous experience, since every result seemed to point in totally different directions. The most common results were related to music production, sound engineering, integrating technology in traditional music education (including tips to use Smartboards and handheld devices in the classroom effectively), and strategies to get started with applications like Sibelius[2], ProTools[3] and GarageBand[4]. Other results talked about very specific and self-contained applications such as Figure, DM1 or SimplyPiano. The only two pertinent results were EarSketch, a project that incorporates computer programming and digital audio workstation concepts to teach computer science through music (Mahadevan et al. 2015); and the book "An Introduction to Music Technology" by Dan Hosken, which covers audio, MIDI, synthesis and sampling techniques.

On the other hand, doing some research about electronic instruments yielded relevant results without too much effort. Within the first few search results there was substantial information about the history and development of analog synthesis, tape recording, sequencers, hardware hacking, digital synthesis, sampling, and many newer electronic musical instruments.

At this point, it was easy to realize that there is a noticeable gap between the research and documentation about electronic and computer music and the available learning resources at

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[2] Music notation software. Available at: http://www.avid.com/sibelius

[3] Digital audio workstation for professional music production.
Available at: http://www.avid.com/pro-tools

[4] Basic digital audio workstation commonly used for podcasts.
Available at: http://www.apple.com/mac/garageband/

a very basic level. The most relevant results started to appear when looking into more specific topics, but even then, users are required to have access to expensive hardware or software to make the most out of the available materials. For example, the available drum machine tutorials are not useful unless the user owns a specific drum machine model, or owns a particular Digital Audio Workstation (DAW) that includes one. This suggests that the instruction of essential skills in music technology concepts at an amateur or casual level has not been explored deeply yet.

Older students across the world who are interested in computer music have the option of attending institutions of higher education that offer formal curriculums in music technology, which are undeniably excellent places to learn and develop the required skills; however, the offered programs that are not completely art-focused in primary schools, secondary schools, and universities, are not in a similar position.

Close inspection of documents such as the scope and sequence, standard and benchmarks, and syllabi across several educational institutions revealed that many schools in the United States have already started to include music technology as part of their education models (Appendix C). Certain programs have preferred to keep it in a supporting role by developing listening, analysis, and music notation skills; while other curriculums have allowed students to go deeper, by going into music production, recording techniques, mixing, editing, and MIDI sequencing.

Additionally, a few schools have started offering higher learning curriculums, and they have included courses in sound design, basic electronic composition, film scoring and integrating music with other digital arts like visuals and photography. This is very exciting, considering that in Latin America, it is far more common to find these courses in independent music production academies than in primary or secondary schools. As a result, students who are interested in music production can begin honing their skills and practicing with other young musicians from an early age.

However, most schools are not integrating important elements of music into their music technology curriculums. Students who only have the option to play sound engineering roles are not meeting all the standards for music education mentioned in 1.1.1, which include performing, reading, creating and evaluating music.

This also creates a division between traditional instrument courses, which normally benefit from parallel music theory, ear training, improvisation, and composition classes; and music production and recording courses, which do not necessarily involve the application of these essential musical skills. As a consequence, it is not rare to see students losing interest on theory classes because they never have the opportunity to use the newly acquired knowledge; or students who feel frustrated because their music technology classes do not integrate or reinforce composition and arranging techniques. This reveals a critical gap in music education because these students will not receive benefits commonly associated with music classes, such as working in a team, applying instrumental technique in practical environments, and showcasing their work in front of a live audience.

Perhaps it would be important to offer adaptive music theory and skills curriculums with appealing options for students who are seriously interested in studio recording and live sound, but giving laptop musicians the chance to be part of the music making process by joining electronic ensembles would also be an effective way to fill this rift.

1.3 Overview

Computers are no longer just studio recording platforms or tools to achieve realism on a budget. As hardware gets more powerful and portable, laptops have actually become new musical instruments, which can be used for live performance, or as part of an ensemble. Computer music now offers endless opportunities for creativity and expression, including unconventional orchestras, immersive experiences, and integration with other digital arts.

Unlike ordinary instruments, computers are extremely flexible and perhaps only limited by the imagination of the user. The theoretical disadvantages of not having standard performance techniques or a traditional repertoire can easily be dismissed by giving the artist a chance to create a performance from the ground up. In this scenario, the performer/composer also plays the role of designer and builder; and in an ensemble setting, he might also have to become a teacher and a conductor (Wang et al. 2008).

The benefits of making art through these processes are not limited to the composition or the performance itself. Computer music offers plenty of opportunities to create while developing 21st century skills, such as collaborating, improvisation, programming, critical thinking, and creative problem solving. These artistic processes also fit a CPR model (creation, performance, and response) for comprehensive, practical and authentic learning (Shuler 2011).

This thesis seeks to present the laptop as a potential solution to fundamental problems in formal and informal music education. A strong music technology and computer music curriculum can facilitate learning through applied concepts and meaningful experiences. Electronic ensembles are inherently creative and naturally evolving, and they can take advantage of the strengths of constructive and connective philosophies to encourage higher order thinking. In the following work, this thesis will attempt to demonstrate how STEAM-based education incorporates powerful strategies to encourage students to make music using a laptop.

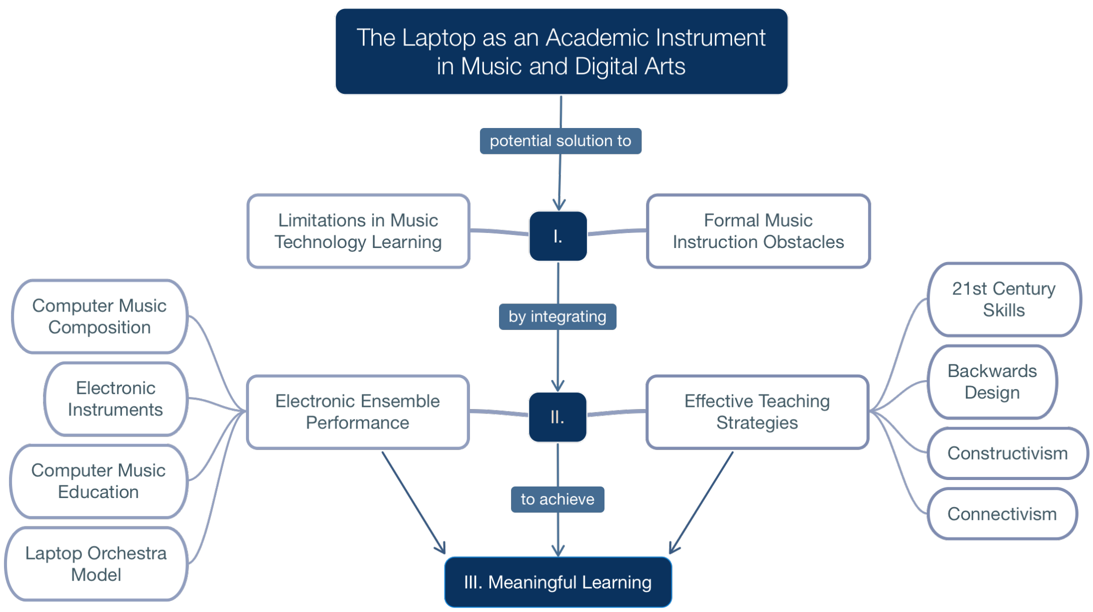

Figure 3: Thesis Outline

The main thesis project, *Laptop Performance Training for Young Artists*, was used as a prototype of the proposed learning experiences with authentic learning and enduring understandings as a goal. It involved a group of students who had a chance to make music in an electronic ensemble and to participate in a user study. The project's design processes and implementation were broken down throughout this work. Chapter 2 establishes a theoretical background in computer music history and instructional theory. Chapter 3 and Chapter 4 outline the application of Backward Design and teaching philosophies to develop the learning progression. Chapter 5 reviews the importance of reliable assessment techniques and evaluates the collected data. Finally, 1.1 consists of the main findings, conclusions, contributions, and the possible next steps in music technology and education research.

Chapter 2

Theoretical Framework

2.1 Computer Music Background

This chapter details essential information to provide context and meaning to the overall research. When teaching art, it is fundamental to understand where it stands currently and where it seems to be going in the near future. It is imperative to review how computer music and electronic performance became what they are today in order to appreciate contemporary electronic artists and their artistic approach.

2.1.1 Review of Computer Music History

The beginning of the twentieth century was marked by a struggle in the development of new musical instruments. Instruments like the Telharmonium, the Theremin, and the Ondes Martenot appeared only to be eventually dismissed due to being impractical or limited. It seemed like there was no place in the world for radically innovative instruments (Kuehnl 2013). At the same time, Luigi Russolo and other Italian futurists started to investigate and design noise instruments, which later on would be used by composers such as Edgard Varèse (Hass 1999). It was Varèse himself who stated that there was a need for new instruments, which was noticeable in the desire of many composers to stray away from the sounds of traditional acoustic instruments. As the first half of the century ended, mechanical instruments such as the phonograph, turntables and tape recorders were more successful as pioneers in what would later be known as the beginning of the electronic era (Kuehnl 2013).

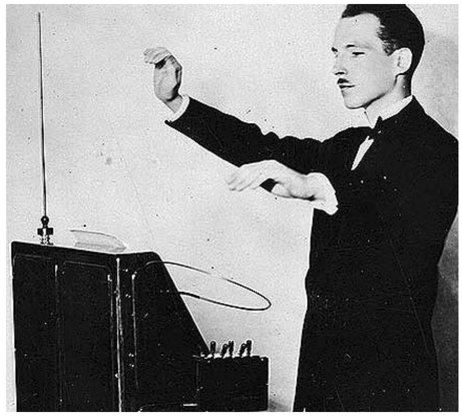

Figure 4: Leon Theremin playing the Theremin

The middle of the century was characterized by Musique concrète, started by Pierre Shaeffer; and the work of composers like Messiaen, Boulez, and Stockhausen highlighted reproduction and transformation of natural and everyday sounds (Hass 1999). This led to technology having a central role in composition, performance, and all sorts of new artistic works and research. Electronic music was born, and with the advent of synthesizer development, composers were drawn to explore and develop new sounds by the end of the 1950s (Hass 1999). The development of voltage-controlled synthesizers was so significant, that music was no longer limited by what could be performed, but by what could be heard by human beings. This is what Milton Babbitt and many others found appealing as they were now able to individually control and manipulate the musical elements of sound, thanks to the efforts of synthesizer developers like Robert Moog and Donald Buchla (Kuehnl 2013).

Even though computers were capable of making noise from early on, it was Max Mathews who developed MUSIC, the first real example of music software in 1957. Understandably, using mainframe computer synthesis to make music was very expensive and slow, but by the time MUSIC IV and V were developed, the idea of sonic generation and manipulation in a computer caught the attention of composers like James Tenney, Jean Claude Risset, Charles Doge, and many others. Eventually these people, including Max Mathews himself, were hired for academic jobs, and major universities started to become the main hubs of computer music research (Kuehnl 2013)[5].

[5] "Computer Music (So Far)" available at: http://artsites.ucsc.edu/ems/music/equipment/computers/history/history.html

By the end of the 1970s, the development of new instruments completely shifted its focus towards the sound generating capabilities of computers; and instrument manufacturers in the United States became heavily interested in the mass production of synthesizers. Systems like GROOVE, developed by Mathews and F. Richard Moore, allowed controlling analog synthesizers using a computer, which led to the construction of computer and analog hybrids[6]. Finally, thanks to John Chowning's research in frequency modulation synthesis, Yamaha introduced the DX-7, a stand-alone digital synthesizer which became a commercial success with over 200,000 units sold.

Figure 5: The Yamaha DX-7 Synthesizer

In 1983, a standard protocol for communications between digital instruments and computers was adopted by all major manufacturers. It was named MIDI (Musical Instruments Digital Interface), and for the first time, it allowed musicians to have full control over several devices (Kuehnl 2013). With the rising popularity of personal computers, which replaced mainframes, electronic composers could easily record and play their actions digitally; and the development of software such as MAX[7] and Csound[8] facilitated new types of computer-assisted performances with relatively little knowledge of computer programming (Hass 1999).

[6] "Computer Music (So Far)" available at: http://artsites.ucsc.edu/ems/music/equipment/computers/history/history.html

[7] Visual programming language for music and multimedia. Available at: https://cycling74.com/products/max/#.V-i18zvqkp1

[8] Audio programming language. Available at: http://www.csounds.com

The development of music equipment, composition processes, and new interfaces and hyper-instruments, demonstrate that the use of computers in music is not simply novelty or a trend—in fact, they mark the beginning of radical changes in music as an art and as an industry.

2.1.2 Computer Music Education and Academic Laptop Orchestras

With the appearance of efficient digital systems and music programming environments, the physics and generation of sounds were not such a big problem anymore. The next challenge was how to control and manipulate these sounds to make music (Cook 2013).

As laptops became more common, new interfaces and meta-instruments began to appear. Composers had to begin to think about the sounds they were going to generate, the control mechanisms, and the composition processes to be used. Careful thought had to be given to the music tools that were going to be employed, such as programming languages, amplification methods, and external devices (D. Trueman et al. 2006).

Eventually, this led to the birth of laptop orchestras, a type of ensemble in which both human beings and machines had a unique role. In contrast to the traditional orchestra, which had a strong history and little room for change and experimentation, the laptop orchestra thrived in the development of new meta-instruments, technologies and techniques (D. Trueman 2007). While a few argued that true art is impossible to make in a computer, laptop orchestras sought to achieve deeper expression in a performance using elements that had not been explored extensively, such as powerful hardware, new interfaces and networked environments (Smallwood et al. 2008).

Universities have supported and financed computer music research and development throughout the history of computer music, which is why a significant number of electronic ensembles have come from academic settings. Thanks to faculty and student-driven projects, the applications of hardware, software, and composition itself have been transformed completely.

2.1.2.1 Hemispherical Speakers and Electronic Chamber Music

Hemispherical speakers were a major piece of hardware in the development of laptop orchestras and electronic ensembles. Dan Trueman, a violinist, fiddler, and electronic musician from Princeton University, realized that playing his violin through a speaker had a completely different feeling from the experience of performing chamber music. The need for amplification and monitoring complicated his rig, and required him to play through a guitar amplifier, when all he really needed was for the audience and himself to be able to listen at the same time. He went to

Perry Cook to discuss the possibility of developing a simple speaker that could allow him to do that. Instead, Cook suggested taking it further, and creating a cabinet that contained many small speakers (Cook 2013).

This is how they started working on spherical and hemispherical speakers using simple objects like salad bowls. Having speaker arrays would offer many possibilities, from simple monoaural setups, to configurations that would model instrument behaviors. Trueman quickly integrated one of this arrays into his Bowed Sensor Speaker Array (BoSSA), an interface that implemented the core performance elements of the violin without the acoustic body or the strings (D. Trueman and Cook 1999).

Figure 6: The "4th Generation Hemi" Speaker

As the speaker arrays became more popular, it was necessary to have a larger number of them made by companies. Eventually, they were also used in larger projects such as Steve Mackey's *Tuck and Roll* guitar concerto with the New World Symphony, directed by Michael Tilson Thomas (D. B. Trueman 2000); *Transfizzle* (DigitalDoo)[9] (Kapur et al. 2003), at an Electronic Arts Residency at Rensselaer Polytechnic Institute; and the KarmetiK Machine Orchestra at California Institute of the Arts (2.1.2.4).

Many more versions of hemispherical speakers have been created, including Curtis Bahn's "Bubba", a considerably larger version of the speaker array; and also his "Bubba Ball", which was not a speaker, but a spherical interface that included several force sensitive resistors

[9] The DigitalDoo is a traditional digeridoo, enhanced with sensors, electronics and a hemispherical speaker.

(FSRs)[10]. Finally, with the appearance of laptop orchestras, these speakers went through major improvements, including support for six channels, and self-contained amplification systems (Smallwood, Trueman, and Cook, n.d.).

2.1.2.2 GigaPop Ritual

A particularly interesting case of laptop performance and networked music was carried out by performers from McGill University and Princeton University in 2003. Gigapop Ritual was a collaborative performance piece that combined electronic music with North Indian classical music. It happened simultaneously at McGill University in Canada, and Princeton University in the United States, and it involved real-time streaming of audio, video and controller data from the musicians on both ends. The performers played new instruments such as the EDholak[11], the DigitalDoo and the RBow[12], and they explored various sounds by reacting to each other over the network (Kapur et al. 2003).

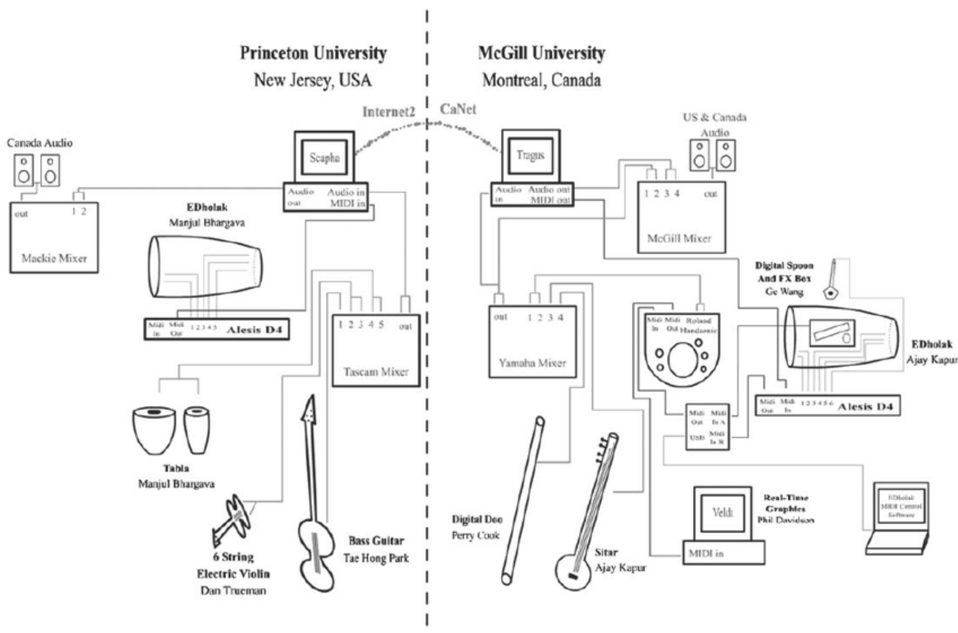

Figure 7: Gigapop Ritual – Ensemble Diagram

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[10] Force sensitive resistors are sensors whose electrical resistance changes when force or pressure is applied to its surface.

[11] The EDholak is a double-sided drum inspired by the Dholak from Northern India. It is played by two musicians; one who strikes both heads of the drum, and a second one who manipulates the first one's sounds using a "Digital Spoon".

[12] The RBow is a violin bow with motion, position, and pressure sensors. It was played by itself, using additional surfaces, or on any violin.

2.1.2.3 The Princeton Laptop Orchestra (PLOrk)

In 2005, Perry Cook, Dan Trueman, Scott Smallwood and Ge Wang created PLOrk, an electronic ensemble whose 15 members used laptops and 6-channel speakers to make music. Unlike many of its predecessors, PLOrk actually resembled an orchestra in form and function (Cook 2013).

This laptop orchestra was highly experimental, and being a performance class for engineers, it delved into the use of gestures, networks, and systems for music performance. In addition to the basic computer and speaker setup, students used various types of controllers for performance, including keyboards, tablets, and sensors. Software development for the ensemble pieces was done with ChucK, a concurrent, strongly-timed audio programming language, and Max/MSP, a modular, patch-based programming language (D. Trueman et al. 2006).

PLOrk repertoire attempted to integrate various types of sound generation, physical modeling and spatialization techniques, while addressing challenges such as ensemble organization, and physical control in real-time performance. As a result, designing and building instruments and systems became an important part of the creative process. This also meant that students needed to find ways to train and organize the rest of the ensemble for each piece (D. Trueman et al. 2006; D. Trueman 2007).

This model was well received, and many Universities started their own laptop orchestras, including SLOrk (Stanford Laptop Orchestra), L2Ork (Virginia Tech Linux Laptop Orchestra), Hybrid Laptop Orchestra (CalArts), MDO (McGill Digital Orchestra), OLO (Oslo Laptop Orchestra), LOL (Laptop Orchestra of Lousiana), among many others (Cook 2013). The first Symposium on Laptop Ensembles and Orchestras (SLEO) took place in Louisiana State University in 2012, in an attempt to address the needs of a growing community around these ensembles ("Proceedings of the 1st Symposium on Laptop Ensembles & Orchestras" 2012).

Laptop orchestras have become an important part of the Society for Electro-Acoustic Music in the United States (SEAMUS) National Conferences[13], which highlight noteworthy performances every year.

2.1.2.4 The KarmetiK Machine Orchestra

The Machine Orchestra built on the principles of the laptop orchestra and extended it to integrate robotic musical instruments, unique musical interfaces, and human performers.

[13] SEAMUS home page: https://www.seamusonline.org

Inspired by the idea of using hemispherical speakers and localized sound (2.1.2.1), the robots in this ensemble were distributed throughout the performance area to allow the audience to understand where the sounds were coming from.

Under the direction of Ajay Kapur and Michael Darling, the Machine Orchestra became an extraordinary learning environment because it involved international musicians and artists, and Music Technology and Technical Direction students from the California Institute of the Arts (Kapur et al. 2011).

2.2 Pedagogy Background

Educational systems and institutions have evolved thanks to the development of new technology and teaching strategies; but teaching in a digital age brings certain challenges with all its benefits. The same devices and instruments that are used to facilitate learning are being constantly improved and offer new features every year. Knowledge is also ever-changing, and what might have been true yesterday, could radically change today.

It is not enough to prepare students for the current truths, concepts and skills. The structure and focus of formal instruction must also grow, and it is essential to teach students how to learn and acquire new proficiencies. In this section we will explore various teaching methods that should be considered to attain authentic and enduring education in any academic area, including music.

2.2.1 Backward Design

Successful music programs nowadays are structured around standards and benchmarks as a way to make sure students are working toward the necessary concepts in a skill-based framework. Backward Design differs from traditional practices, which usually select activities and materials first. It is an educational model that recommends targeting goals and standards before developing the learning progression. Its three stages are shown in Figure 8.

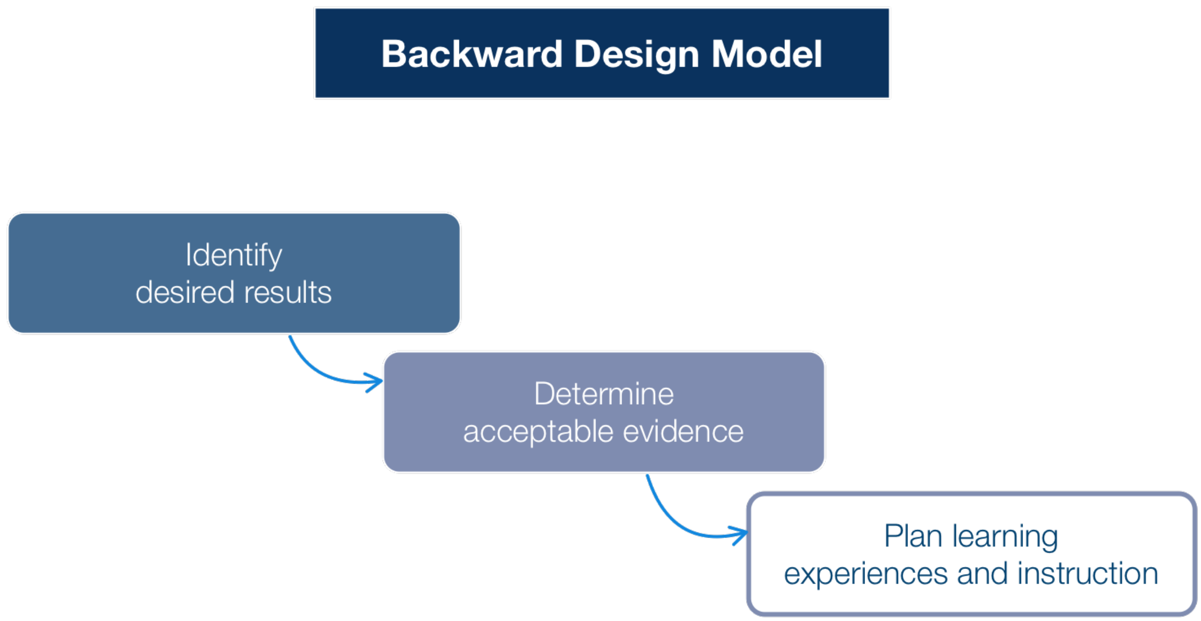

Figure 8: The Backward Design Process

2.2.1.1 Identify Desired Results

During its first stage, Backward design proposes thinking about what students should know and understand while considering instructional goals and standards. This is where knowledge is categorized according to its relevance.

Core concepts, principles and processes are included as enduring understandings. Other important information is used to support comprehension or avoid misconceptions. Finally, non-essential information worth being familiar with is considered (G. P. Wiggins and McTighe 2005).

2.2.1.2 Determine Acceptable Evidence

During the second stage of planning, a curriculum designer will think about what will be accepted as evidence of understanding and proficiency. Considering assessments as a first step helps instructors determine what they want from their students, who will also perform better if they have a goal.

There are many ways to monitor and measure student learning. Basic concepts can be evaluated through simple checks of understanding; usually done verbally, or through brief questions to be answered in writing. More important knowledge and skills might require more elaborate prompts, or performance tasks and projects (G. P. Wiggins and McTighe 2005).

2.2.1.3 Plan Learning Experiences and Instruction

Finally, instructors who use the Backward Design model will only proceed to designing the instructional phases once they have identified the desired results and assessments. This is where teaching choices, organization of knowledge, applied methodologies, and required resources can be selected to answer key questions throughout the learning experience (G. P. Wiggins and McTighe 2005).

2.2.2 Bloom's Taxonomy

Bloom's Taxonomy has been a popular teaching framework ever since it was published in 1956 by Benjamin Bloom and a few collaborators (Bloom et al. 1956). It is considered a valuable tool in objective-based education, which is a very efficient and organized way to deliver instruction[14].

The cognitive domain of Bloom's Taxonomy is at the core of skills-based teaching philosophies. It categorizes learning goals according to its complexity, as shown in Table 1. This classification is commonly represented as a pyramid (Figure 9).

Table 1: Bloom's Taxonomy Hierarchies in the Cognitive Domain

Revised Bloom's Taxonomy[15]	
Remembering	Recalling specific elements and concepts.
Understanding	Demonstrating comprehension through explanation.
Applying	Using acquired knowledge.
Analyzing	Examining and taking apart the concepts to make connections.
Evaluating	Formulating and defending opinions about the information.
Creating	Producing new work with the acquired knowledge.

[14] Article available at: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

[15] Article available at: https://en.wikipedia.org/wiki/Bloom%27s_taxonomy#The_Psychomotor_domain_.28action-based.29

Figure 9: The Categories of Bloom's Taxonomy

The revision in 2000 was considerably important for music education because having *Creating* at the top suggests that students who are composing or improvising are putting together their previous knowledge and functioning at the highest level of thinking. This highlighted the creative and original work as a priority in music curriculums (Shuler 2011).

2.2.3 Learning Theories and Digital Art

Instructors and curriculum designers have the responsibility to consider various strategies to help students absorb, process and retain information. In the digital arts, it is not enough to simply provide facts and demonstrate methods that are currently accepted. Students need to become effective and independent lifelong learners, prepared to embrace rapidly changing tools and techniques.

This section investigates the different approaches that could be used to develop meaningful learning progressions in contemporary arts education.

2.2.3.1 Behavior and Knowledge: The Oxymoron of the Passive Artist

Behaviorism and cognitivism are very different, but they both have the teacher playing a major role in the learning process.

Behaviorism claims that the learners are a clean slate, and their behavior is simply a response to stimuli. Behaviorist learning consists of shaping these responses through positive and negative reinforcement. The odds of behaviors repeating themselves can be controlled by providing the right rewards or punishments in the appropriate order. This philosophy has been criticized as a simple extrapolation of animal behavior to humans that does not account for complex factors such as language and environments[16].

Cognitivism focuses on the mind and the acquisition of information. It was a reaction to behaviorism, and its counterargument was that not all learning occurs through conditioning. Concepts are presented in an organized manner, and problem solving is an essential part of learning. However, this structure makes it hard for learners to be very flexible and adapt to changes[17].

The problem with behaviorism is that students assume a passive role, and possibly unaware about the learning process. On the other hand, cognitivism allows them to be more active, but it does not encourage them to adapt to new scenarios. These philosophies do not lead toward independent and flexible learning, and they fall short before even considering expression, originality, and creativity. This is evident in (Broomhead 2005), when he compares his work on phrase-shaping between two different groups of students, and the results observed during their performances.

One of them was a high school chamber ensemble that consisted of senior students. They had the opportunity to work with him for four years, and they were used to his teaching methods and conducting techniques. Although working with them in the classroom was immensely comfortable and effective, when asked to prepare a performance independently, they were unable to demonstrate proficiency in phrase-shaping. They had assumed a passive role throughout the learning process, and they became excessively dependent of their instructor.

The second group was comprised of eighth graders who had only studied under him for a few months. Rehearsing with them was more challenging than with the previous group, but when they worked in an activity which had the ensemble prepare folk song phrases on their own, they showed proper understanding of the reviewed skills. They assumed an active role, and had a chance to solve problems and make creative decisions.

Studying music is a complex and dynamic process, and it requires learners to be actively involved and to have an attitude of constant exploration. The following section will closely examine two philosophies that enable this type of engagement and experimentation.

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[16] Article available at: https://ci484-learning-technologies.wikispaces.com/Behaviorism,+Cognitivism,+Constructivism+%26+Connectivism

[17] Article available at: https://ci484-learning-technologies.wikispaces.com/Behaviorism,+Cognitivism,+Constructivism+%26+Connectivism

2.2.3.2 Constructivism and Connectivism: The Advantages of Active Learning

Traditionally, education and learning systems have been designed to provide students with knowledge and expertise meant to last for the rest of their lives. Learners have been expected to acquire specific concepts related to a single career choice through a slow schooling process. In the last few decades, however, technology has changed how individuals interact and communicate with the world around them. (Siemens 2014) analyzes how learning has become a lifelong process that is bound to incorporate concepts across various fields. Technology has influenced the way people think and learn; and knowing where to find the solution to a problem has become more important than having reviewed it beforehand.

Constructivism considers that learning is not passed on or transferred, and that it is something that needs to be done by the subject (J. Wiggins 2007). This philosophy is completely student-centered, and learners are encouraged to build new mental structures by combining new knowledge with the one they already have from previous experience. Unlike cognitivism, which prepares students to solve specific problems, constructivism gives them opportunities and responsibilities to find the solutions by building on what they already know (Broomhead 2005).

Connectivism explores the possibility of knowledge being outside the learner. Students become capable of making connections and finding credible sources, which turns them into better researchers[18]. The strength of connectivism is in the understanding that new information and rapidly altering foundations should be considered in learning and decision-making.

These two philosophies help students become agents of their own learning. Although instructors might find it tempting to do the hard work for their students to get quick results, allowing them to explore and make mistakes leads to continuous and authentic learning. Digital arts education could benefit significantly from constructivist and connectivist processes.

Massive Open Online Courses (MOOCs) are a clear example of learning empowered by technology. As one of the most recent developments in distance education, their popularity is rapidly growing because they offer affordable and accessible courses. Most MOOC providers include a wide array of courses in computer science, engineering, mathematics, and business; however, arts education courses are still considerably underrepresented. (Peng 2016) investigates how this is a consequence of art courses having more active learning needs, and the possible challenges in online instruction and assessments.

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[18] Article available at: https://ci484-learning-technologies.wikispaces.com/Behaviorism,+Cognitivism,+Constructivism+%26+Connectivism

Peng's research shows that much like in traditional learning, many MOOCs rely heavily on lectures and demonstrations, and the few online art courses that are available do not differentiate its pedagogical approaches. In fact, most of the teaching methods can be considered passive according to The Learning Pyramid[19] (Figure 10), which illustrates common teaching strategies, and their corresponding retention rates. Arts education requires teaching philosophies with a greater focus in participatory teaching methods.

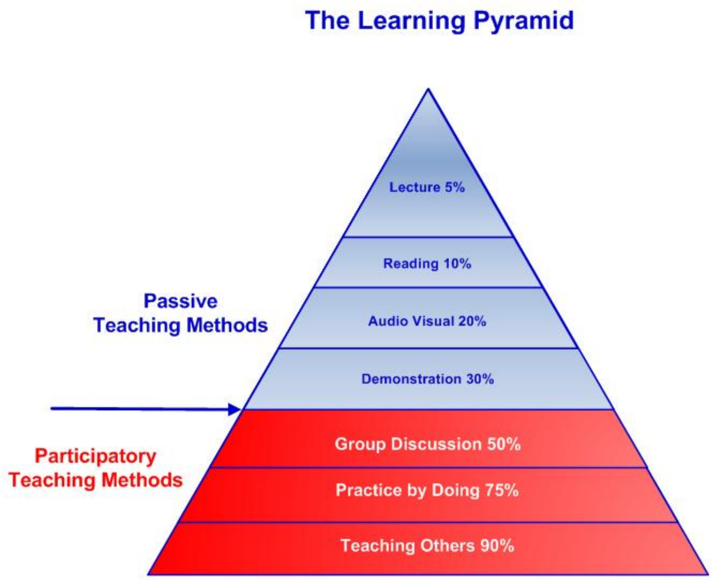

Figure 10: The Learning Pyramid

(Peng 2016) also highlights the importance of active learning in arts courses because they involve complex creative processes such as designing, programming, and composing. This makes it critical for students to have access to an interactive learning environment, and guidance from an experienced instructor. Her case study on Kadenze[20], a MOOC provider that offers online arts and technology courses, illustrates an example of effective implementation of active teaching strategies in the virtual classroom.

Launched in June 2015, Kadenze offers various creative online courses, and it partners with leading arts education institutions including California Institute of the Arts, Princeton University, Stanford University, California College of the Arts, Seoul Institute of the Arts, and Goldsmiths University of London. They have implemented their own MOOC platform built specifically for their courses, which enables learners to benefit from accessible media players,

[19] Available at: http://thepeakperformancecenter.com/educational-learning/learning/principles-of-learning/learning-pyramid/
[20] Kadenze home page: https://www.kadenze.com

customizable assignment and assessment builders, and course galleries and forums to facilitate feedback and communication. Each course is designed to allow instructors and students to engage in discussions and to exchange feedback. This is an environment in which complex constructivist and connectivist processes like creation, problem solving, and decision making, strengthen independent learning.

2.3 Summary

There are several important moments that have defined the history of computer music, such as the hiatus in the development of new instruments during the first half of the twentieth century; the birth of the electronic era that led to the popularization of synthesizers and sequencers; and the development of new audio generation and manipulation techniques, MIDI, and laptop orchestras, thanks to the work of great composers, instrument designers, scholars and engineers. These laptop orchestras have played an important role in the advancement of computer music by incorporating various meta-instruments and exploring different performance types.

The evolution of technology has also changed how people think, learn, and interact with each other. As a consequence, the lifespan of knowledge has shortened considerably, and now professionals are expected to possess skills beyond a single field; which creates the need to educate flexible and open-minded students who are prepared to be lifelong learners. Teaching in a digital era requires key instructional concepts and methods focused on enabling authentic learning and enduring understandings, such as Backward Design, higher-order thinking, and educational philosophies like constructivism and connectivism.

In the following chapters, this thesis will seek to demonstrate how these teaching strategies can be applied through the inherent creative processes in modern electronic ensembles.

Chapter 3

Integrating Electronic Ensembles in Music Curriculums

3.1 Why the Laptop?

Computers have become important tools in contemporary education because they can provide various benefits that can positively impact the learning processes. With them, the classroom is no longer the only place to study, and students have a chance to be more involved in their own education.

Computers also offer a wide array of materials and tools to make learning more interactive, which allows for deeper understanding and creativity. Students can do their own research and follow the course content at their own pace, which addresses many classroom management and differentiation challenges.

Additionally, acquiring new knowledge and skills is not limited by a teacher's availability anymore. The internet makes it easy for learners to access new content anytime and anywhere, and the potential for collaboration with peers or people with similar interests has no boundaries. Greater access to learning materials and paperless resources, increase productivity and improve learning results at a reduced cost (Page 2016).

To this end, laptops enable students to have an identity within global learning environments through efficiency, exploration, and expression. Evidence of this can be found in the efforts that many countries are making in integrating laptops and other digital technology into their educational systems.

In the United States, Maine became a pioneer in strategies to bring laptops to school curriculums thanks to the Maine Learning Technology Initiative (MLTI)[23], one of the most important one-to-one computing initiatives in the country. Since its beginning in 2002, it has facilitated access to learning technology to 7^{th}-12^{th} graders, and transformed education in classrooms across the state (Trucano 2009; Trucano 2013). Cities such as Los Angeles and Miami have also implemented plans to bring iPads and digital devices to the classroom (Trucano 2013).

In the last decade, countries with powerful economies and even some developing countries, have realized the potential of integrating computers and laptops into their educational models. Portugal, Peru, Kenya, and Rwanda have all designed projects to bring one-to-one laptops to their schools, particularly the ones in struggling communities. Thailand, Turkey and India have also been part of these efforts with plans to provide tablets and handheld devices to their students. Although there are considerations to be made, such as how to pay for these initiatives and maintain them without neglecting other educational priorities; educational reformers and technology proponents in many of these countries feel confident that introducing technology into the classrooms will bring positive changes to education (Trucano 2013).

One Laptop per Child (OLPC)[24] is a non-profit initiative to improve education for children in low-income economies by producing and distributing low-cost laptops. Since its beginning, OLPC intended to keep production prices low by opening its designs to manufacturers and highlighting its educational objectives. It received strong support from many governments, particularly Latin American and Caribbean countries, which were eager to adopt OLPC and other one-to-one computing projects. Over 1 million laptops were deployed in over 40 countries by 2010 (Nugroho and Lonsdale 2010).

OLPC has been acclaimed for its purpose in integrating computer literacy and technology into education; but it has also been criticized for its implementation and results. The OLPC deployment projects have been evaluated on many occasions, and results have varied greatly due to differences in project subjects, contexts, and execution. Informal evaluation methods included case studies and documentation, while formal evaluation consisted of more

[23] MLTI website: http://www.maine.gov/doe/mlti/index.html
[24] OLPC website: http://one.laptop.org

complex studies that combined qualitative and quantitative data collection, observations, interviews, and surveys. In many places, these results have raised questions such as if OLPC projects should really be a priority, when there are healthcare and quality of life issues to be addressed in developing countries; or if OLPC initiatives are really sustainable after the departure of the project staff supplied at the beginning of the project (Warschauer and Ames 2010; Nugroho and Lonsdale 2010).

(Nugroho and Lonsdale 2010) also mention that results are highly dependent on the focus of the OLPC deployment. Laptop use failed to raise standardized score results in Southern California because teachers and students had limited experience with computers. Something similar happened in Colombia, because there was no visible improvement in math and Spanish test scores, but the program did successfully increate students' use of computers. In India, studies revealed that the deployment programs were effective when complimenting an existing curriculum, instead of attempting to replace traditional teaching methodologies. A study by the Organisation for Economic Co-operation and Development (OECD)[25] also showed that Portuguese students showed remarkable progress in a number of areas, as part of a large scale project that included free educational content, training, and technical support (Trucano 2012b). On the other hand, an evaluation conducted in Peru revealed that there was no evidence about increased learning in math or language, but there was an improvement in the development of cognitive skills. This was not surprising, considering that there were no efforts to integrate the laptops to the curricula, and the computers did not include math or language software (Economist 2012; Trucano 2012a).

The outcomes of Peru's OLPC initiative, "Una Laptop por Niño", reminds us that having access to computers does not guarantee benefits in education. Teachers might not be properly trained, or might not understand how to effectively integrate the computer within their established pedagogical framework. Also, misuse of technology, poor maintenance, and lack of resources, represent serious complications for projects of this nature. (Trucano 2010) details the worst practices in the integration of technology into the classroom:

- Supplying technology without any implementation plans and expecting results.
- Designing plans in a learning environment and attempting to implement them in a different one without considering the local reality.

[25] OECD website: http://www.oecd.org

- Not considering the educational content and the issues that are being addressed before providing hardware.
- Assuming that content can be imported without any consideration to context, culture, curricula, and teaching practices.
- Not monitoring or evaluating the implementation process.
- Taking a risk on technology that is not standard, or relying on a single technology provider without thinking about how to terminate the relationship if anything goes wrong.
- Not acknowledging the total cost of owning and maintaining the hardware.
- Ignoring social and economic issues.
- Not providing essential training to teachers and administrative personnel.

These worst practices show that technology is simply a resource, and it needs to be backed by best practices in education.

Uruguay's Plan Ceibal is an interesting case of large scale design for education. This project had the objective of achieving social inclusion through digital inclusion. Its main goals were to improve the quality of education by integrating technology into the classroom, developing a collaborative culture between children and adults, promoting literacy and critique through technology, and promoting equality in Primary Education by providing laptops to students–ages 6 to 12–and teachers.

Ceibal was not simply conceived as a pedagogical undertaking; it was a countrywide development strategy which involved parents and teachers, and required heavy investment for proper implementation. Ever since its beginnings from 2005 to 2007, it had a lot of support from citizens, government organizations, and institutions (such as RAP Ceibal and CeibalJAM) that were created specifically to support it (Rivoir 2012), and as a result, Ceibal became part of the educational culture of Uruguay.

Currently, children in Uruguay have easier access to computers and internet services, which has had a considerable influence in the education and family dynamics. Figure 11 shows the results of a survey in 2009 that compared computer use by children ages 6–11 between the Interior region, already part of Ceibal, and Montevideo (as a control group). It is important to consider that previous studies revealed that the groups were not at the same level initially, because children from Montevideo were already familiar with the use of technology. The data showed that the Interior region areas where the plan had been implemented already had a 91% of students using computers, over a 69% in Montevideo, even though the Interior children had started at a disadvantage.

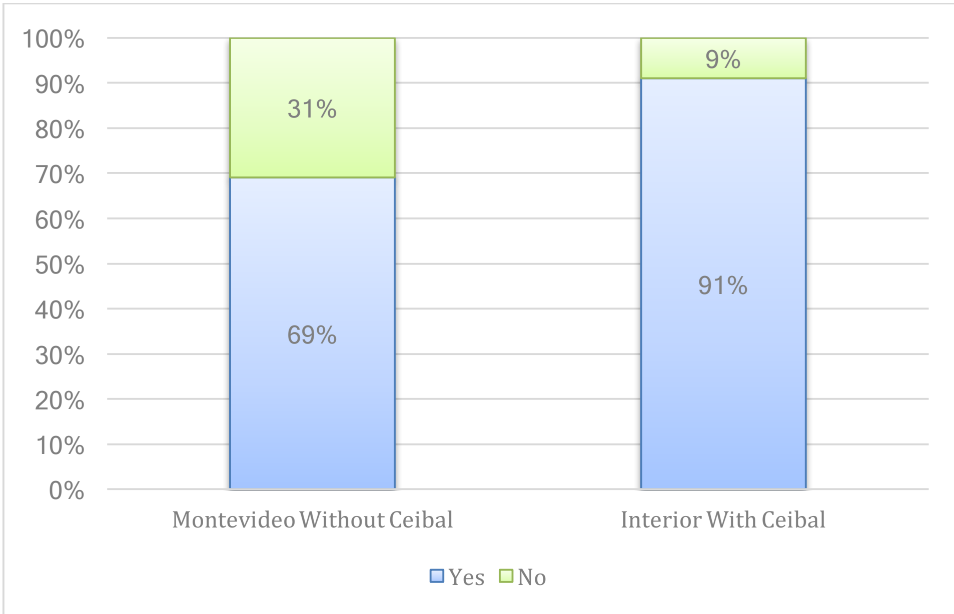

Figure 11: Plan Ceibal – Children Using Computers
(Montevideo without Ceibal vs. Montevideo with Ceibal)

Figure 12 shows the progression of the percentage of families with access to computer and internet services in major urban areas between 2001 and 2010. There is no significant growth until 2006, when public policies, changes in the technology market, and an improvement in the country's economy after the 2002 crisis, caused a noticeable increase. This development was amplified after plan Ceibal was implemented, because low-income families had better access to computers and internet. This is why 2007 marks the beginning of a steady rise in these percentages, when computer access for these families went up from 26.5% to 30%, and internet access increased from 14.9% to 17.4%

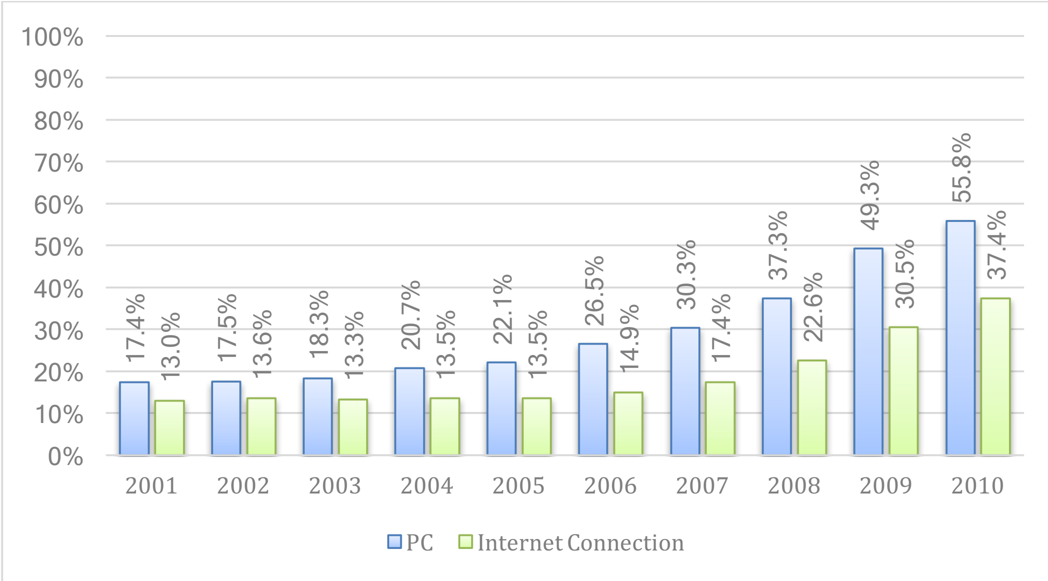

Figure 12: Plan Ceibal – Evolution of the Percentage of Homes with Access to PC and Internet 2001–2010, Major Urban Areas

In an attempt to achieve a similar growth in computer literacy, other countries like Paraguay and Argentina have been inspired to carry on similar endeavors (Trucano 2013).

It is evident that schools all over the world are trying to integrate technology tools into their curriculums, and laptops have proved to be one of the most popular instruments in the transformation of worldwide education. The next sections explore how music programs can benefit from these changes if they use electronic ensembles as a catalyst.

3.2 Why an Electronic Ensemble?

It is important to consider that electronic ensembles are not completely different from traditional band and orchestras, and as a collective music making experience offered to students, their purpose is still the same, even if their rehearsal techniques and workflow may be completely different. They are environments for students to apply their instrumental knowledge, develop social skills, and experiment with new techniques.

3.2.1 Structure and Configuration

One of the most interesting aspects of laptop orchestras is that they are not made exclusively of traditional instruments, and there is no convention that defines how the setup of a laptop performer should look as a part of the ensemble. The meta-instruments that make-up the orchestra can be one of its most colorful elements.

For example, meta-instruments in PLOrk tend to include a laptop, a rack with an audio interface and speaker amplification, and a hemispherical speaker. The most common examples of software used for these musical purposes are Max/MSP, SuperCollider, and ChucK, which are popular audio programming languages and environments. Their open-ended nature allows the user to develop unique compositions, systems, algorithms, scores, and interactive structures for performance scenarios. Custom musical interfaces and controllers utilizing various sensors, and other networked elements are also commonplace in the laptop orchestra (D. Trueman et al. 2006).

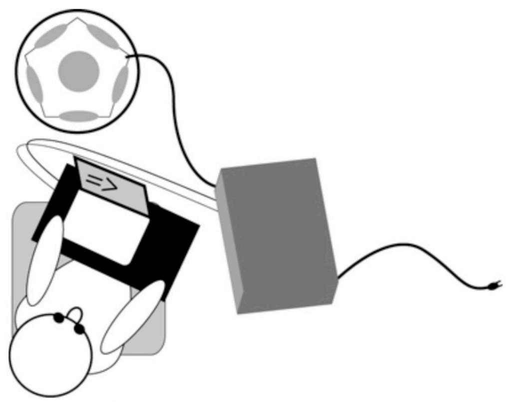

Figure 13: A PLOrk Meta-Instrument

However, laptop orchestras have not been limited by their gear or by what the hardware allows them to do. Some ensembles like the Experimental Headbang Orchestra in Stanford (Figure 14), have already integrated a human element to their playing. They used body movement to develop their music, which allowed them to deliver a powerful embodied performance.

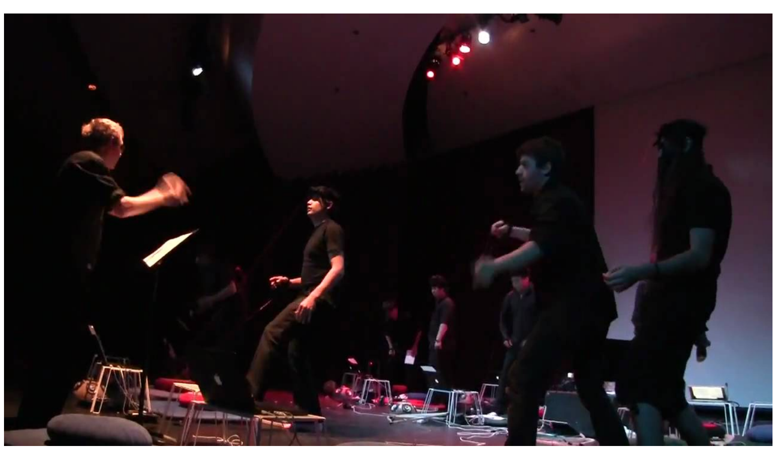

Figure 14: Stanford's Experimental Headbang Orchestra

3.2.2 Interfacing with the Laptop

Computer music has changed the rules of ensemble performance completely. Computers do not need constant input or actions from a performer to generate sound, which has led computer musicians to think carefully about what their role is, and what they want to do to play their laptop.

Audiences are used to having a visual connection between what the performer is doing and the sound coming out of their instrument. The most traditional complaint comes from people being thrown off by the concept of seeing someone sitting in front of a laptop on stage. Some electronic orchestras have started to use visuals to support their performance, but some argue that this only feels like a distraction because the ensemble itself is uninteresting to watch (D. Trueman 2007).

(Vallis 2013) takes a look at the division between the performer and the audience, and analyzes the challenge of comprehending the interaction and the intents of the performer. In a live performance, computer musicians have to find the best way to interact with their interfaces while trying to find balance between two approaches to performance: (1) A many-to-one mapping in which various inputs generate similar outputs, and the performance highlights procedure over aesthetics; and (2) a transparent one-to-one approach that ties singular actions to individual effects, but runs the risk of turning the performance into a simple demonstration of technology. In any case, audiences can still be confused and feel like the performance is disembodied if they cannot understand what drives it.

(Vallis 2013) also examines how the faith an audience puts in the authenticity of a performance is at risk because computer music performance goes beyond physical actions and triggers. Performance-composers have evolved, and they have adopted computers to facilitate the diffusion of their actions into many separate musical events; this could work against them, however, because it does not reinforce the usual physical gestures involved in an acoustic performance. Vallis' research reveals that musicians and audience members still have to go through technological mediation which is the cultural process in which technology enhances perception, redistributes social relations, and creates new meanings for visual language. It is this process that will enable musicians to find ways to bypass the division between performers and the audience; and audiences to reach a new level of understanding about what the computer musician is doing on the stage.

Furthermore, performer-composers have embraced two approaches to attempt to create a connection with the audience. The first one is to use external controllers, sensors, or even hyper-instruments to perform while getting away from the computer. Spectators find this appealing again because the sounds they can hear are being caused by electronic instruments or contraptions.

The second approach is that of the computer musicians who decide to embrace the look of the computer user. They make music on a laptop, and the fact that it does not look like a typical instrumental performance is inconsequential. In her research, Rebecca Fiebrink highlights the expressive potential in the native input capabilities of the basic hardware itself. By using various mapping strategies and creative design, it is possible to make music with keyboard, mouse, and trackpad interaction, or even microphones and webcams.

(Fiebrink, Wang, and Cook 2007) includes examples of instrument design and performance using native laptop input through PLOrk case studies of various mapping strategies. Pieces like Wang's *Crystalis*, and Fiebrink, Wang and Cook's *Joy of Chant*, use pitches mapped in a fretboard-like configuration to different keys on the laptop keyboard (Figure 15). This configuration allows performers to play notes and chords with one hand, while operating a different controller with the other one.

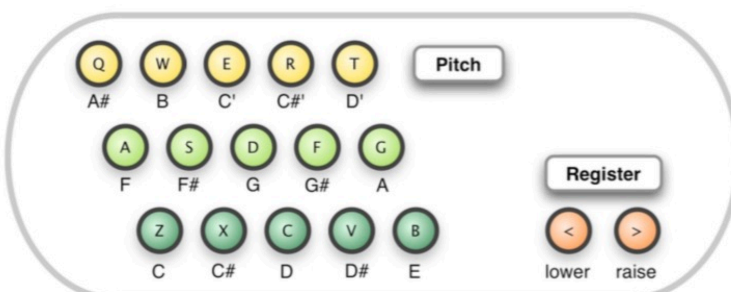

Figure 15: Fret-based pitch selection

Crystalis also uses trackpads because of their potential as a sensitive and tactile interface and its ability to track two-dimensional motion. In this piece, players use "bowing" gestures by moving their fingers at different speeds, which combined with keyboard pitch control, enable them to manipulate synthesis models (Figure 16).

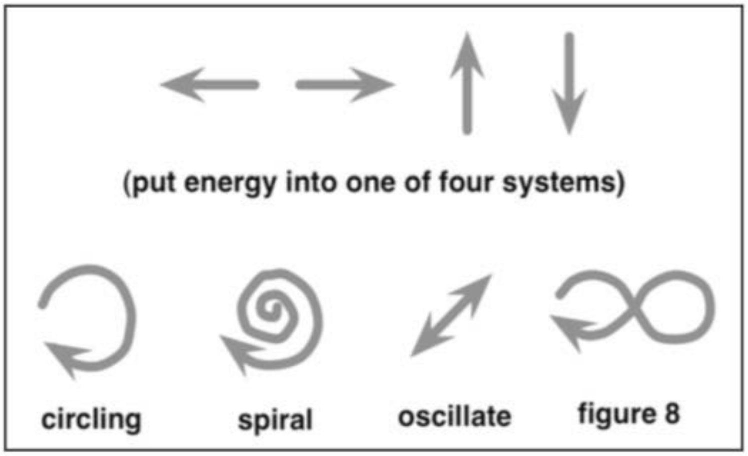

Figure 16: Trackpad bowing motions

Accelerometer-based motion sensors used to be commonly found in many laptop models, and they were an interesting example of native input through gestures like "smacking" and "tapping" the laptop. In Fiebrink's *Smacking Music*, performers hit PowerBook laptops with their hands or other objects to create "acoustic" sounds, and the sensors would track these events to generate a synchronous visual accompaniment. Conveniently, the motion sensors would also protect the laptop's hard drive from harm throughout the piece.

These strategies have been widely accepted by ensembles and audiences, and they show the power of artistic choice in computer music.

3.2.3 New Paradigms in Composition

There is an interesting contrast between the traditional orchestra and the type of ensemble that laptop orchestras represent. Orchestras have been a part of formal music for centuries. They are highly structured, organized, and specific about what they do. A director selects the repertoire to be played, and it is performed with very precise stylistic considerations.

On the other hand, laptop orchestras represent a format that encourages exploration, creativity, and experimentation in new ways. They highlight how large ensembles are still appealing to composers and performers, and they have been an important factor in the development of new musical interfaces and technologies (D. Trueman et al. 2006; D. Trueman 2007).

Laptop orchestras have a particular way of working because there are no defined conventions about instrumental technique, and there is no standard literature or repertoire. Fortunately, computer musicians have regarded this as an opportunity instead of a shortcoming, because it enables them to design and create new musical interfaces and environments for each piece (D. Trueman 2007). For example, in Perry Cook's and Ge Wang's *Non-Specific Gamelan Taiko Fusion Band* (Figure 17), the ensemble is synchronized by a network pulse which can be visualized as it moves along the grid of an onscreen interface. This grid consists of colored boxes, and each color represents a different sound that will be played as the pulse triggers each box. Performers can select the sounds that they would like to hear from a palette at the bottom, while following a conductor or score (Smallwood et al. 2008).

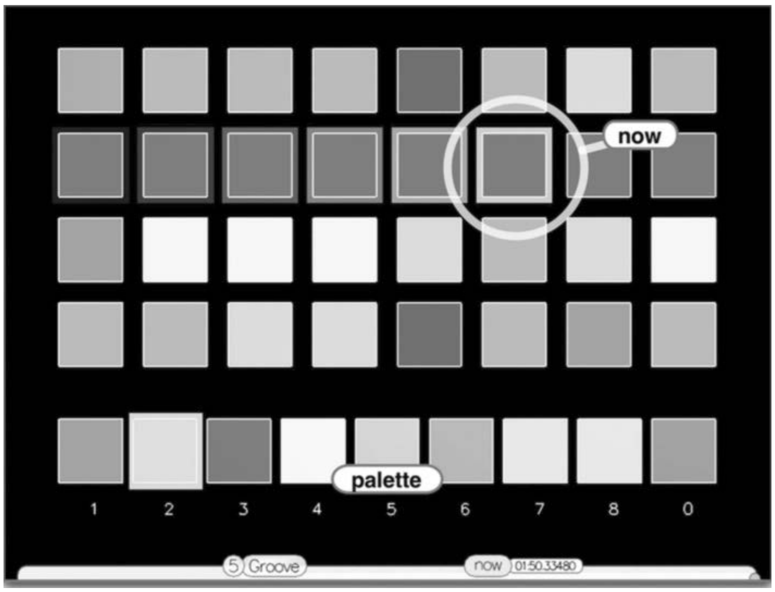

Figure 17: The Onscreen Interface for *Non-Specific Gamelan Taiko Fusion Band*

Artistic choice is a critical part of each performance, and ensemble members are not restricted to a particular role or instrument. Each laptop orchestra is unique, which offers many exciting opportunities for contemporary composers. Music styles that are continuously explored include traditional western music, electronic music, world music, and experimental styles. (Smallwood et al. 2008) describes many pieces performed by PLOrk, and how they can be treated as soundscapes, games, or performance art. In Dan Trueman's *The PLOrk Tree* (Figure 18 and Figure 19), all the orchestra players have the same instrument, which is a step sequencer. The conductor starts the piece, and then the music propagates through the ensemble–or the tree–as adjacent performers react to what they hear. The conductor can modify the instruments, and everyone can send text messages to the rest of the ensemble, effectively feeding information back into the network.

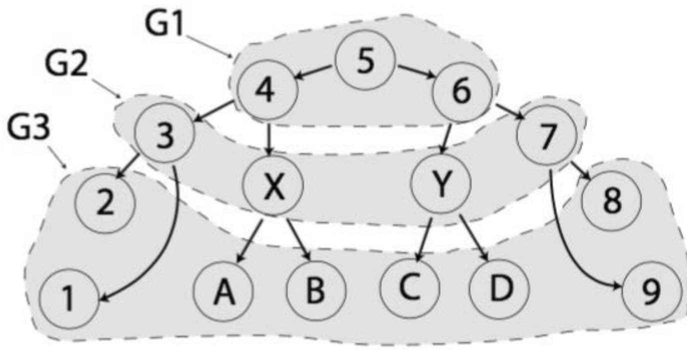

Figure 18: The PLOrk Tree

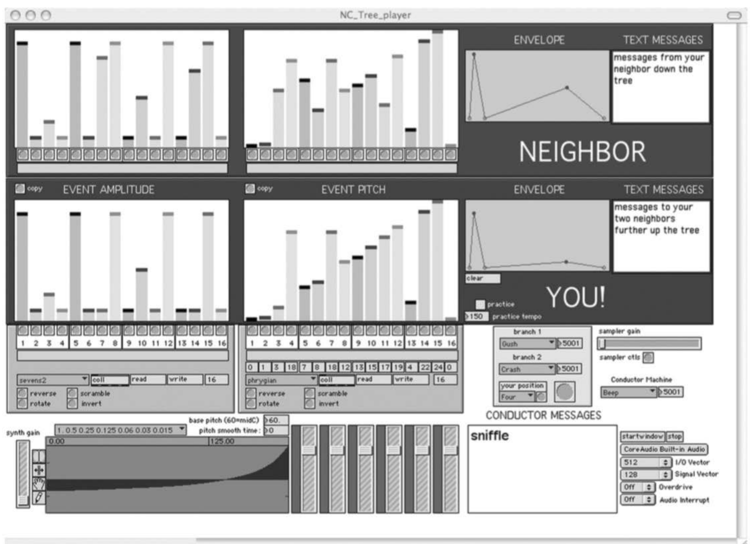

Figure 19: The PLOrk Tree Player Interface

PLahara is another one of Truman's pieces (Figure 20), which features three conductors. In this composition, inspired by the traditional North Indian lahara, a simple tune is played repeatedly, and it provides a context for improvisation by the percussionists. The composer plays the tune on the Hardanger fiddle[26], and one of the conductors doubles it on a MIDI keyboard. They also add a pre-composed bass line, and its pitch information is sent to the rest of the ensemble, who will use microphones to excite tuned comb filters. The conductor's laptop also handles the pitch and the tempo through a tempo follower, which allows for a smooth performance without needing to lock to a network pulse (Smallwood et al. 2008).

[26] Norwegian folk fiddle.

Figure 20: Dan Trueman's PLahara

PLOrk has also performed pieces that explore music as a game. Scott Smallwood's *On The Floor* (Figure 21), simulates the sounds of the environment of an Atlantic City casino. Each musician has access to a virtual slot machine written in ChucK, and with a user interface programmed in the Audicle[27]. Each player starts with 30 "credits", and they can bet 1–3 credits each turn. The overall soundscape consists of actual casino recordings, and additional cues develop as players lose their credits. When players lose all their credits, they are left with a drone on random note from a C-Major triad, in such a way that when everyone is out of credits, the only remaining sound is that of the chord structure (Smallwood et al. 2008).

[27] Context-sensitive audio programming environment. Designed for on-the-fly coding with the ChucK programming language.
Audicle website: http://audicle.cs.princeton.edu

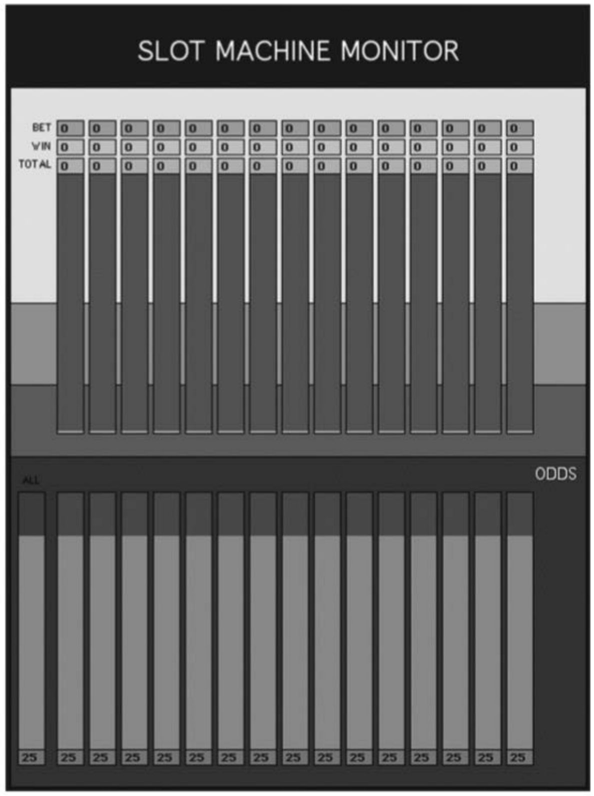

Figure 21: Scott Smallwood's *On The Floor* - Conductor Interface

Laptop orchestras challenge composers and performers to play a different role in every piece, and to become designers, builders, multi-instrumentalists, and conductors through creation and collaboration.

Laptop orchestras have not only changed the way musicians think about art and expression, they have changed art itself by integrating new composition approaches and techniques such as algorithms, live coding, and networked performances.

3.2.4 New Paradigms in Education

As mentioned in Chapter 1, many music curriculums outside a few Music Technology specializations in higher education institutions[28] only include music production and sound engineering elements; essential music skills such as performance, improvisation, and composition are relegated to traditional music education or composition programs, and this detracts from a real and complete integration of music technology into music curriculums.

[28] Usually universities with formal Music Technology programs such as California Institute of the Arts, New York University, and Georgia Institute of Technology.

Music departments everywhere have started to offer innovative and original classes, but if there are no adjustments to the core program to make sure these courses actually have a clear purpose, students will lose interest after the novelty wears off. The next sections will take a closer look at the numerous problems and limitations in the scope and structure of music technology curriculums that were mentioned in 1.2.2.

3.2.4.1 Discrepancies Between Theory and Practice

Schools have discovered the benefits of investing in a well-rounded music program that includes formal study courses in music theory, ear training, music history, and other advanced classes. These classes encourage students to explore music beyond their instrument, and to find a new meaning in their art practice.

However, many programs that have started to include music technology have not been successful at integrating it with the rest of its courses. If students only have access to classes in recording, mixing and live audio techniques, it should not be surprising for them to display a complete lack of interest in music theory and skills.

Additionally, conflicts between subjects are not uncommon in programs that have added music technology classes to a previous set of courses, or in curriculums that are heavily focused in a particular style. It can be challenging to teach core musicianship skills and training through traditional western classical harmony or baroque studies to a student who is interested in electronic music—especially if it means forsaking skills or knowledge that would be applicable immediately. This is where practical curriculum designers would consider adding courses in contemporary composition techniques and collaborative music.

It is important to have a consistency between the concepts taught in formal music courses and their direct application in practical and instrumental classes. Schools are constantly trying to integrate technology into their lessons, and the music classrooms are not an exception. Music technology should not be appended to an existing program; it should be integrated completely by incorporating the most critical elements of meaningful education into a cutting edge curriculum that encourages exploration and creativity.

3.2.4.2 No Clear Opportunities to Develop Leadership and Teamwork Skills

Unless schools have a good reason to offer a set of courses in sound engineering exclusively, students will be missing out on a good part of their educational experience if they do not have a chance to practice and perform music regularly. There are key skills that can be developed from music creation and ensemble work; and as a long-term added benefit, a sound engineer with a high level of music proficiency is highly valued professionally.

Collaborative music presents a larger challenge than working individually, but the end product and the educational value tend to scale accordingly. Working with others can lead to considerable growth in leadership, teamwork, critical thinking, and problem solving skills. Additionally, having the chance to showcase their own work through exhibitions or live performances can give students the chance to really own their work and to assume responsibility for their learning progression.

These 21st century skills, which will be discussed extensively in Chapter 4, are regarded as a top priority by parents and educators. Programs designed with these skills in mind will be more useful to the students regardless of them continuing with music later on.

3.2.5 Closing the Gaps in Music Technology Education

In order to deal with the concerns mentioned in the previous sections, it is necessary to rethink and reorganize present-day music curriculums. Schools are constantly trying to integrate technology into their classrooms, and they want to teach interesting new and interesting courses, so this is a great opportunity to do so. A curriculum in electronic ensemble performance has the potential to revolutionize music education, and to directly address the struggles of currently available music technology programs.

The laptop is a protean musical instrument, and the freedom it offers to the performer is what makes it so powerful. Considering the creative and expressive possibilities mentioned in 3.2.2 and 3.2.3, using a computer in collaborative music provides the opportunity to constantly compose and play new material. Electronic ensembles also have inherent prototyping, construction and design processes, which help students naturally develop their organizational, teamwork, and teaching skills.

Courses in new composition techniques, and computer music could also be a powerful way to update a music curriculum and to integrate electronic ensembles with the rest of the program. Finally, integrating these ensembles to existing orchestras and bands could encourage collaboration across various instrumental formats.

3.3 User Study: Laptop Performance Training for Young Artists, Part 1

The *Laptop Performance Training for Young Artists* user study was designed to test the educational model proposed in this thesis. The objective of this project was to integrate electronic ensemble performance with effective teaching strategies to support meaningful and authentic learning experiences.

A group of students was selected and had to learn about a specific music technology or electronic performance topic. The main challenge was to design the best possible learning experience to help them become proficient in relevant concepts and skills. Successful implementation of this educational model was then measured through surveys, observation, and evaluation of the acquired data. This was an example of direct application of Backward Design for a small sample of students, and it focused on the development of 21st century skills.

In this section we will review the preliminary steps of the study, the selected content, and the creation of an educational tool to facilitate authentic and practical learning. The user study and the learning process will be detailed in Section 4.2; and the results and observations will be discussed in Section 5.2.

3.3.1 The P5 Sequencer

The first step in the planning process was to determine the general content and skills to be taught. The selected topic was *The Study of Sequencers and Drum Machines* because it included concepts and skills that are fundamental in any contemporary music technology curriculum.

Music sequencers are interfaces designed for audio recording, editing, and playback, for pattern-based composition and performance. Their usage commonly involves manipulating a grid to construct repeating melodies and rhythms which are locked to a steady meter. There have been many types of sequencers throughout history, starting with the music boxes and the pianola in the 18th century, which were the first form of sequencers, even though people usually bought them as toys. Halfway through the 19th century, Raymond Scott created his "Wall of Sound" (Figure 22), a large electro-mechanical array of sequencers that took up a whole wall of his studio. Scott's work inspired Robert Moog, and their efforts in the development of analog sequencers popularized many forms of electronic music. In 1959, Wurlitzer created the Sideman, which was the first commercial drum machine (Arar 2013).

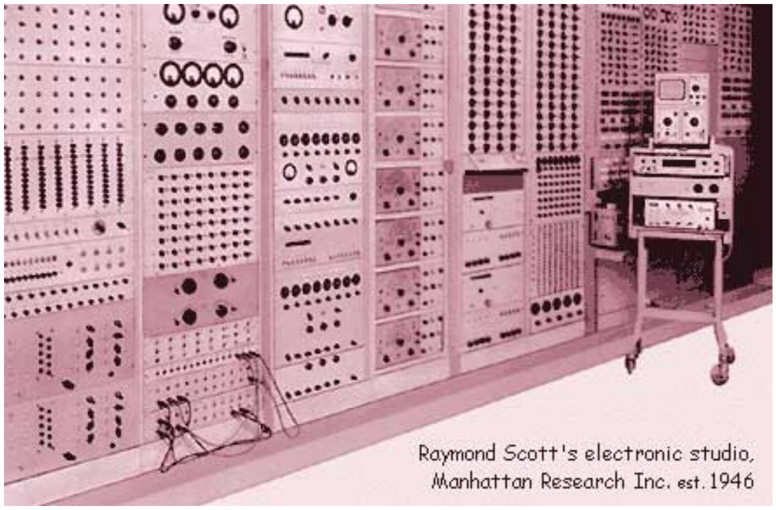

Figure 22: Raymond Scott's "Wall of Sound"

Software sequencers came with technological advancements and the growing computer industry. Sequencers like the Synclavier I in 1977 and the Fairlight CMI Series II synthesizer in 1980 were built to function like their analog predecessors. With the creation of MIDI in the 1980s, and the rise of DAWs in the 1990s, sequencing techniques became an integral element of complete music production suites like ProTools, Ableton Live[29] and Logic[30]. The development of MIDI also enabled communication between computers and various devices. Many performers explored music creation through grid-based MIDI controllers, which are interfaces that must be connected to a computer to interact with music software. "Controllerism"[31] as a movement was born, and commercial controllers such as the Novation Launchpad[32], Akai APC40[33], and the Monome[34] became popular. Touch surfaces have also become fairly accessible and several artists have integrated touch display tangible sequencers like the reacTable[35], and Lemur[36] into their musical rigs (Arar 2013).

[29] Digital audio workstation and music sequencer used for studio work and live performance. Available at: https://www.ableton.com/en/live/
[30] Digital Audio Workstation application developed originally by C-Lab/Emagic. It became an Apple product in 2002.
Available at: http://www.apple.com/logic-pro/
[31] The practice of making music using software controllers.
[32] Available at: https://us.novationmusic.com/launch/launchpad#
[33] Available at: http://www.akaipro.com/product/apc40
[34] Available at: http://monome.org
[35] ReacTable website: http://reactable.com
[36] Lemur website: https://liine.net/en/products/lemur/

In the last two decades, sequencers have also appeared in contemporary art. Tim Hawkinson's "Uberorgan" was a massive sound sculpture which consisted of thirteen large bags inflated by tubular ducts, triggered by a sensor that read a continuous sheet of marked paper. Trimpin's "Sheng High" was another sound installation that used water pressure to push air through thirty bamboo pipes. This installation also incorporated a wall scanner through infrared sensors that read patterns created with recycled CDs (Arar 2013). Finally, Mo H Zareei's "Rasper" and "Rippler" are mechatronic sound-sculptures which can be used for performance or as an autonomous installation because of their functionality around micro-controller programming, which combines the essential concepts of music sequencing applied through programming languages (Zareei, Carnegie, and Kapur 2014; Zareei et al. 2015).

Music sequencers present an intuitive approach to organize and modify music, and they have had a considerable impact in contemporary music composition, production, and performance. With technology moving forward, and artists attempting to incorporate innovative and expressive interfaces into their music, evidence suggests that music sequencer proficiency is essential for professional and aspiring musicians.

Following the Backward Design model described in Section 2.2.1, the desired results were defined as students being able to:

- Identify different hardware and software sequencers and their main parts
- Program basic musical patterns, including beats and melodies, at different tempo settings and time signatures
- Control and manipulate sequencer sounds and samples
- Perform simple compositions using a sequencer
- Perform with sequencers in a small ensemble setting

These learning outcomes focused on understanding and instrumental dexterity, and they were aligned with the expectations from a student who is learning a traditional musical instrument. Additionally, these outcomes were aligned with common standard and benchmarks in music curriculums at various levels through the development of core musicianship skills and ear training. Figure 23 shows that this was the first step–identifying desired results–applied to the Backward Design model illustrated in Figure 8.

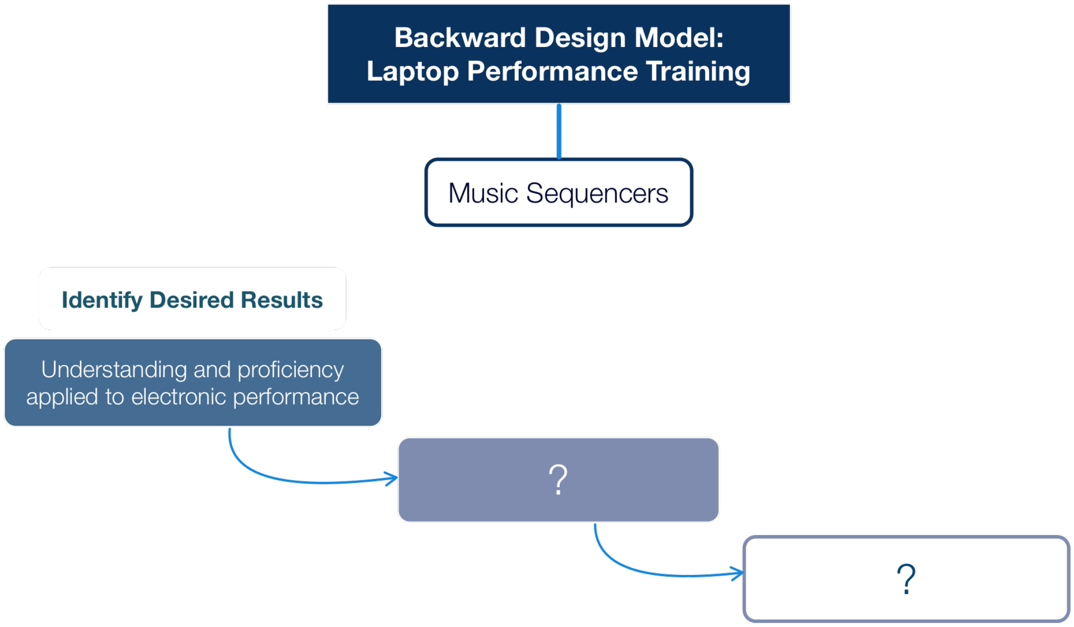

Figure 23: Laptop Performance Training, Identify Desired Results

During this planning stage, it was also essential to consider possible complications and teaching considerations. One of the main challenges was that software and hardware sequencers are expensive interfaces, with price points of $100 and up, which can be discouraging for aspiring artists who are interested in electronic music but who do not necessarily want to do this at a professional level. Furthermore, sequencers are hardly ever the only piece of gear in a performer's rig, which increases the cost of making electronic music considerably. Creating and developing an inexpensive and user-friendly musical interface became a priority to make sure students had access to an instrument for practicing purposes.

The "P5 sequencer", an online browser-based music sequencer, was developed as an example of electronic instrument with a focus on smooth and effective learning. This instance of software instrument did not require any previous purchases, and it was easily accessible from any computer connected to the internet.

3.3.2 The P5 Sequencer as a Learning Interface

Designing an instrument for this particular scenario required the right tools. The main goals were to make instruction easier while empowering young artists to create interesting music without feeling restricted. Using any type of hardware would have made it hard to replicate and distribute the instrument; on the other hand, using stand-alone applications of any sort would have probably been intrusive, and would have required additional steps such as downloading and installing supplementary software, which tends to be enough to discourage inexperienced users.

Using the internet as a means to provide access to the learning tools was a good option, because students only needed to know how to use a browser. Considering that the average student is already familiar with the vocabulary and gestures used for internet navigation nowadays, common actions such as clicking, dragging, and interpreting visual cues or alerts, could be used to simplify the complex processes that come with learning a new musical interface.

For audio generation, the Web Audio API[37] was considered ideal to facilitate working with common audio processing techniques through an audio context. Although programming and sound design elements are essential in music technology education, having students work with the Web Audio API directly would not have been a good choice, since these skills were beyond the scope of this particular learning progression. This did, however, present an interesting avenue for future work.

Finding a way to provide a proper learning tool without getting students sidetracked by the need to learn a great amount of supplementary skills was still the main concern. It was clear that a simple graphical user interface was going to be the best avenue to take advantage of the Web Audio. Various frameworks and libraries were considered as potential design tools, including: (1) Web Audio API eXtension (WAAX)[38]; (2) Gibber[39]; and (3) EarSketch[40].

Gibber and EarSketch had been developed for text-based programming skills, which went back to students having to go through additional learning processes before focusing on the sequencer as an electronic instrument. On the other hand, WAAX made it easy to access the Web Audio API while providing user interface elements with controls and visualizers commonly found in electronic instruments, as seen in Figure 24. So far, WAAX seemed to be the most appropriate tool for a browser-based interface.

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[37] A high-level JavaScript application programming interface (API) for audio synthesis and processing in web applications.
Documentation available at: https://webaudio.github.io/web-audio-api/

[38] Project page available at: http://hoch.github.io/WAAX/

[39] Project page available at: http://charlie-roberts.com/gibber/gibber-lib-js/

[40] Project page available at: http://earsketch.gatech.edu/landing/

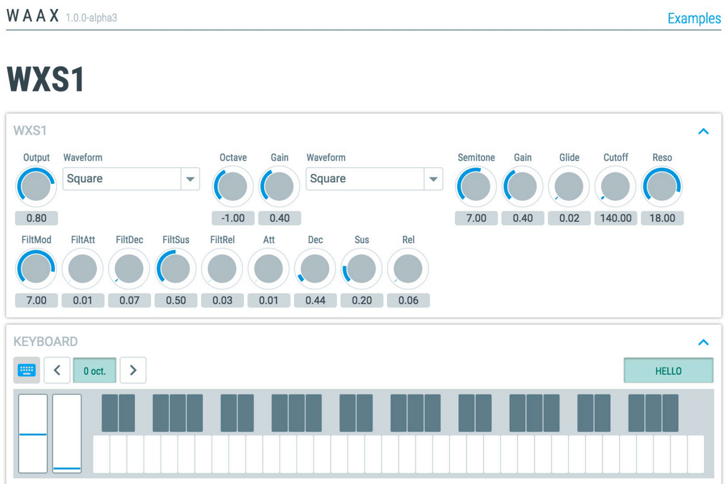

Figure 24: Custom User Interface Layout in WAAX

After the initial research, and developing a few basic web instruments on WAAX for approximately two months, it was apparent that the user interface controls, called MUI Elements, were convenient from a programmatic standpoint. Early trials with a few students determined that it was easy for them to figure out how a simple web-based instrument worked through these visual controls. However, additional testing determined that there were certain gaps and limitations; many audio objects and visual controls could not be connected properly, and several commands did not seem to work anymore. A brief conversation with Hongchan Choi, the creator of WAAX, determined that its development was currently on standby. As nice as it would have been to work with the features that WAAX had to offer, the future of the framework was up in the air, and thus it was decided to consider other alternatives.

P5.js [41] is a JavaScript library created by Lauren McCarthy and supported by the Processing foundation (McCarthy, Reas, and Fry 2015). Although it was developed for visuals on the web, additional libraries make it very easy to access HTML5 objects, including Web Audio. Just like in Processing, the popular Java framework for creative coding in which P5.js was inspired (Reas and Fry 2014), keyboard and mouse interaction could be used in conjunction with robust drawing routines to facilitate the design of custom user interfaces and other visualizations. The P5.dom library offered many ways to interact directly with elements on the page via the standardized HTML5 Document Object Model (DOM), while the P5.sound library made it possible to include web audio elements.

[41] Project page available at: https://p5js.org

The P5 Sequencer's graphical user interface (GUI) was designed to be clear and easily understandable. In order to allow beginners with little prior experience to focus on the sequencer itself and the fundamental performance concepts, it was important to provide a platform for them to make music without having to worry about any programming or design prerequisites. This is why the core of the instrument was limited to the most basic elements found in hardware sequencers. A few additional features were added or refined after selecting a group of students for a user study, and as the development of the educational experience began.

Figure 25 shows the final user interface, which was one of many iterations throughout the design process. The goal of the P5 Sequencer was to illustrate how sequencers work and to allow the user to relate to already existing interfaces; which is why the main concern was to keep the feel of the online instrument as close as possible to the sequencers that inspired it, such as the Arturia BeatStep[42] and the Korg Volca[43] family. Adding new interesting or unique features would have detracted from the project because they are not found in commercially available sequencers.

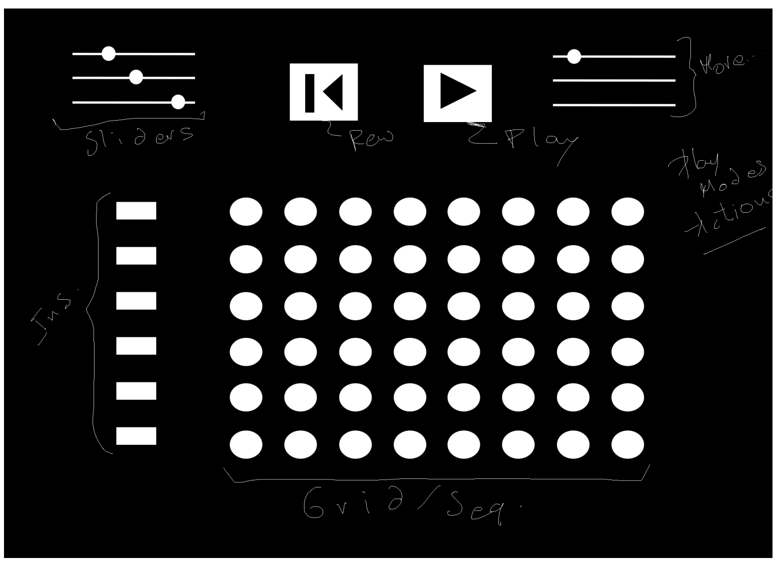

Figure 25: P5 Sequencer – Designing the GUI

The controls and the interactive elements also required careful thought to avoid confusing or overwhelming the user. Moreover, the students who were going to be using this did not have much experience in the subject, so it was very important to encourage best practices and reinforce key concepts through the GUI and user interaction.

[42] Available at: https://www.arturia.com/products/hybrid-synths/beatstep
[43] Available at: http://i.korg.com/volcaseries

Using common sequencer layouts and utilizing common human-computer interaction metaphors was extremely helpful. Visual cues, triggers and familiar computer interface components helped users understand that they could interact with a button or a menu, and determine if the different parts of the instrument were currently active. This reinforced the idea of using familiar knowledge to accelerate learning.

3.3.3 The P5 Sequencer as an Instrument

The P5 Sequencer's GUI, as seen in Figure 26, utilized a common visual layout found in numerous hardware and software sequencers. Its similar functionality and controls were designed to make it easy for students to transition to other commonly found sequencers.

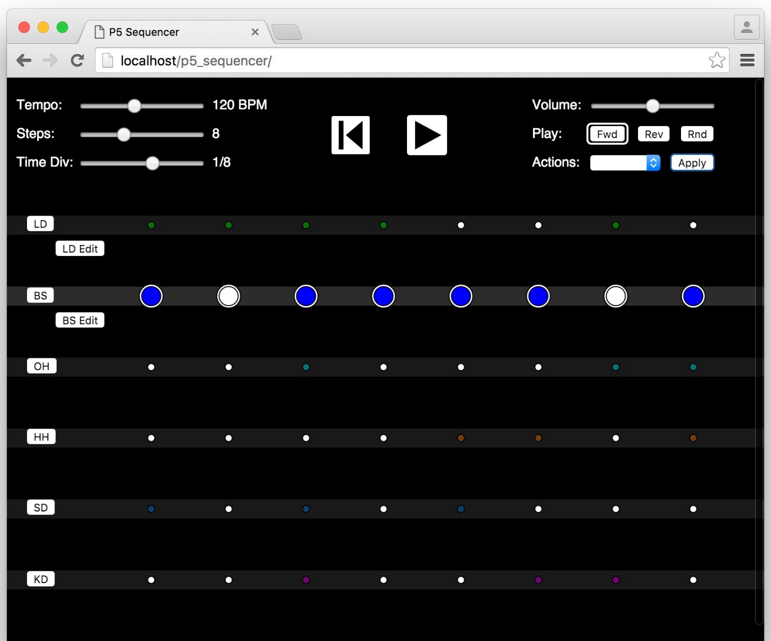

Figure 26: The P5 Sequencer – Graphical User Interface

The main area consisted of a group of six step sequencers controlling different sounds, each with its own controls to allow the user to interact with the instrument. Each group represented a few of the core sounds frequently found in contemporary music: lead, bass, and various drums.

Additionally, these instrumental groups were flexible, and could be changed using the Tempo, Steps and Time Division sliders found at the top, which determined the speed and length of the programmed beats, melodies and grooves.

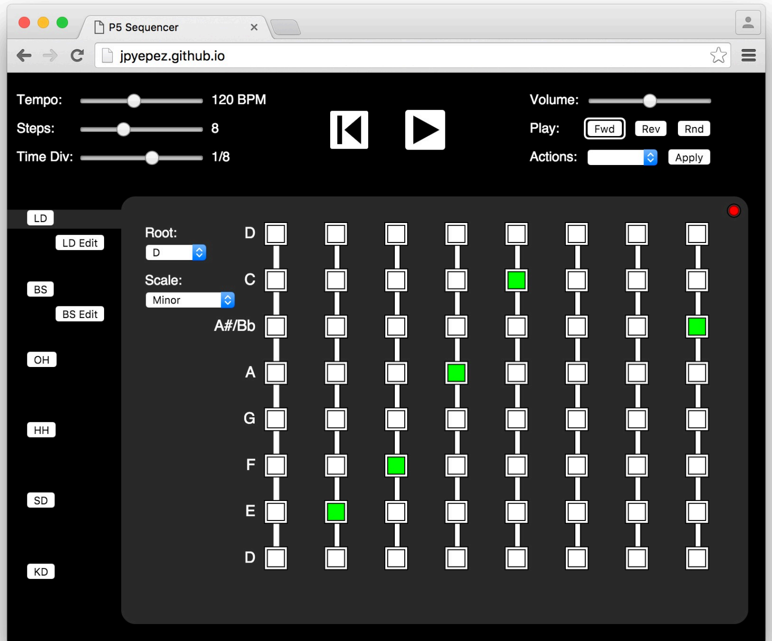

Figure 27: The P5 Sequencer – Melody and Bass Editor

The lead and bass sequencers were not limited to rhythms, and a melodic editor allowed the user to program unique pitches for each step. As seen in Figure 27, the melodic editor used a grid layout to facilitate note selection while maintaining the horizontal rhythmic steps. Further melody adjustment could be done through the dropdown menus to change the current key and scale.

Basic playback controls were also present, such as the play and rewind buttons, and the volume slider. These were an important part of the instrument because they allowed students to have additional options while performing in real-time. A few advanced controls were also included to enhance the instrumental experience, including reverse and random playback, and the option to completely randomize or clear the step sequencers.

With the flexibility that P5.js offered, it was appealing to try to add features and functionality to make the instrument more interesting, but as a learning tool it was necessary to prioritize a simple and clear interface to reinforce student understanding and better lesson design. Features like velocity, probability, presets, and external tempo sync with other sequencers or devices would be an interesting area to explore in the future.

3.4 Summary

Laptops are valuable instructional tools. They can enhance and accelerate learning by making a large amount of materials available and facilitating communications between teachers and students. Many countries are already implementing ways to provide computer access to students at various levels.

Laptop orchestras have a unique configuration and function, which consists of meta-instruments used in many contexts; and they have become an exciting environment to explore new types of composition and performance in all styles of music. This has led computer musicians to constantly try to find an artistic approach to interface with the laptop, including software interfaces and other forms of external controllers.

Nowadays, music technology curriculums are considerably small and very limited, mostly restricted to studio and sound engineering work. This leaves gaps between music theory learning and the practical material being taught, and it also causes students to miss out on many opportunities to develop 21st century skills through performance and creation. It is important to redesign these music programs to transform contemporary music education.

The Laptop Performance Training for Young Artists user study was designed to demonstrate an electronic ensemble model applied to a music technology classroom. Implementation began with the first stage of Backward Design–determining the desired results–applied to the study of music sequencers. This chapter also presented the "P5 Sequencer", a practical tool designed to facilitate learning of relevant skills and concepts in sequencers and drum machines, and to enable immediate application through ensemble performance. This first step established clear goals and expectations for student learning, which were essential to move on the next stages of Backward Design. The following chapter details how this understanding enabled integration of these curriculum design processes and effective teaching strategies, aligned with constructivist and connectivist philosophies.

Chapter 4

Redesigning Education in Music Technology

4.1 The Purpose of Digital Arts Education

There are many reasons for educational institutions to include a solid digital arts program in their curriculum. Practicing art itself is important, but the skill sets developed by the students can be both practical and immediately applicable to real life scenarios that require problem-solving, teamwork, and critical thinking.

In this chapter we are going to explore the value of skills-based education and active learning philosophies as the backbone of authentic and meaningful student growth. We will take a closer look at the actual design and the reason to incorporate each pedagogical element.

4.1.1 Ensemble Performance and 21st Century Skills

In 2007, P21, the Partnership for 21st Century Learning, developed and published the Framework for 21st Century Learning in a collaboration with teachers and education experts[44]. As shown in Figure 28, this framework illustrates essential student outcomes as the arches of a rainbow, which are skills, concepts and competences that should be mastered for student success. It also represents the main support systems as pools at the bottom, which reinforce development and mastery of 21st century skills.

[44] Article available at: http://www.p21.org/component/content/article/2-publications/1020-artsmapresources

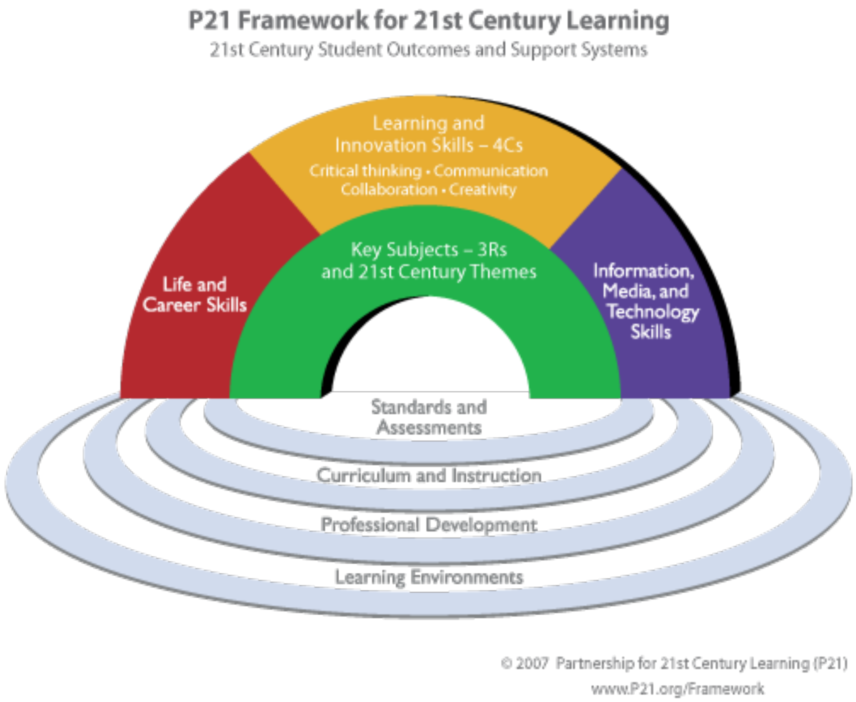

Figure 28: P21's Framework for 21st Century Learning

Additionally, P21 developed an arts skills map, displayed in Table 2[45].

Table 2: P21's Arts Skills Map

21st Century Skills Map		
Critical Thinking and Problem Solving	Information Literacy	Social and Cross-cultural Skills
Communication	Media Literacy	Productivity and Accountability
Collaboration	Information, Communication, and Technology Literacy	Leadership and Responsibility
Creativity	Flexibility and Adaptability	Interdisciplinary Themes
Innovation	Initiative and Self-direction	

Keeping in mind the artistic and pedagogical considerations explored in Chapter 3, it is evident that ensemble performance experiences naturally involve the entirety of the previous arts skills map, and they are also a great strategy to encompass most of the outcomes and support systems in P21's Framework. For example, activities that encourage student ensembles to find the most appropriate interpretation for a particular piece by performing a musical passage using

[45] Resource available at: http://www.p21.org/storage/documents/P21_arts_map_final.pdf

different articulations, are ideal for student discussion and critical thinking. This is a scenario in which they have a chance to use various types of reasoning and solve problems through communication and collaboration. Alternatively, innovation and information literacy can be applied in assignments that ask students to study a particular composer's work or an unfamiliar style of music, and to compose a theme and variations using what they have learned from their research. Electronic ensembles present an opportunity to integrate innovation, interdisciplinary themes, and technology literacy extending these exercises into performance pieces similar to the examples reviewed in 3.2.2 and 3.2.3 (Partnership for 21st Century Skills 2010).

With art as a key subject, education through collaborative music is at the center of the framework; and it is such a complete learning experience that it covers all the other outcomes. The learning and innovation skills, also known as the 4Cs, are particularly important because creativity, critical thinking, communication, and collaboration are at the core of music education. The "Three Artistic Processes" model detailed in (Shuler 2011)–creating, performing, and responding–covers and reinforces these 4Cs through complex activities like improvisation and composition, and by challenging students in settings that demand individual responsibility and shared leadership.

Lastly, the importance of developing a proper curriculum is emphasized by the support systems in the framework, which are aligned with the teaching resources and strategies that have been reviewed throughout this thesis. For example, Backward Design and connectivist approaches are empowered by this framework through 21st century standards, assessments, curriculum, and instruction; and they prepare students for today's digitally and globally interconnected world. Additionally, 21st century skills are developed through active learning and practical learning environments, which aligns with constructivist practices, and encourage music courses to work at the upper levels of Bloom's taxonomy.

4.1.2 The Path to Authentic Learning Experiences

In an effective instructional design process, every element in the learning experience should be considered and carefully planned to help students work toward enduring understanding and independence.

This thesis proposes a learning model that integrates the reviewed curriculum design strategies with constructivist and connectivist processes described earlier in 2.2.3.2. As discussed previously, an authentic learning experience in this scenario requires the student to go through a constructive learning experience and to actively do the learning. The teacher designs the process and provides support as the learner uses connectivist processes to acquire the information and skills needed for problem solving. The resulting knowledge constructs and networks developed by the student are the ones that lead to authentic learning. This learning model is visualized in Figure 29.

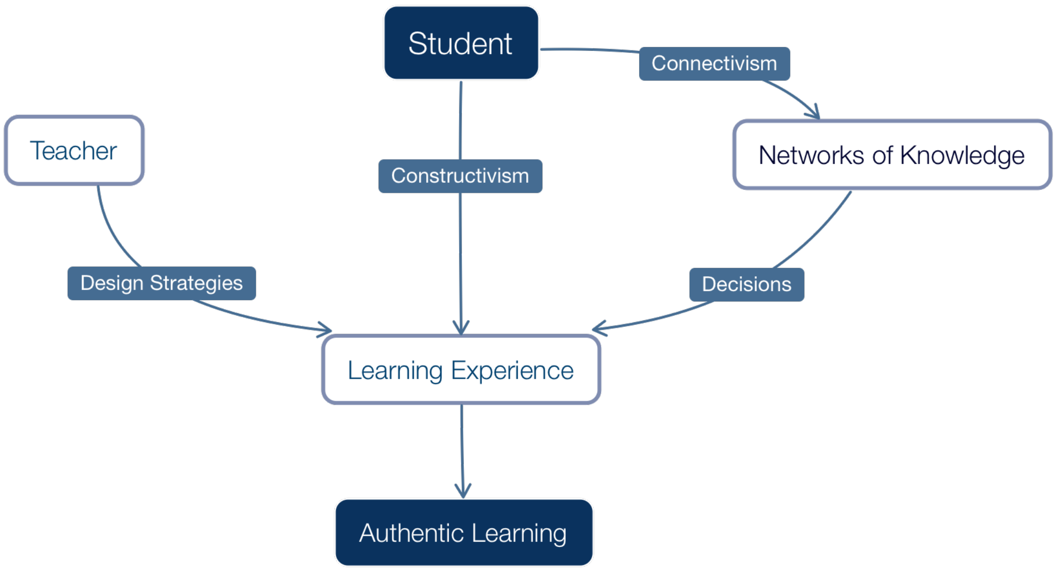

Figure 29: Complete Learning Model

When designing a constructive process, it is important to remember that constructed knowledge is unlikely to occur in isolation. (Barron 2007) draws on the ideas of Jackie Wiggins, who affirms that constructed knowledge and developed understanding happen "as a result of interaction between teacher and students and also as a result of interaction among students". Constructivist programs are built around situations that are:

- Real-life, problem-solving opportunities
- Holistic in nature
- Ideal to interact with the subject matter
- Active experiences
- Opportunities to work independently, with a team, or with an instructor as needed
- Oriented towards a clear goal

Electronic ensembles offer such opportunities by allowing students to play the roles of composer, designer, teacher, and performer. When first joining an ensemble they start as beginners, and as they acquire experience, they develop more complex knowledge structures and skills that will eventually turn them into experts. For example, it is not unusual for laptop orchestras to put together members who are just learning to make music and members who are capable of designing or building a new performance interface. They are powerful learning environments because they benefit from developmental learning and expert-novice differences. (Shuell 1990) describes meaningful cognitive learning as an active, constructive and cumulative process that occurs gradually. Knowledge acquisition is achieved through clear goals and problem solving, and it is not an additive process due to qualitative and quantitative changes in what is being learned. Electronic ensembles include complex and interactive practices that lead to gradual construction and accumulation of long-lasting meanings and competences.

4.2 User Study: Laptop Performance Training for Young Artists, Part 2

One of the most important steps in lesson planning and curriculum design is to consider the student population and the learner's background. This allows one to determine how meaningful and relevant the teaching content is, and it also helps organize and plan the lessons according to their previous knowledge and experience.

This section provides information about the selected student groups, and describes stages two and three of the Backward Design process.

4.2.1 The Selected Study Group: Saturday Music at CalArts CAP

The Community Arts Partnership (CAP) at CalArts is an educational initiative based in public schools and communities across Los Angeles. Their goal is to offer free art education to children ages 6-18, while providing CalArts students with a chance to work and acquire valuable teaching experience. CAP participants have access to every discipline taught at CalArts, and they learn how to create and showcase their original work from accomplished CalArts community members.[46]

The CAP Saturday Music program provides valuable music learning experiences at the CalArts campus. Offered courses include private instrumental lessons, ensembles, music theory,

[46] Available at https://www.calarts.edu/cap.

composition, music technology and production, and world music. CAP students have a chance to participate in big projects like performances, recordings, and a concert at the end of the school year.

Children enrolled in the music technology courses were between the ages of 12-17, and they all had previous experience in instrumental performance and music theory. A few of them were also familiar with songwriting, composition and other forms of art like acting and film. The whole group had a handle on basic computer skills, and a great majority acknowledged to have access to a computer and internet at home. However, only two or three students had music software such as Ableton Live and GarageBand installed on their computer. Considering their age ranges and skill level, it was highly unlikely for parents to be willing to invest in expensive DAWs, software instruments, or libraries, even if they could afford them.

This study consisted of two groups of 13-15 CAP students in the Music Technology and Production courses at Saturday Music. The students attended one 60-minute-long session every week throughout the spring cycle, which ran for approximately 3 months. The goal of the user study was to effectively demonstrate what a module with a focus in electronic ensemble performance would look like. Furthermore, this user study was interested in determining the value of the teaching model through continuous observation and assessment.

These groups of students were selected for the user study because they belonged to a sample of young artists with a high level of interest in electronic music and production, and who would benefit considerably from affordable and accessible music technology curriculums and tools. Appendix A shows the document submitted for project approval.

4.2.2 Complex Assessment as a Planning Instrument

After explicitly going through the desired outcomes, the Backward Design model moves on to defining what would be acceptable evidence of learning (G. P. Wiggins and McTighe 2005). In this case, this was done through observation and evaluation of specific behaviors and skills directly related to the results in the first stage (3.3.1). Acceptable evidence of learning was found in students who displayed:

- Fluent and conscious use of vocabulary related to the relevant topics on sequencers, music technology and music theory.
- Quick and efficient operation of the P5 sequencer controls to make music.

- Proficiency in the use of the step sequencers and melody editors to create grooves in different time signatures, tempo speeds and scales.
- Ability to create a performance in an ensemble setting by communicating, composing and improvising with their peers.

Observation and monitoring were extremely helpful throughout the learning process to guide students towards the established goals, but as mentioned in Section 2.2.1, it was important to use specific assessments to determine growth in particular areas. A complex and thorough assessment process provided a clear picture of student progress.

Moving on with the implementation of the Backward Design process initially shown in Figure 8, Figure 30 builds on the expected results from Figure 23 (Section 3.3.1).

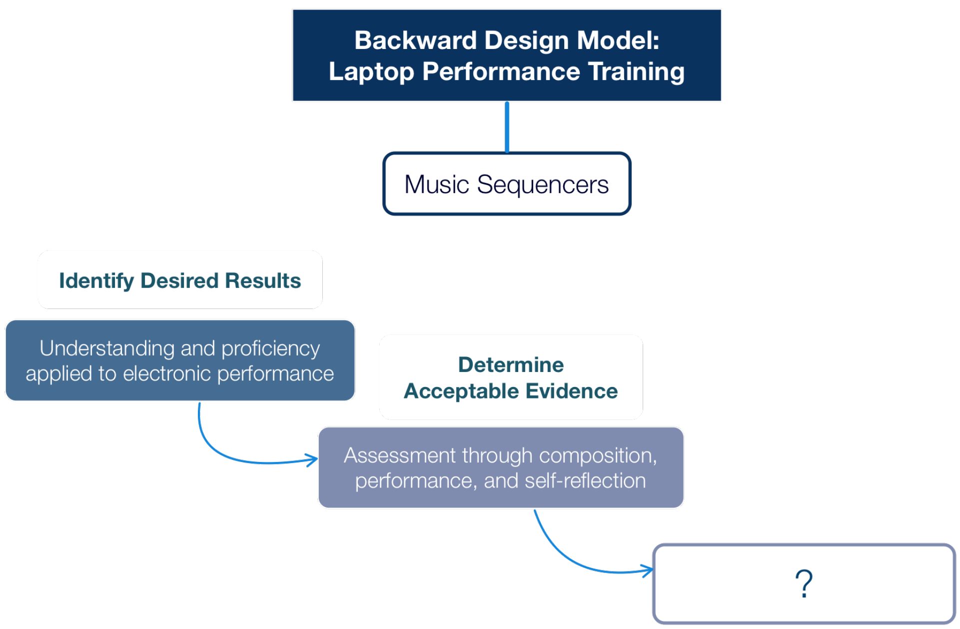

Figure 30: Laptop Performance Training, Determining Acceptable Evidence

The evaluation model used in this study measured basic knowledge and understanding about relevant vocabulary and concepts through quizzes. Real-life performance scenarios were used to evaluate enduring understandings in performance-oriented skills. Students first had a chance to use the online sequencer in an ensemble rehearsal to compose a piece. The next scenario allowed them to perform and record their piece. Both activities were done in front of the rest of the class as an audience to develop performance skills, and to include discussion and critique in the assessment process.

Finally, a supplementary survey was used alongside the quiz to encourage students to reflect on what they had learned and to collect data about the research process itself. This part was completely optional, and it was meant to determine if students considered that this hands-on learning model was more helpful than traditional classroom techniques.

4.2.3 A Practical Approach to Electronic Ensemble Music

Understanding what is expected from the students allows an instructor to be more effective when organizing and designing the learning progression. Finding the best way to teach the selected content is always a challenge, but computers and electronic ensemble performance can simplify this by allowing students to be more involved in their own learning.

4.2.3.1 Applied Lesson Design

Considering that there were 15 to 20 students in the same classroom but only three or four available laptops, it was imperative to find a way for them to work on the online sequencer while avoiding idle periods for most of the class. The learning activities emphasized constructivism practices by having students go over the material independently, as they experimented and got used to the new instrument.

Figure 31 shows the third and final step in the curriculum design process that began with Figure 23 and Figure 30, and concludes implementation of Backward Design (Figure 8) applied to music sequencers.

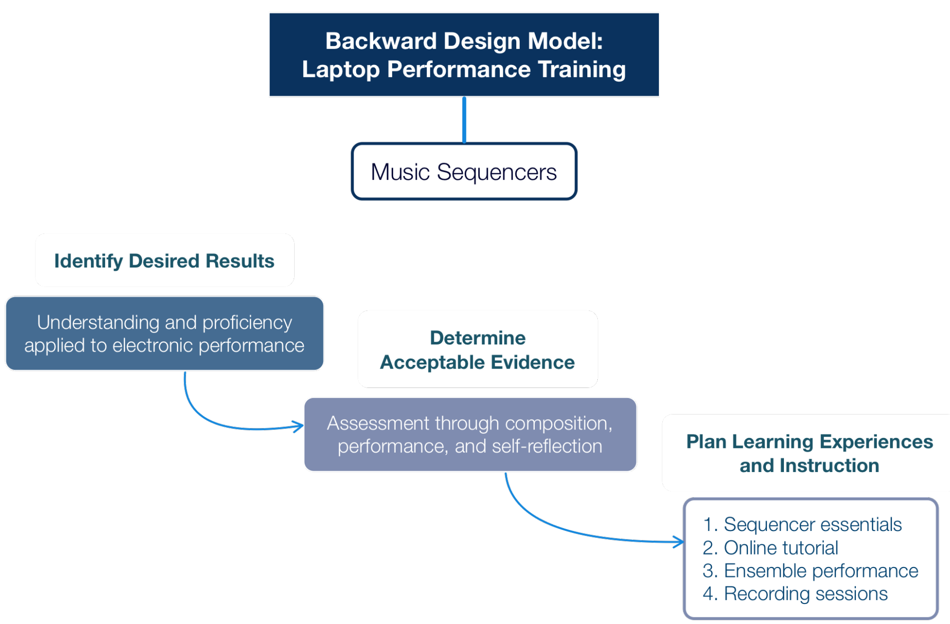

Figure 31: Laptop Performance Training, Planning Learning Experiences and Instruction

The set of lessons began with a brief lecture and demonstration on sequencer essentials, in which students had a chance to get familiar with the most basic concepts. Next, they worked on an online tutorial in small groups, which later became their performance ensembles. This tutorial introduced the fundamental functionality and skills required to play the online sequencer, and it allowed them to learn in an interactive environment while going back and forth through the content as needed. This workflow was meant to encourage everyone to stay on task while reinforcing integration between team members. Finally, they moved on to the performance tasks to get started with electronic performance, and to go through the assessment processes. These assessments, mentioned in Section 4.2.2 measured their understanding and proficiency in sequencers through quizzes and ensemble work, and their perception of the learning experience with a short survey.

The proposed music technology education model builds upon constructivism by using practical tasks, interaction, and previous experience (Ertmer and Newby 1993); it also integrates connectivism through the design of learning environments, and encouraging students to acquire new, dynamic, and ever-changing knowledge and skills (Siemens 2014).

4.2.3.2 The Tutorial as a Creative Teaching Tool

There was no reason to stick to traditional teaching practices and tools if the main motivation of this research was to find creative solutions to conventional problems. The *P5 Sequencer Online Tutorial* was designed as one of such creative tools. As seen in Figure 32 and Figure 33, it was designed as a prototype to model the experience of studying using an interactive interface. By using a mix of direct instruction and controlled interaction students were able to learn actively and go through the content at a comfortable rate. This went back to the idea of computers simplifying classroom management and differentiated learning.

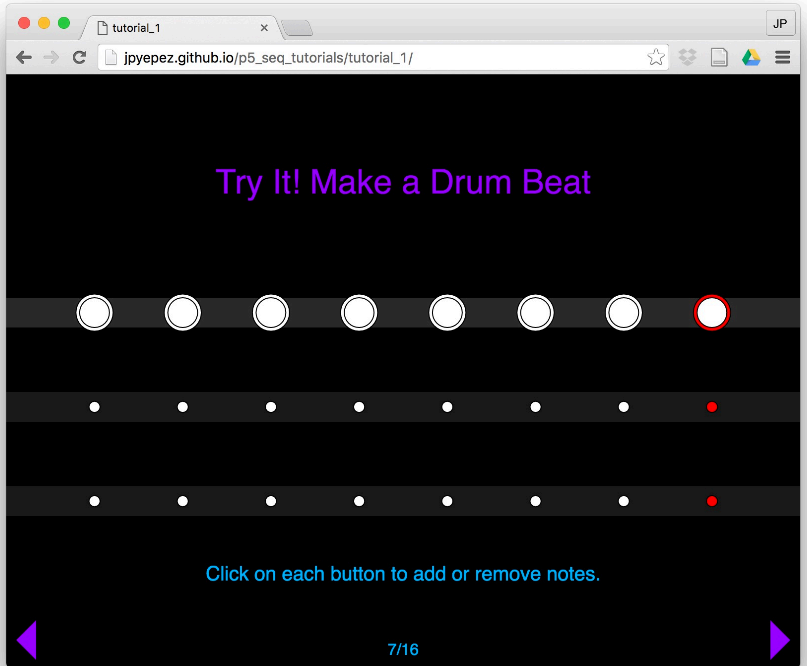

Figure 32: P5 Sequencer Online Tutorial 1

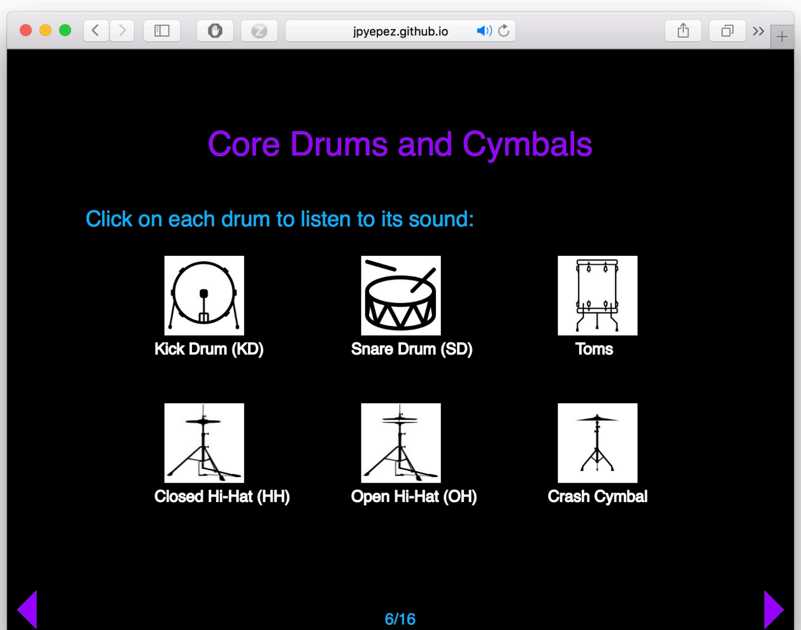

Figure 33: P5 Sequencer Online Tutorial 2

The main goal was to get students to use the newly acquired knowledge and skills to create their own small ensemble performance, so it was important for them to spend some time with the instrument and explore its rhythmic and melodic possibilities. This process integrated musical knowledge and technique much like in traditional instruments, but it was strictly centered around immediate application and creation.

The online sequencer was developed considering a learning progression focused on higher-order thinking and advanced skills and abilities (Figure 34). As demonstrated in the figure, the proposed model started on understanding and application as a baseline, but immediately moved on to a creative environment. The "P5 Sequencer" and tutorials introduced a practical method to develop essential music concepts, instrumental knowledge, and instrumental technique, with the objective of reinforcing ensemble performance.

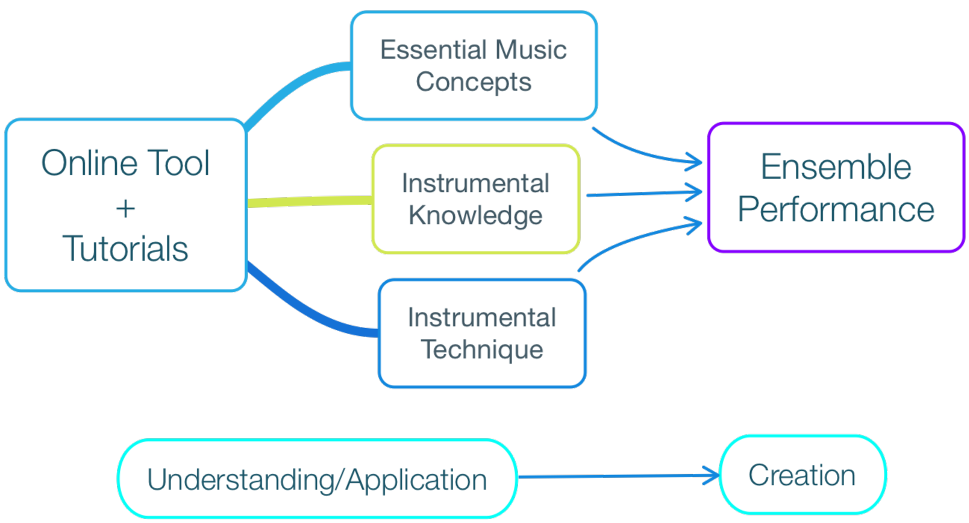

Figure 34: Laptop Performance Training – The Learning Process

4.3 Summary

Digital arts education includes 21st century learning at its core by focusing on the development of the essential skills that are currently needed for success in today's global society and workforce. Collaborative music experiences are one of the most complex and challenging environments in art because they encourage students to engage in creative processes while using teamwork and leadership strategies to work with their peers. These experiences directly reinforce the learning and innovation skills–critical thinking, communication, collaboration, and creativity–through higher order thinking.

This thesis posits that students in an electronic music ensemble can achieve real and meaningful learning through constructivist experiences while engaging in connectivist processes. By playing essential creative roles in problem-solving situations, they can build on their previous experience and create connections to the newly acquired knowledge. This section went over the *Laptop Performance Training for Young Artists* user study, where young students were able to experience this first-hand as they put together an original performance for a sequencer ensemble. Chapter 5 will focus on the execution of the project, the collected data, and the analysis of the evaluation results.

Chapter 5

Evaluation

5.1 The Importance of Assessment

Teaching is not a unidirectional process. Experienced instructors understand that monitoring the learning progress constantly can greatly enhance teaching by allowing them to build on students' strengths or reinforcing concepts that are not clear. The notion of assessment as a tool to be applied at the end of the teaching process is a misconception; it is essential to observe student learning at all stages (G. P. Wiggins and McTighe 2005).

This research adopts an assessment approach from (Levy 2008) which can be broken into the following phases:

- Pre-assessment: Simple activities focused on determining current student knowledge.
- Formative Assessment: Periodic checks throughout the teaching process. These are used to monitor student progress and to determine the direction for further instruction.
- Summative Assessment: Critical assessment at the end of the learning process. These are the larger activities used to find out if students learned successfully.

5.2 User Study: Laptop Performance Training for Young Artists, Part 3

The goal of this learning module was to teach students essential concepts and skills in ensemble performance using music sequencers. As mentioned in 4.2.1, both groups consisted of students in a similar age range; Figure 35 shows that Group A included student ages 13-17, while Group B's age range was 12-17, and both groups had their median at 15,

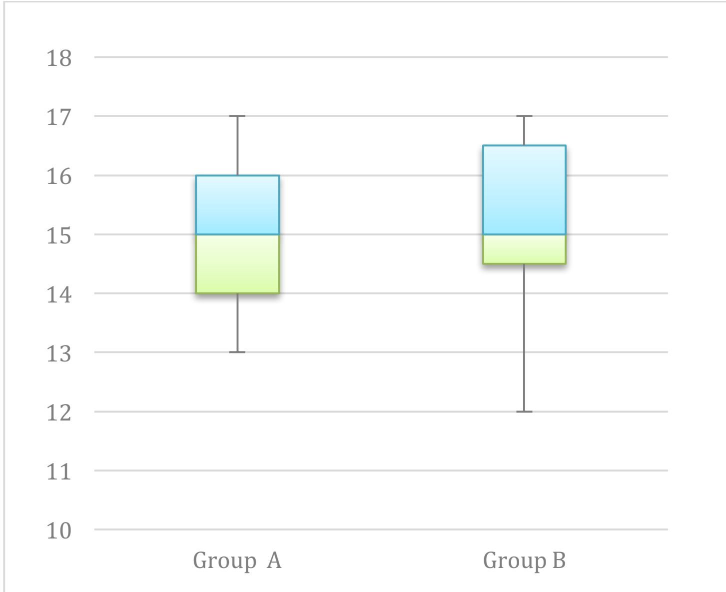

Figure 35: Laptop Performance Training – Group Age Ranges

Group A had an even distribution of students at around the age of 15 with a few 13 and 17 year olds as outliers; Group B's amount of student above and below 15 was balanced, but the older students were closer to the age of 17, and most of the younger ones were around 15, with a single outlier at 12. However, their skill levels and experience were considerably different, which made it important to consider differentiation in the teaching process. To do this, the user study with the selected CAP groups was carried out over the course of four weekly lessons, as seen in Table 3. Group A was slightly larger, but students were not as experienced, so it was important to go over essential music theory in addition to the sequencer essentials during the first lesson. Students in Group B did not need this reinforcement, which gave them more time to practice performance with the online sequencer during the second lesson.

Table 3: Laptop Performance Training – Lesson Overview

	Lesson 1	Lesson 2	Lesson 3	Lesson 4
Group A: **(4 Ensembles)**	Theory Review Sequencer Essentials	Sequencer Examples Online Tutorial	Ensemble Rehearsal Discussion/Critique	Recording Session Discussion/Critique
Group B: **(3 Ensembles)**	Sequencer Essentials Sequencer Examples	Online Tutorial Practice Time	Ensemble Rehearsal Discussion/Critique	Recording Session Discussion/Critique

The *Sequencer Essentials* lessons included pre-assessment activities, while formative assessment was done in *Online Tutorial* and *Ensemble Rehearsal*. To wrap up this short module, the *Ensemble Rehearsal* and *Critique* sections were used as a summative assessment. The ensemble rehearsal and recording lessons were critical since this is where most of the practical learning and formal evaluation procedures were done.

5.2.1 Implementation

As mentioned in the previous section, Group A started with a brief theory review with a heavy emphasis on rhythm. Being familiar with concepts such as tempo, meter, and rhythm figures was extremely important to fully understand how to make music with sequencers.

The *Sequencer Essentials* and *Sequencer Examples* lessons provided an introduction to various types of hardware and software sequencers through direct instruction, and selected video performances. CAP students were used to working in Ableton Live, so they had a chance to make connections between the new material and the electronic software instruments they were already familiar with. This was an effective way to develop learning connections from the start.

5.2.1.1 Tutorial

The tutorial was the most important part of the second lesson for both groups. The students were provided a link to a website with the tutorial and the sequencer (Figure 36). Being web-based addressed one of the primary considerations mentioned in Section 3.3.2, since not having to install additional software allowed students to start immediately. This was one of the main considerations in the teaching process because the model sought to enable the continuous learning and development of skills for the contemporary world, unhindered by any needs to acquire external knowledge,

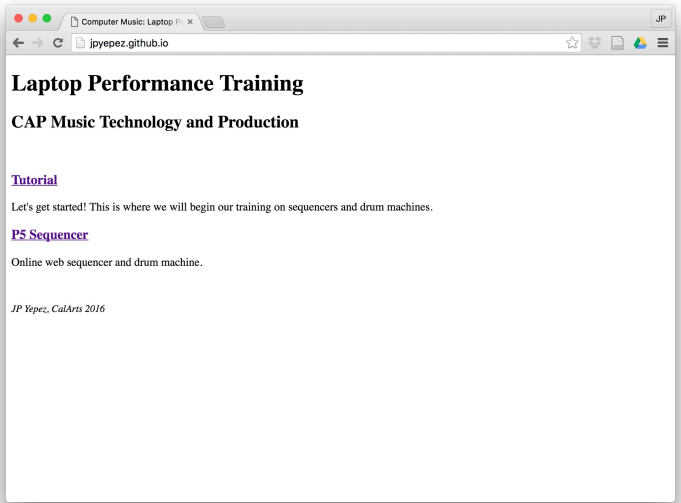

Figure 36: Laptop Performance Training – Main Hub

Students were allowed to select who they wanted to work with, but in certain cases, it was necessary to consolidate student pairs into larger groups due to a reduced number of laptops. They were also instructed to work together and to go over the tutorial contents, which provided essential information about sequencers, and how to play the P5 Sequencer. Students were asked to make sure that everyone in their group had a chance to interact with the tutorial, and they were encouraged to help each other if any group members found any challenges throughout the activities. Once they had completed the tutorial, students could navigate to the sequencer page to start practicing and experimenting on the online sequencer page.

This was a critical stage of the user study because group work is a fundamental element of music making, which has been a collaborative practice by tradition; however, there are also many benefits associated with teamwork in any educational setting. (Burke 2011) goes over six advantages of working in a group:

- Groups have more information and resources than an individual.
- Groups stimulate creativity.
- Group learning and discussions develop learning comprehension.
- Decision-making and problem-solving encourages students to own their work and to take responsibility for their own learning.
- Students understand themselves better.
- Teamwork skills are highly valued in the contemporary world.

(Webb 1982) also weights the benefits of teamwork by observing the presence of helping behaviors. Peer tutoring, mixed levels of ability, and team-oriented rewards have been associated with higher achievement results for students who provide help, and students who directly ask for assistance.

Both Webb and Burke go over the importance of student monitoring throughout group activities because of possible negative practices, such as passive behavior, dominant opinions and personalities from particular students, and children not receiving help when the ask for it.

5.2.1.2 Live performance and recording

The next phase of the user study followed a project-based learning (PBL) structure to reinforce constructivist practices and meaningful learning. PBL is an instructional methodology in which students apply concepts to solve real-world problems in order to produce tangible and concrete projects and artifacts as evidence of learning (Andres 2006).

PBL can be applied in many ways, across any subject, and it involves critical thinking, time management, organizational skills, knowledge application, and self-motivation. According to a study conducted by the Center for Research in Educational Policy in 1999, students who were part of PBL initiatives improved their test scores over a two-year period (Andres 2006).

At this stage, the lessons focused completely on performance tasks and creative ensemble work. The main objective was for students to create a short composition with their group and to play it in front of their classmates. This performance was recorded during the final lesson, and they received a CD with the final version of their pieces at the end of the course, which served as the previously mentioned evidence of learning.

The classroom was arranged to enable group performance in front of the rest of the class, as seen in Figure 37. Each ensemble had approximately 10 minutes to set up, present their piece, and perform it.

Figure 37: Laptop Performance Training – Classroom Layout

The performance and the CD represented a fruitful learning experience in which students had something to show for all their work. Project-based learning bridges the gap between learning and artistic processes by giving students the opportunity to create and share their original material.

5.2.2 Assessment Results

The final step in the thesis project was the evaluation and analysis of the collected data. In order to get a clear picture of the overall learning experience, it was necessary to assess concepts, skills, and the student experience.

To be in accordance with the U.S. Department of Health and Human Services regulations, 45 CFR 46, and with the authorization of the CalArts CAP office, names and personal information were kept confidential throughout the evaluation. Also, assessment result numbers were combined for both groups to better protect their privacy, and students were informed that the participation in the data collection process was completely optional (Office for Human Research Protections 2016). The quiz and survey that were used in the user study are shown in Appendix B.

5.2.2.1 Assessing Concepts

The objective of the first evaluation phase was to assess the overall comprehension and learning of the essential sequencer concepts. A series of open-ended questions were designed to encourage the student to construct responses using what they had learned throughout the lessons. Open-ended questions are commonly employed in academic prompts[47] to measure critical thinking through actions like analyzing, synthesizing and explaining, which are aligned with the constructivist and connectivist philosophies that were adopted throughout the research project. This also made them more useful than simple test items that assess facts and only require the student to recall knowledge (G. P. Wiggins and McTighe 2005). The first set of questions were the following:

1.a) In your own words, explain what a sequencer is.

1.b) How do you usually "play" a sequencer?

1.c) Can you play many sequencers at the same time? If so, how would you do this?

1.d) What is tempo?

1.e) Name a few rhythmic figures that can be used to make a beat.

Figure 38 compares the number of correct and incorrect answers for this section across both groups. Overall, the number of correct student responses in questions 1.a, 1.b, and 1.d exceeded the incorrect ones by a large margin, with percentages of 70% or higher; while the outcome of questions 1.c and 1.e was different, and revealed important information about the children and the learning process.

[47] A structured performance task that challenges the student to create a performance or a product.

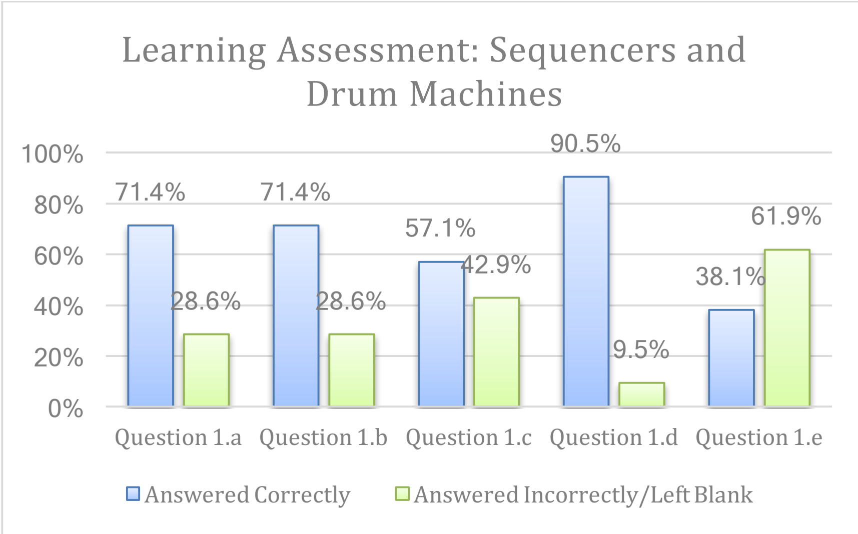

Figure 38: Laptop Performance Training – Learning Assessment Results

Question 1.a (Figure 39) shows that 71% of the students were able to define or explain what a music sequencer is. In general, correct responses included a description of the sequencer as an instrument or a device, and its purpose as a beat-making tool.

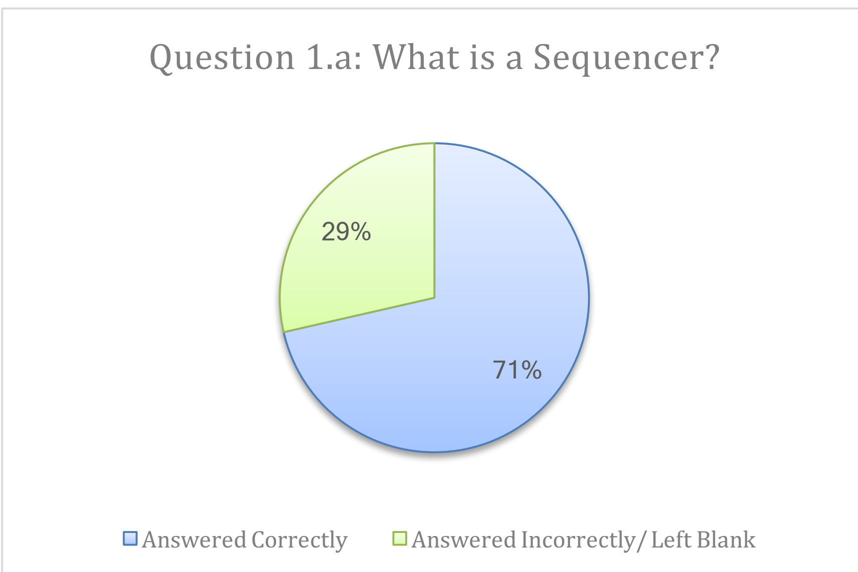

Figure 39: Laptop Performance Training – Learning Assessment 1.a

Question 1.b (Figure 40), also with 71% of correct responses, revealed a critical piece of information. When describing how to play a sequencer, the students specified actions like to "press", "select", "input", or "push", even though what they really did was to interact with a laptop by clicking on a mouse or trackpad. This was evidence of them being able to associate and transfer the newly acquired knowledge from a digital environment to the physical instrument.

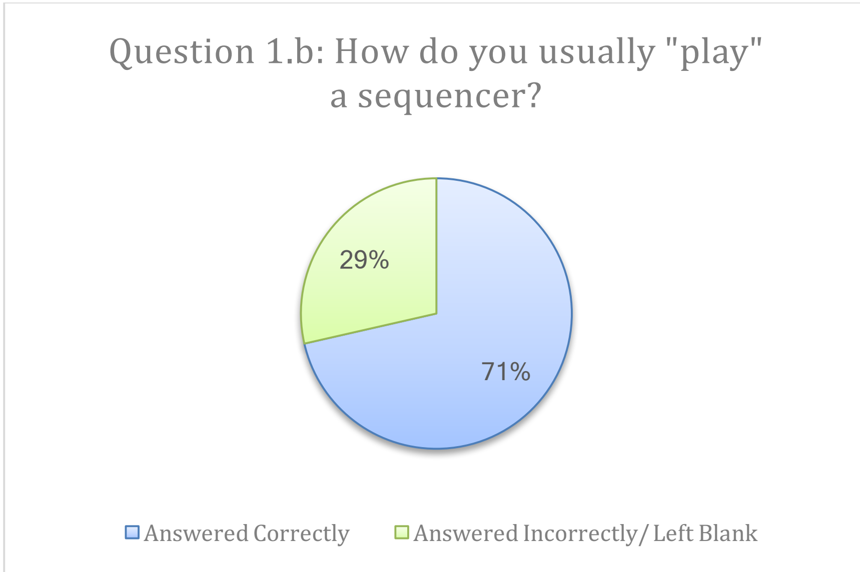

Figure 40: Laptop Performance Training – Learning Assessment 1.b

The objective of question 1.c (Figure 41) was to challenge students to solve a problem–how to play many sequencers at the same time–and to describe how they would do it. Students were free to choose what type of sequencer to focus on, so many of them decided to write about each one of the instruments in the online interface as an individual sequencer; while other students considered creative ways to perform with hardware sequencers or laptops at the same time. The difference between the correct and incorrect responses, 57% to 43%, was smaller than in questions 1.a, 1.b, and 1.d. An important observation was that several students chose to simply write down "yes", "no" or "I don't know", and to ignore the second part of the question. Although it is possible for some students to not have known the right answer, it is important to consider that some of them might not have been comfortable with working on complex or open-ended questions.

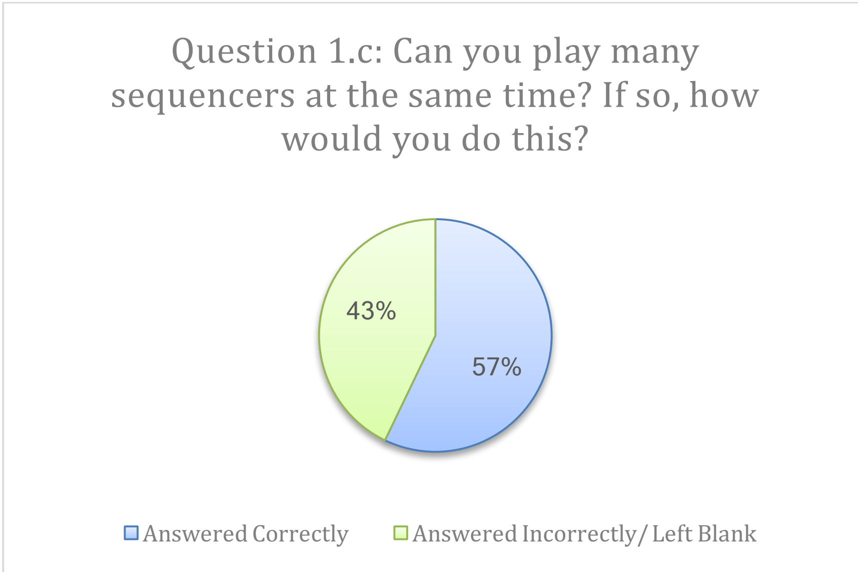

Figure 41: Laptop Performance Training – Learning Assessment 1.c

Figure 42 shows a that 90% of the answers for Question 1.d were correct, and they included key terms like "speed", "fast", "slow", "consistent", "time", "pulse", and "Beats Per Minute (BPM)". These were indicators of development in relevant vocabulary, which was established as acceptable evidence of learning during Backwards Design planning, as detailed in 4.2.2.

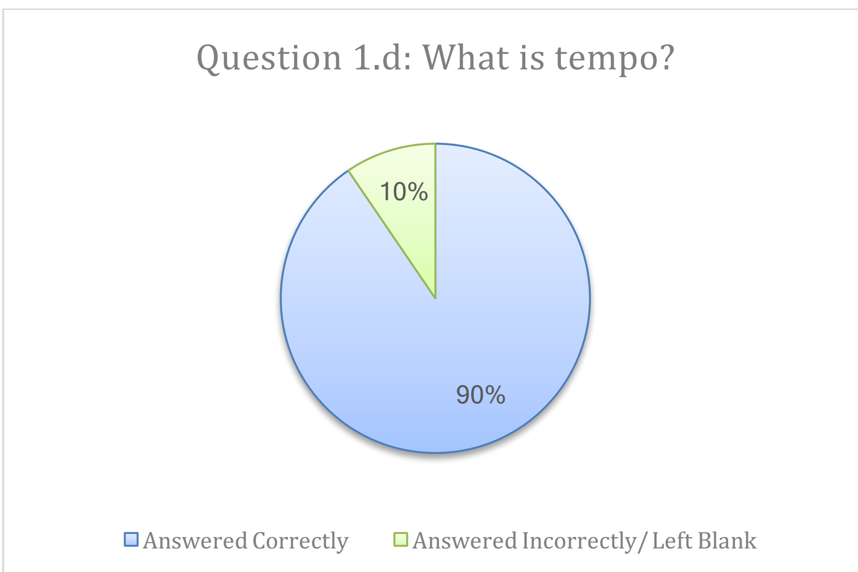

Figure 42: Laptop Performance Training – Learning Assessment 1.d

Finally, question 1.e (Figure 43) shows a large deviation from the rest of the quiz, and only 38% of the students answered correctly. A good number of students had to ask for clarification before answering, and it was clear that either the question, or the concept of a rhythm figure was not completely clear. A 62% of the responses being incorrect or blank called for further investigation from the instructor. Talking to the students made it possible to determine that they had not worked on this topic extensively in other ear training or theory courses, and it needed to be reinforced. This emphasized the importance of assessment as part of the learning process, because it helped to identify a learning weakness that needed to be addressed.

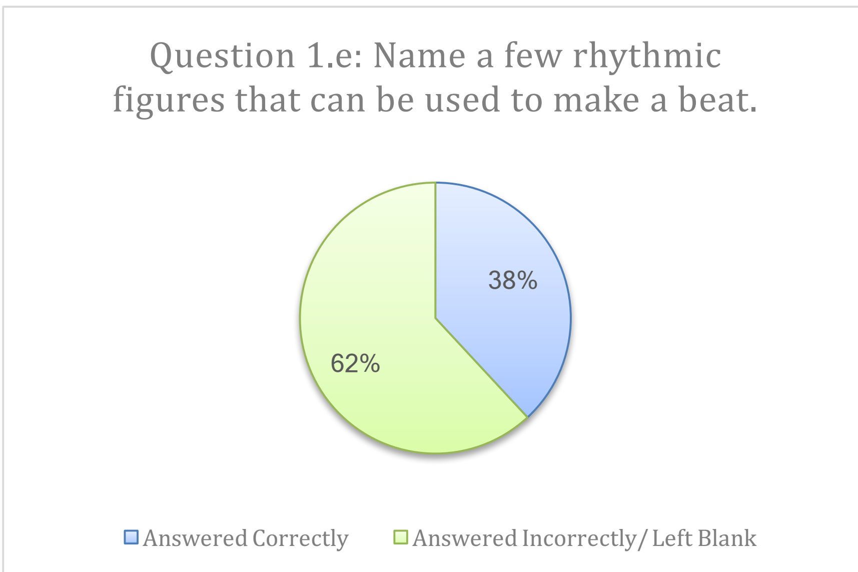

Figure 43: Laptop Performance Training – Learning Assessment 1.e

5.2.2.2 Assessing Students

The second evaluation phase sought to determine if the students felt like the experimental learning process helped them throughout the user study. In this case, the point was not to find correct or incorrect responses, but to determine how students felt about the work they did throughout that month.

To measure this, the students were asked to rate a few statements about the research project following the standardized Likert scale, by providing a quantitative value from 1 to 5 according to their level of disagreement or agreement. The survey items were the following:

2.a) The online lesson was simple and easy to understand.

2.b) The interactive examples were helpful.

2.c) I understand what a sequencer is.

2.d) I understand how to make a basic beat.

2.e) I would like to have access to more laptop instruments.

2.f) I feel like I am skilled enough to make music with the online sequencer.

2.g) I think this type of lessons are better than lectures.

2.h) I enjoyed playing the online sequencer.

2.i) I enjoyed working with my peers to create a performance.

Figure 44 reveals that the overall satisfaction level of students was above "neutral", with the combined positive responses, "agree" and "strongly agree", always being between 52% and 100%. In contrast, responses of "disagree" and "strongly disagree" never exceeded 10%, which shows that they had a high interest in making electronic music in an active environment, and working with their classmates.

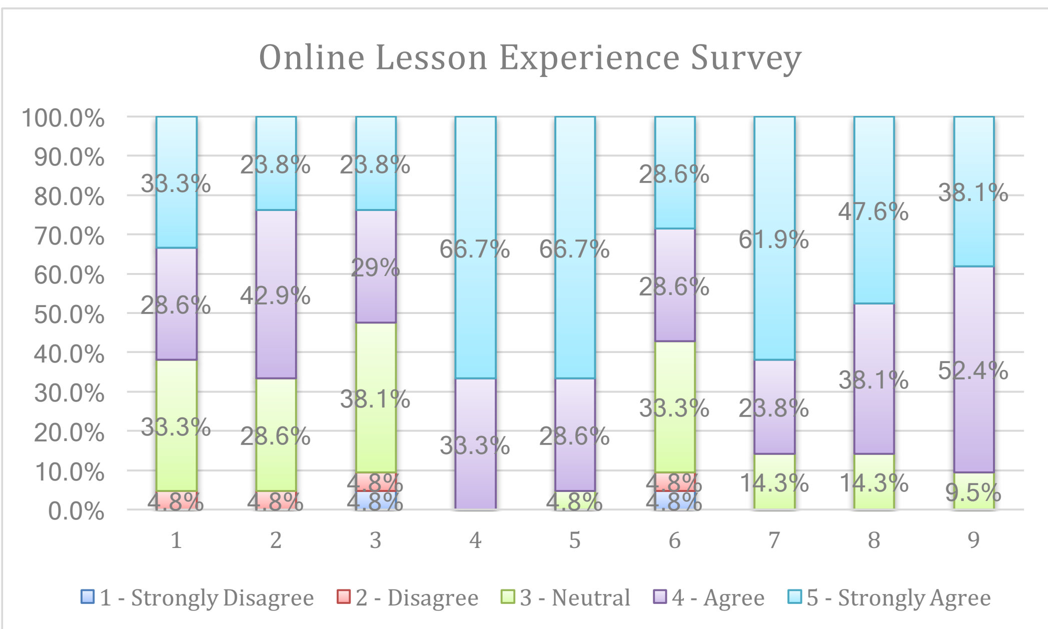

Figure 44: Laptop Performance Training – Student Experience Survey Results

Question 2.a (Figure 45) showed the students' perceived level of difficulty throughout the learning experience. Approximately 67% of them agreed that the online lesson was easy enough to reinforce the learning process, while 28% felt neutral about it. In contrast, 5% of them did not consider that to be the case, and found this learning method challenging, which possibly slowed down their learning.

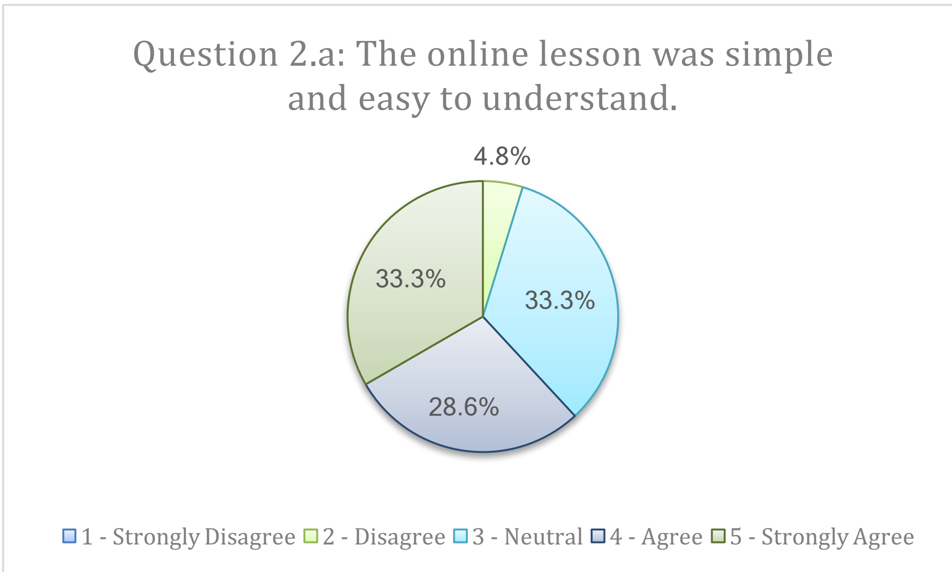

Figure 45: Laptop Performance Training – Student Experience Survey 2.a

Question 2.b (Figure 46) built on the previous one and attempted to determine if the interactive elements helped the students. The results were similar to 2.a (Figure 45) with 67% of the responses being positive, 28% neutral, and 5% negative; but in this case, there was a slight variation in which the positive responses leaned toward "agree" rather than "strongly agree". Also, the 5% in "disagree" aligned with the previous question and revealed that there was a small population of students who did not feel that these learning methods were helping them.

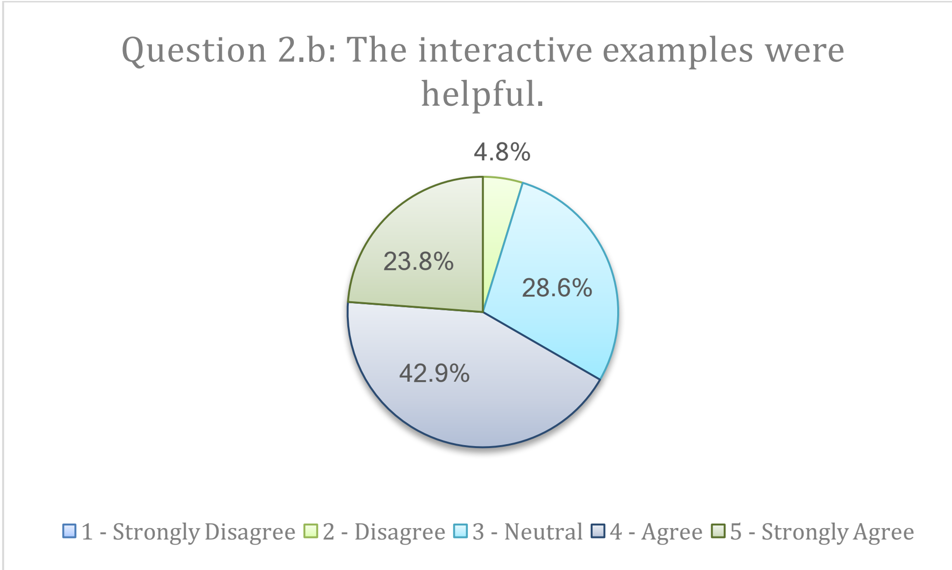

Figure 46: Laptop Performance Training – Student Experience Survey 2.b

The next question, 2.c (Figure 47), attempted to gauge the students' confidence level about the reviewed content. These responses showed that 52% of the students felt confident about what they had learned, while 38% of the them picked "neutral", and did not feel completely confident about their understanding. Finally, the negative responses went up, and 10% of the students maintained that they did not understand what a sequencer was.

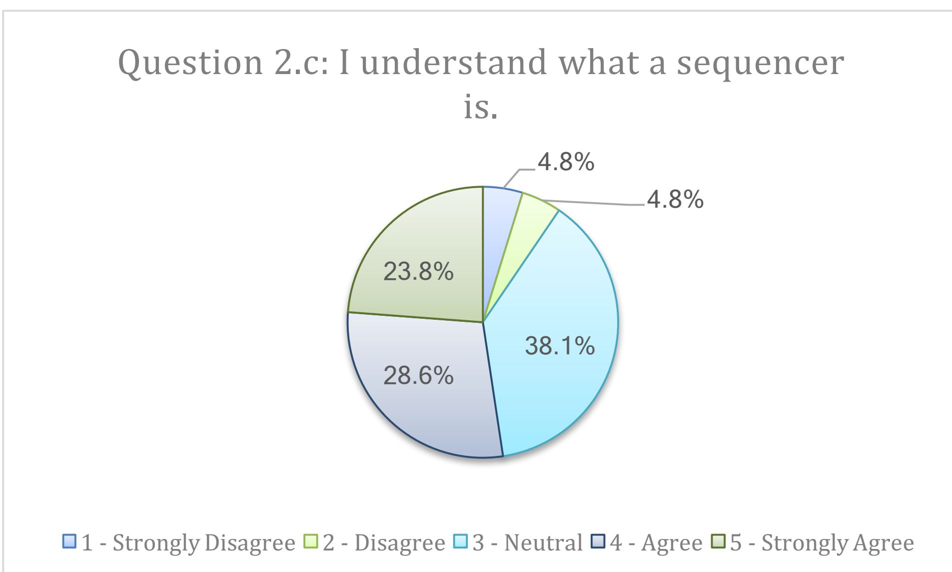

Figure 47: Laptop Performance Training – Student Experience Survey 2.c

The next two questions were characterized by having almost exclusively positive responses. In 2.d (Figure 48), every single student confirmed that they understood how to make a basic beat, with 67% of responses in "strongly agree", and 33% in "agree". This highlighted the importance of previous knowledge and experience, because these higher levels of confidence were reinforced by their previous work in Ableton Live. As a result, they were able to successfully translate music sequencing and beat-making concepts into the new interface.

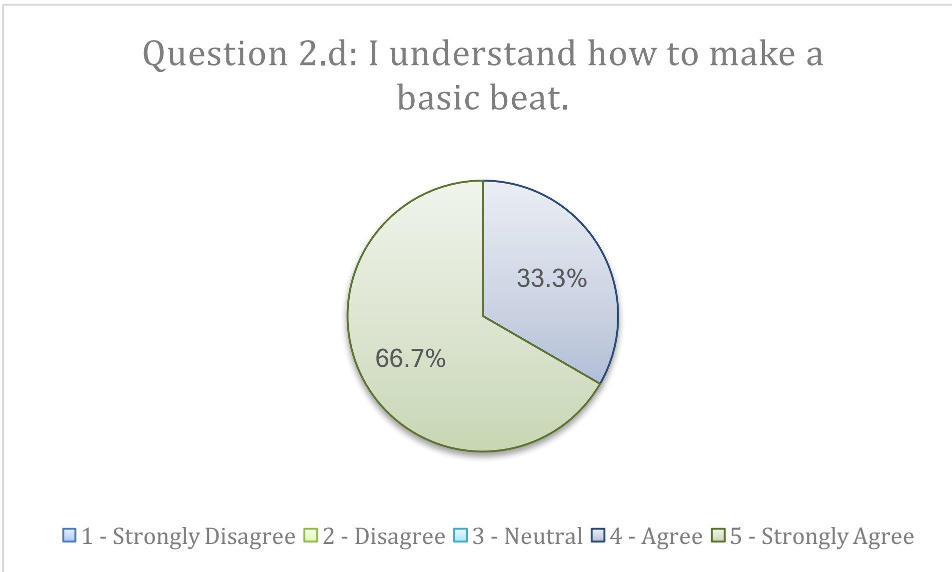

Figure 48: Laptop Performance Training – Student Experience Survey 2.d

Similarly, in 2.e (Figure 49), 95% of students declared that they were interested in exploring additional laptop instruments and interfaces, with 67% having picked "strongly agree" and 28% "agree". In this question, there was a resurgence of the 5% outlier, but it was in the "neutral" range instead of the negative ranges.

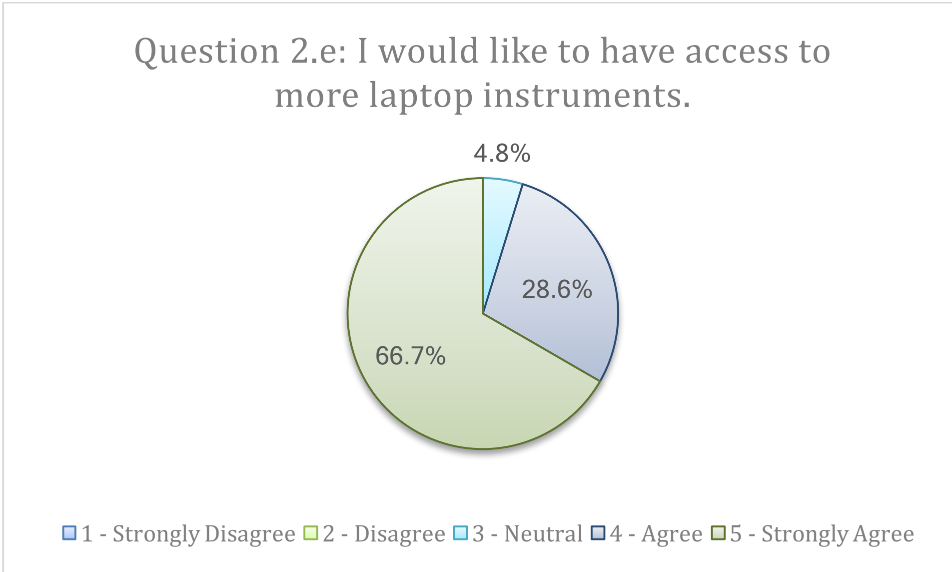

Figure 49: Laptop Performance Training – Student Experience Survey 2.e

Question 2.f (Figure 50) measured the students' perception of learning once again, and the distribution of the results resembled the responses in 2.c (Figure 47). In this question, there was a similar presence in "strongly agree", "agree", and "neutral", at 28.6%, 28.6% and 33% respectively; while the 10% of negative responses were present once more. The numbers in 2.f and 2.c suggested that there was a correlation between the students' confidence in their performance skills, and their knowledge.

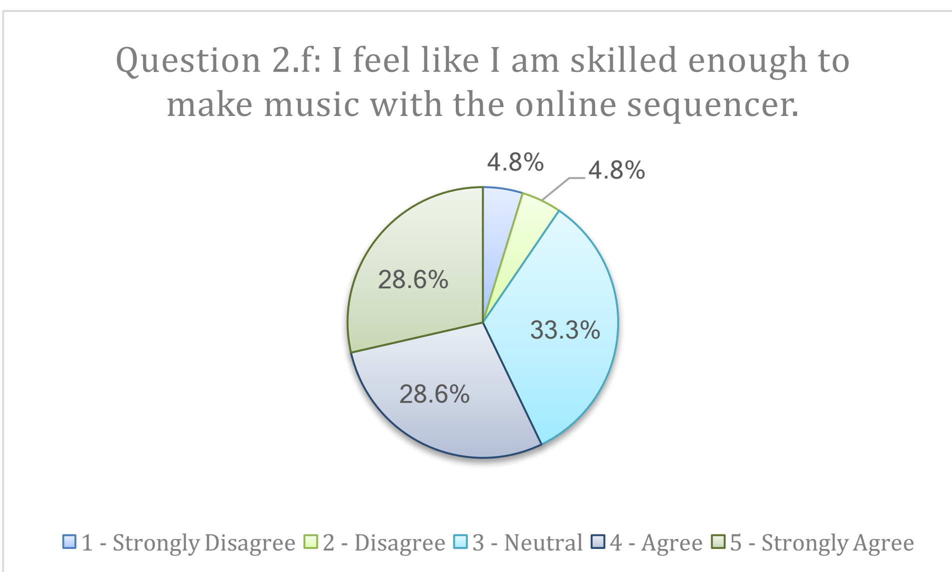

Figure 50: Laptop Performance Training – Student Experience Survey 2.f

The last three questions assessed the student's personal experience throughout the user study. Question 2.g (Figure 51) showed that the majority of students preferred the proposed learning model over lecture-based classes, with 62% of the responses in "strongly agree", 24% in "agree", and 14% in "neutral". This suggested that the student experience was improved by focusing on active learning through constructivism and connectivism.

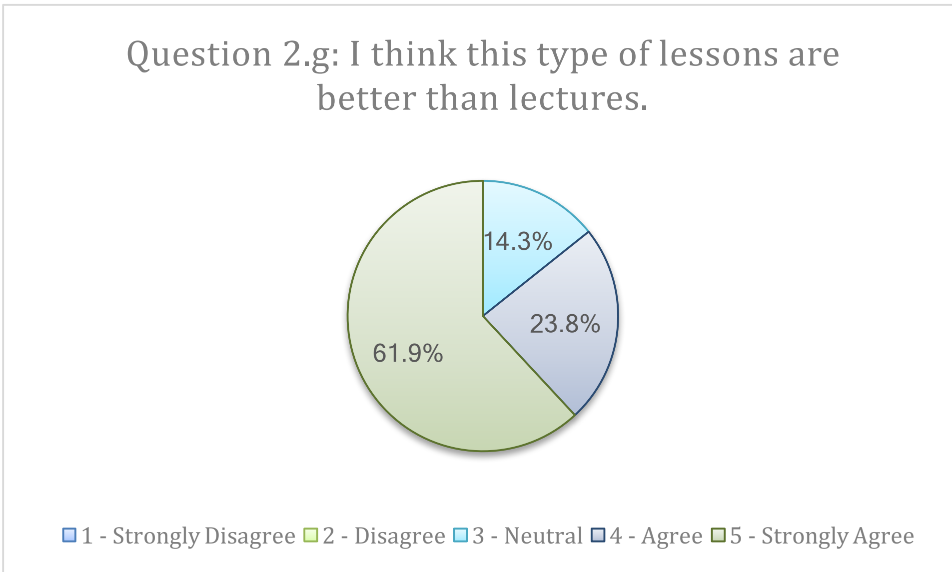

Figure 51: Laptop Performance Training – Student Experience Survey 2.g

Question 2.h (Figure 52) revealed a similar amount of positive responses, at 86% of the students; however, there was a larger representation in the "agree" range at 38%, which brought down "strongly agree" to approximately 48%. A possible explanation was that many students were excited about learning to use sequencers, but they were not enthusiastic about leaving Ableton Live aside for the duration of the user study. This led to a bigger question, because even if more affordable alternatives for music technology learning were available, this would not bypass students' need to transition to industry standard software at some point, which could be an interesting topic for future research.

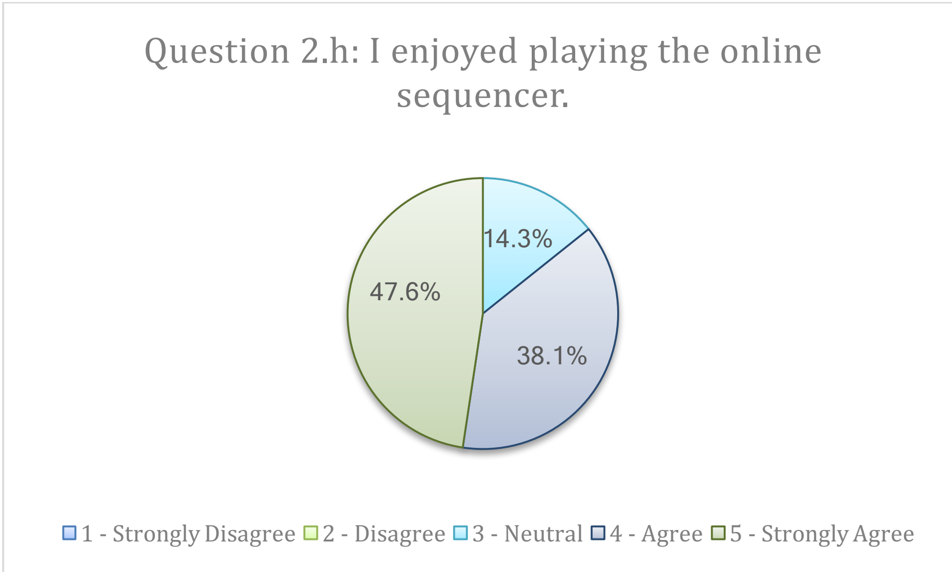

Figure 52: Laptop Performance Training – Student Experience Survey 2.h

Finally, question 2.i (Figure 53) measured how students felt about teamwork and ensemble performance. When asked if they enjoyed this part of the learning process, 38% of the students said that they strongly agreed, 52% agreed, and around 10% were neutral. Realizing that these groups showed no negative reception toward participating in creative work with other students was one of the most important conclusions drawn from these results.

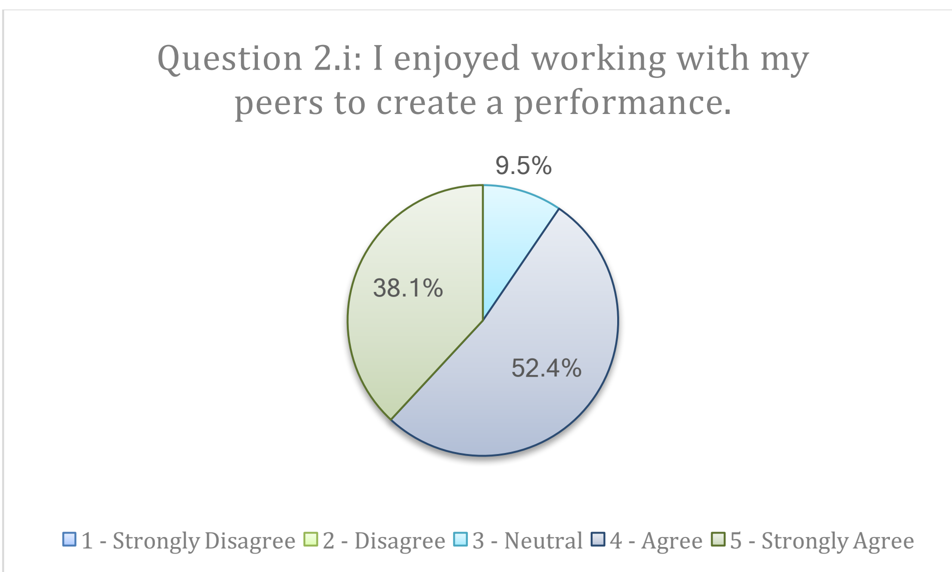

Figure 53: Laptop Performance Training – Student Experience Survey 2.i

By the end of the thesis project, at least 90% of the students were pleased with their participation in the user study. They were also particularly happy about getting their own CD with their recorded pieces to add to their portfolios. These were major indicators on how computer music and effective teaching strategies can lead to concrete goals and authentic learning.

5.3 Summary

Effective teaching benefits from continuous assessment and feedback to adapt to student needs. Properly implemented, assessment reveals critical details about the learning progression and the degree of success after teaching.

Assessment was a key element in the thesis project because it facilitated monitoring the student progress from many angles and at all stages of the learning activities. Firstly, it allowed to monitor vocabulary and concept growth, as demonstrated in section 5.2.2.1. Secondly, it helped determine the educational value of the project from the students' perspective. As shown in the analysis provided in section 5.2.2.2, the data indicates that they enjoyed the experience, and by the end of the fourth week, they were excited about the possibility of getting more involved with electronic instruments and musical collaboration.

Chapter 6

Future Work and Conclusion

6.1 Future Work

There are certain considerations to keep in mind when carrying out research projects like this one. From a statistical point of view, it would have been beneficial to have a larger population of students, or an extended term for additional instructional modules. In the future, it would be useful to implement the proposed model in with students from various different backgrounds, demographics, education levels, and artistic experiences. Cultural, political, and socio-economic conditions have a considerable impact in arts and education, and further research in the application of educational strategies across different settings could deliver promising results.

With new technology being developed every day, there is a lot of room for exploration in instructional design for the arts. As tools become cheaper and more accessible, it will not be long before classrooms are equipped to take on the most interesting challenges.

With this in mind, I intend to continue developing educational tools and interfaces that could facilitate music technology education and electronic music. Students gained noticeable learning benefits from having easy access to an online interface, so it would be interesting to extend this research to other environments like common handheld devices, such as phones or tablets. If other types of synthesizers and electronic instruments could be represented in any of these environments, this project could definitely be extended into a *Laptop Orchestra Performance* curriculum at various levels.

It would also be interesting to give students a chance to learn at even higher levels of thinking. At an individual or ensemble level, this could be done by developing a node-based language or design environment to encourage aspiring artists to get involved in music technology. This would be an interesting step towards filling the knowledge that is missing outside of formal programs.

Finally, there is no reason to not apply these learning processes to instruments that already exist. It would be very exciting to get software developers or electronic instrument builders to support formal music programs that are interested in teaching their instrument in an ensemble setting. I believe it is essential to find a way to make industry standard software more accessible for students, and maybe some sort of educational undertaking and business agreement could benefit both sides.

6.2 Conclusion

Music and digital arts education have earned an important place in formal curriculums, but there is much room for growth and they are still in a vulnerable spot. This work shows how integrating computer music and collective/ensemble based learning strategies such as laptop orchestras can be a valid approach to address the concerns and difficulties that often arise. Namely, the research proves that integrating electronic ensemble performance into contemporary music curriculums can fortify many of the vulnerabilities in formal music education; computer music can bridge the existing gaps between formal music technology learning and traditional music education programs; and authentic 21st century education can be reinforced by incorporating teaching strategies and philosophies centered around active student engagement into music and music technology education.

This research sought to determine the reasons why art programs are not a priority in many formal curriculums, even though they are already considered a core subject. The research indicated that a heavy emphasis on standardized testing and reduced budgets are the primary reasons.

This study also sought to find out why many aspiring artists find it hard to learn music technology independently, and many music programs struggle to integrate it to their curriculums. This was attributed to a lack of available resources and content that are up-to-date and universally applicable. Furthermore, these concerns were aggravated because many formal music programs were still not utilizing music technology curriculums to their full potential. As stated in 1.2.2, not enabling music technology students to develop skills like performance, creativity, and improvisation, interferes with the goal of providing them quality standards-based education. The pedagogical framework presented in this thesis provides a low-cost solution to help address both of these concerns.

The user study revealed that there is a lot of potential in an educational model that combines laptop orchestras and authentic teaching strategies such as Backward Design, effective assessments, project-based learning, and practical feedback; focused on higher-order thinking and 21st century skills. One of the key questions in this research was if students would find such a model useful in their individual learning. The results showed that this process facilitated self-motivation (approximately 60% of the students said that they were prepared to make music with the online sequencer) and curiosity (90% said that they were interested in exploring more laptop instruments and interfaces) by giving them clear goals and by teaching them how to learn by themselves. Furthermore, one of the most important conclusions was that students were highly receptive to being involved in group work and collaboration (90% said that they enjoyed participating in an electronic ensemble and making music with their classmates).

Finally, this work shows how the innovative model of a laptop orchestra challenges the comfort zone and the creativity of students, while opening its doors for people who are not completely proficient in laptop music. By providing the right tools, and fostering the necessary skill sets, music educators have the opportunity to employ laptops to transform contemporary music education.

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Appendix A: CAP Project Proposal

Laptop Performance Training for Young Artists
Project Outline

Juan Pablo Yépez

Introduction

Music technology and technology tools for the digital arts have come a long way in the last few decades, and it is important for educational strategies and art programs to keep evolving as well.

Nowadays, contemporary composers and electronic musicians have more tools for their art making than they have ever before. Instrument and interface developers are constantly manufacturing new and better products, and computers are becoming more powerful every day. However, it seems like music education programs at all levels have not managed to keep up with this growth.

This project in music technology and arts education seeks to explore the benefits of laptop performance as part of a formal music curriculum. The objective is to achieve higher-order thinking and meaningful learning through constructivist and connectivist approaches in a music technology and production classroom.

Motivation

It is not difficult to realize how much the music industry has changed ever since the beginning of the electronic era. Recording and post-production processes allow artists to deliver extremely polished albums and performances; and laptop orchestras, algorithmic composition and integrated art pieces are not that hard to find anymore.

In contrast, there is a noticeable lack of teaching and learning materials for music technology; and most programs at an amateur and semi-professional level are very shallow and under-developed, only going over basic production techniques and simple beat-making.

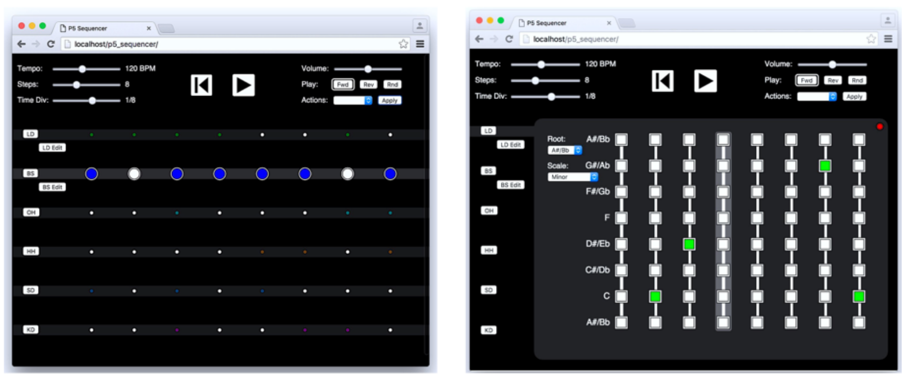
I believe that a possible solution to this is in the consolidation of traditional music ensemble pedagogy with the contemporary composition processes of laptop orchestras and electronic ensembles. This is a great opportunity to update the knowledge available to young artists, and to develop innovative methodologies and learning strategies.

This project seeks to create meaningful learning experiences and to gather relevant data, by providing easy access to common music technology tools for composition and performance.

Project Details: p5 Sequencer

The main idea behind Laptop Performance Training for Young Artists is to implement a small set of lessons or tutorials to allow students to learn about music sequencers and drum machines. These electronic instruments present an opportunity, because even though they are very common in contemporary music styles, it is extremely hard for a beginner to find relevant literature or learning materials.

The p5 Sequencer is an example of a simple drum machine with a simple user interface. Freely available, and easily accessible through an online browser, it can be used immediately without needing to purchase or install any software.



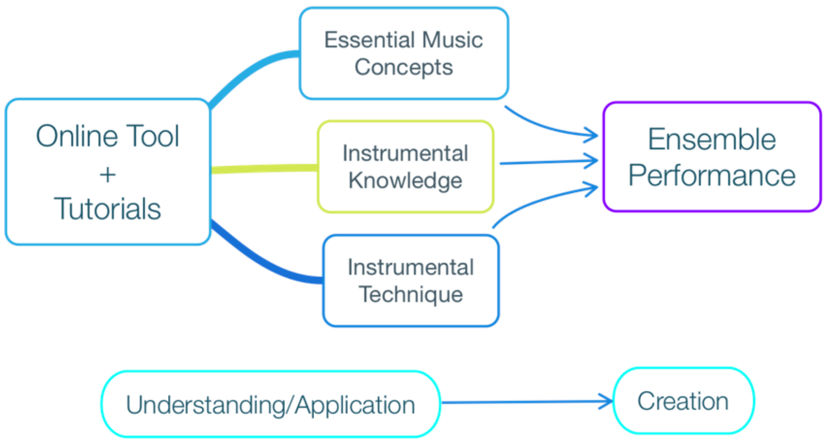
p5 Sequencer
Online sequencer and drum machine

The Laptop Performance Training Tutorials use a mix of direct instruction and controlled interaction to help students understand and apply the essential concepts behind using a sequencer. After that, it is important for them to spend some time with the instrument and to explore its rhythmic and melodic possibilities. Finally, the main goal is to get students to use the newly acquired knowledge and skills to create their own small ensemble performance.

The observed student proficiency, in combination with a short survey, should provide basic evidence of learning, and some data to evaluate the results of the learning process. Even though this is an experimental project, it builds upon contemporary educational philosophies and effective curriculum design strategies.

Timeline:

Project implementation: Last two weeks of February 2016
Assessments and Data Evaluation: March 2016



The Learning Process
Concepts and Objectives

Conclusion

In an environment in which the art making itself has evolved considerably, it is essential to go beyond teaching concepts and behaviors. Teaching through an actual laptop instrument should help students experience real learning, and fill the existing gap between computer music, and musical skills and performance.

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Appendix B: Thesis Project Survey

CalArts Community Arts Partnership (CAP)
Music Production: Introduction to Laptop Performance
Student Assessment and Survey

About this questionnaire:

This activity is completely optional, participation is anonymous and voluntary. Although the Laptop Performance and Electronic Ensemble modules are part of this course, CAP students are not required to complete this form as part of their coursework. The objective of this questionnaire is to simply gather useful data about effective learning strategies and teaching philosophies in Music and Digital Art courses.

1) Learning Assessment Questions: Sequencers and Drum Machines

   Answer the following questions using what you have learned in class.

   a) In your own words, explain what a sequencer is.

   b) How do you usually "play" a sequencer?

   c) Can you play many sequencers at the same time? If so, how would you do this?

   d) What is tempo?

   e) Name a few rhythmic figures that can be used to make a beat.

2) Online Lesson Survey

Please choose **only one** response for each item.

a) The online lesson was simple and easy to understand:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

b) The interactive examples were helpful:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

c) I understand what a sequencer is:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

d) I understand how to make a basic beat:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

e) I would like to have access to more laptop instruments:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

f) I feel like I am skilled enough to make music with the online sequencer:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

g) I think this type of lessons are better than lectures:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

h) I enjoyed playing the online sequencer:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

i) I enjoyed working with my peers to create a performance:

- ❑ 5 - Strongly Agree
- ❑ 4 - Agree
- ❑ 3 - Neutral
- ❑ 2 - Disagree
- ❑ 1 - Strongly Disagree

Appendix C: Contemporary Music Technology Curriculum Examples

Chelmsford Public Schools, England

FINE ARTS COURSE SYLLABUS

Course Title: INTRO TO MUSIC TECHNOLOGY

Department: Fine Arts

Primary Course Materials:
1. Text: Making Music with GarageBand and Mixcraft - Hodson/Frankel/Fein/McCready
2. Audio Editing Software: GarageBand, Audacity
3. Music Notation Software: Sibelius, Finale

Course Description: **Intro to Music Technology is open to students who have at least one year of high school performance music ensemble or music theory experience. The purpose of this course is to increase students' musical awareness through technology based experiences. Students will develop musicianship in a 21st century enviroment by completing projects utilizing critical response, reading and notation, improvisation and composition as well as some singing and instrumental performance.**

Essential Questions:
1. What is music?
2. How does electronically generated music differ from traditional, acoustic music?
3. What are the basic elements of music?
4. What is electronic music's place in society and culture?
5. What is active listening?
6. How can we create and respond to music using appropriate terminology?

Course Objectives:
Students will be able to:
1. Create music using a variety of computer software.
2. Critically respond to music examples through active listening techniques.
3. Transfer knowledge gained through active critical response to composition and arranging.
4. Gain an appreciation for modern world tools to create an art form.

Common Goals:

Thinking and Communicating
1) ☒Read information critically to develop understanding of concepts, topics and issues.
2) ☒Write clearly, factually, persuasively and creatively in Standard English.
3) ☒Speak clearly, factually, persuasively and creatively in Standard English.
4) ☒Use computers and other technologies to obtain, organize and communicate information and to solve problems.
5) ☒Conduct research to interpret issues or solve complex problems using a variety of data and information sources.

Gain and Apply Knowledge in and across the Disciplines
6) Gain and Apply Knowledge in:
   a) ☒Literature and Language
   b) ☐Mathematics
   c) ☒Science and Technology
   d) ☐Social Studies, History and Geography
   e) ☒Visual and Performing Arts
   f) ☐Health and Physical Education

Work and Contribute

3/21/2013 - 1 -

7) ☒Demonstrate personal responsibility for planning one's future academic and career options.
8) ☒Participate in a school or community service activity.
9) ☐Develop informed opinions about current economic, environmental, political and social issues affecting Massachusetts, the United States and the world and understand how citizens can participate in the political and legal system to affect improvements in these areas.

Learning Standards from the Massachusetts Curriculum Framework:

A chart is attached identifying which of the standards from the Massachusetts Curriculum Frameworks will be assessed in this course.

Additional Learning Objectives Beyond the Curriculum Framework:
Personalizing instruction
Engaging students in cross-disciplinary learning
Engaging students as active and self directed learners
Emphasizing inquiry, problem solving and higher order thinking
Applying knowledge and skills in authentic tasks
Engaging students in self assessment and relection
Integrating technology

Content Outline:

UNIT ONE: MUSIC THROUGH TECHNOLOGY

Preparation:
Audacity tutorial

Activity:
"Gettysburg Address" exercise: the student will learn about the different effects through Audacity by reconstructing (correcting) a spoken recording of the Gettysburg Address. In this unit, students will go on to record their voices speaking or singing a simple melody that can be performed in a round. They will then mix and edit these recordings using Audacity to create a single person-performed multi-part recording. Students who show proficiency in this can move on to the challenge of singing or instrumentally performing the parts of a four-part harmony piece, singing multiple partner songs, and then editing them together, or creating an accompaniment using MIDI files through GarageBand.

Assessment:
1. "Gettysburg Address" project
2. Self-recorded multi-track recordings.

Grading:
Student demonstrates an excellent understanding of the software, is able to manipulate the recordings to produce a cohesive product. - 100 points

Student demonstrates a good understanding of the software, is able to manipulate the recordings to produce a good product with minor flaws that do not detract from the overall recording. -85 points

Student demonstrates a basic understanding of the software, is able to manipulate the recordings, but the product shows unrefined edits that detract from the overall quality of work. - 70 points

Student does not demonstrate understanding of the software, and shows little or no attempt at editing the original materials to create a quality product. - 60 points

UNIT TWO: (RE)CONSTRUCTING MUSIC THROUGH TECHNOLOGY

Preparation:
GarageBand tutorial, review of score reading.

Activity:
"Fantasia on the Dargason" exercise: the studend will review the basics of reading a conductor's score. Each student will have access to the score to Second Suite in F for Military Band by Gustav Holst. This piece has a simple melody which repeats itself 26 times from section to section. The class will identify which instrument is playing the melody for each repetition, then discover the supporting instruments which will give context clues for the second part of the project. The students are then given 26 audio tracks which they then have to reassemble in order, using the score as a reference as to which section comes next.

Assessment:
1. "Fantasia on the Dargason" project

Grading:
Student demonstrates an excellent understanding of score reading and is able to successfully recreate the piece to produce a cohesive product. - 100 points

Student demonstrates a good understanding of score reading and is able to recreate the piece to produce a good product with 1-2 misplaced sections. -85 points

Student demonstrates a basic understanding of score reading and is able to recreate a semblance of the original, but overall the product is basically incorrect. - 70 points

Student does not demonstrate understanding of score reading, and shows little or no attempt at recreating the piece into a quality product. - 60 points

UNIT THREE: RE-SCORING

Preparation:
Review of key signatures & the relative minor, GarageBand loops

Activity:
"Row Your Boat" exercise: the student will have an opportunity to explore the offerings of GarageBand MIDI loops - short digital pre-recordings of bass lines, melodic grooves, and drum beats. After reviewing the concept of Major vs. minor keys, the class will then work towards "rescoring" a simple tune (Row, Row, Row Your Boat) from it's Major key to it's relative minor key. Students who complete this task proficiently may move on to rescoring more complex melodies.

Assessment:
1. "Row Your Boat" project

Grading:
Student demonstrates an excellent understanding of GarageBand loops and relative key signatures. The student is able to successfully rescore the melody to produce a new sounding product. - 100 points

Student demonstrates a good understanding of GarageBand loops and relative key signatures. The student is able to recscore the melody to produce a good product. -85 points

Student demonstrates a basic understanding of GarageBand loops and is able to rescore the melody but overall the product is basically incorrect. - 70 points

Student does not demonstrate understanding of GarageBand loops and relative key signatures. The student shows little or no attempt at rescoring the piece or inundates the product with non-relevant material. - 60 points

UNIT FOUR: MULTI-TRACK RECORDING

Preparation:
Review of Audacity, GarageBand, overview of chamber music

Activity:
"Solo Multi Part Recording" exercise: the student will experiment recording themselves performing on their primary instrument or voice and then experimenting with the audio editing process. Once they have shown proficiency of this procedure, the student will choose a piece of music (trio or quartet) for their instrument or voice. They will then record each part as a separate track and edit the audio all together to form a cohesive multi-part piece.

Assessment:
1. "Solo Multi Part Recording" project

Grading:
Student demonstrates an excellent understanding of parts playing and the audio editing process. The product is cohesive in time, intonation, and overall musicality. - 100 points

Student demonstrates a good uunderstanding of parts playing and the audio editing process. The parts of the product is mostly in time with few intonation concerns and overall good musicality. -85 points

Student demonstrates a basic understanding of parts playing and the audio editing process. The product has several flaws in timing, intonation and is lacking in overall musicality. - 70 points

Student does not demonstrate understanding of parts playing or the audio editing process. The product is not timed accurately, has poor intonation, and displays little to no musicality. - 60 points

UNIT FIVE: FINAL PROJECT

Students will write, record, mix, edit, and produce their own commercial jingle. Students will utilize GarageBand loops, music writing software, editing through Audacity. Projects should use outside source material (singers, instrumentalists, voice-overs).

Grading:
Student demonstrates an excellent understanding of the software. Content is original, engaging, and contains all pieces of criteria; acoustic instruments, appropriate length, and balance and blend of the final audio editing procedure. - 100 points

Student demonstrates a good uunderstanding of the software. Content is original and contains most pieces of the criteria: acoustic instruments, appropriate length, and balance and blend of the final audio editing procedure. - 85 points

Student demonstrates a basic understanding of the software. Content is original but is lacking in many pieces of criteria: acoustic instruments, appropriate length, and balance and blend of the final audio editing procedure. - 70 points

Student demonstrates a little understanding of the software. Content is not entirely original and is lacking in most pieces of criteria: acoustic instruments, appropriate length, and balance and blend of the final audio editing procedure. - 60 points

Torrington High School Music Technology

Overview of the Torrington High School Music Technology Program
Torrington, Connecticut 06790 USA

Music Technology I

Music Technology I is an introductory course that exposes students to basic music concepts using the MIDI , Digital Audio and Multi-media applications. Sound Systems, MIDI, Band In A Box, Master Tracks Pro MIDI Sequencing Software, PowerPoint, Sound Forge Digital Audio Editing and ACID Pro Looped Based Creation Software are studied. Music Technology I meets 4 days a week for one semester (half-year). Upon completion of Music Technology I with a C or better students have the option of registering for Music Technology II.

Music Technology II

Music Technology II is an advanced course that explores the real world applications of Music Technology. Radio Commercials, The Art of Foley, Podcasting, Film Scoring and Website Design are all studied using the applications learned in Music Technology I

Music Technology Website.

The Torrington High School Music Technology Website www.thsmusic.net/tech.htm is the online home for daily assignments, student work and more. Over the years the THS Music Tech website has been a resource for music educators from throughout the world with schools from the United States, Canada and as far away as Australia using the website to enhance their curriculums.

Popular Elective.

Each year there is a waiting list for students wishing to take Music Technology at THS. This is due to the hands-on approach and lab setting. Students can use their IPOD/MP3, bring in their guitars, keyboards and use their iPhones to complete their assignments.

I hope you find the lessons below useful for your individual situations. If you have any questions please feel free to contact me.

Email: Wsplettstoeszer@torrington.org
Phone: 860-489-2294
Website: http://www.thsmusic.net/tech.htm

Torrington High School
Music Technology

Music Technology I Lessons

Unit 1 Sound Systems

This unit will cover the basics of operating a sound system. Topics included but not limited to: Mixers, speakers, microphones, cords, cables, effects processors, recording equipment.

Unit 2 Musical Instrument Digital Interface

This unit will cover MIDI. All the who, what, when, where, and why?
How MIDI is used. What MIDI is and what it is not!

Unit 3 – Software Applications

MIDI and Audio Sequencing
Creating a song from scratch using"Master Tracks Pro
Music Accompaniment – Band In A Box
Audio Editing -"Sonic Foundry's Sound Forge 5.0
Looped Based Music Production – ACID Pro

Grading will be based on homework, class projects, tests and quizzes.

Projects will include:
Creating your own songs
Editing MP3 Files
Podcasting
Soundscapes
Techno/Dance Remixing

Torrington High School Music Technology

Music Technology I Lessons

Sound Systems.
Musical Instrument Digital Interface
Band In A Box MIDI Accompaniment Software - Introduction
Band In A Box MIDI Assignment # 1 – Improvisation
Master Tracks MIDI Sequencing Software
Master Tracks Assignment # 1 Remix
Master Tracks Assignment # 2 Rhythm Section
Research Assignment - Digital Audio and The Apple IPOD
Introduction to Sound Forge Audio Editing Software
Sound Forge Assignment # 1 - Song Form
Sound Forge Assignment # 2 - Movie Speeches
Sound Forge Assignment # 3 - Soundtrack of My Life
Introduction to ACID Pro Looped Based Creation Software
ACID Pro Assignment # 1- Sound Effects Story
ACID Pro Assignment # 2 - Techno/Remix
ACID Pro Assignment # 3 - Podcast
Final Project/Final Exam - ACID and Art

Music Technology II Lessons

Software Checklist
Research Assignment # 1
Research Assignment # 2
Podcasting
Podcasting Questions.
Podcasting Assignment # 1
Podcasting Assignment # 2
Film Scoring
Film/Music Analysis Project
Film Scoring Listening Journals
Film Scoring Movie Journals
Website Design
Electronic Portfolio – Final Project/Fina Exam

Torrington High School

Music Technology

Music Technology I

Lesson # 1

1. Class Overview
   2. Class Website
   3. Create Network Folders

   In your network folder create the following folders:

      Create the folder "MUSIC TECH"

   Inside of MUSIC TECH create the following folders:

      "Sound Systems"
      "MIDI/BIAB"
      "Master Tracks"
        " IPOD"
        "Sound Forge"
        " ACID"
        " Final Project"

Websites for Assignment

http://www.thsmusic.net/sound_systems.htm

http://www.blobprod.com/mixers/beatbox/beatboxmain.asp

Greenwich Public Schools
Electronic Music Curriculum 9-12

Overview

Electronic Music courses at the high school are elective music courses. The Electronic Music Units of Instruction include four strands—Meter & Rhythm, Timbre, Form/Structure; Expression and Technology.

Table of Contents

Title: Introduction to Drum Beats **Topic**: Meter/Rhythm	**Course**: Introduction to Electronic Music **Grades**: 9-12

Stage 1—Desired Results

Established Goals:

National Standards

Standard 2: Performing on instruments, alone and with others, a varied repertoire of music.
Standard 5: Reading and notating music.
Standard 6: Listening to, analyzing, and describing music.
Standard 8: Understanding relationships between music, the other arts, and disciplines outside the arts.

GPS Overarching Big Ideas

Making meaningful expression/performing
Interpreting symbolic expression/literacy
Making connections to and through the arts

Understandings:

Students will understand that…

Performing
- Playing an instrument allows a musician to express musical ideas that exceed the range, timbre, and dynamics of the voice.
- Performing involves interpretive decisions.

Literacy
- Each arts discipline is a language unto itself, communicated through a unique system of symbols and terms.
- Literacy in the arts is valuable in facilitating the transfer of artistic expression.
- Notational literacy empowers independent musicians.
- Notation gives permanence to a composition.
- Standard music notation includes symbols that visually represent sounds, and a universal set of terms that aid understanding.
- Since music is an aural art form, aural literacy (e.g. listening critically) is an important component of being musically literate.

Connections
- The arts connect to other disciplines, personal experiences, and daily life.
- There are similarities and differences in the arts produced among cultures and across time.
- Music connects us to the past, present, and future.

Essential Questions:

Performing
- How do the arts express ideas, feelings, and experiences?
- How does working in a group influence expression?

Literacy
- Why do I need to be literate in my chosen art form?
- What does having a common system of symbols and terms for the arts allow us to do, and why is this important?
- Why do composers use standard notation?
- Is notation "music"?
- What is the value in becoming musically literate?
- What would change if we didn't have a system of written music notation?

Connections
- How do artists from different eras and cultures explore and express similar themes?
- How does my artistic work connect to other subjects I study?
- Why is some music timeless?

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<table>
<tr>
<td>Students will know…
• The names and meanings for the following notation symbols: staff, quarter notes and rests, eighth notes, sixteenth notes, bar line, measure, time signature, double bar line, and repeat sign.
• Basic techno and rock beats.
• The meanings of the following terms: steady beat, tempo, and metronome marking.</td>
<td>Students will be able to…
• Perform, from notation, rhythm patterns in 4/4 time, including the following notes: quarter notes and rests, eighth notes, sixteenth notes.
• Perform a rhythm to a steady beat and maintain a consistent tempo.</td>
</tr>
<tr><th colspan="2">Stage 2—Assessment Evidence</th></tr>
<tr><td colspan="2">Performance Tasks:
Students will deconstruct, perform, and record basic techno and rock beats.</td></tr>
<tr><td colspan="2">Key Criteria:
Students will be graded on the accuracy of their recorded performance of Techno, Rock, and Rock Variation beats using GHS Electronic Music Composition Rubric.</td></tr>
<tr><td colspan="2">Other Evidence:
Formative assessments on students' in-class performance of rhythm patterns selected from Garwood Whaley's Basic in Rhythm text.</td></tr>
<tr><th colspan="2">Stage 3—Learning Plan</th></tr>
<tr><td colspan="2">Learning Activities:
To be developed by individual teacher.</td></tr>
</table>

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Title: Affecting Timbre with Technology **Topic**: Timbre	**Course**: Intro to EMusic **Grades**: 9-12
Stage 1—Desired Results	
Established Goals: *National Standards* Standard 4: Composing and arranging music within specified guidelines. Standard 6: Listening to, analyzing, and describing music. Standard 7: Evaluating music and music performances. *GPS Overarching Big Ideas* Expressing personal ideas/creating Responding to the arts	
Understandings: *Students will understand that…* Creating • Creating in the arts uses imagination, self-discipline, problem solving and experience. • Process impacts product. • Composition requires imagining, planning, creating, evaluating, and refining one's musical ideas. • Composition results in a work that can be performed and replicated. • Improvisation and composition involve guidelines and structure, which may be amended during the creative process. • Composition can be achieved through using technology or through using an instrument. • Composition and improvisation is not merely an activity to be undertaken by accomplished musicians, but rather can be achieved by anyone as a means of expressing their own musical ideas to the extent their musical development and understanding will allow. Responding • Artistic expression can be analyzed, described, and evaluated, both intellectually and emotionally, in a variety of ways. • Responding to the arts enhances one's life and influences one's personal expression. • The depth of musical knowledge one possesses impacts how, and to what degree, one analyzes, describes, and evaluates music.	**Essential Questions:** Creating • What inspires or moves me to be creative? • How do my creative choices best express my idea and intent? • How does my artistic work impact myself and/or others? • How do you know when the creative process is complete? • How do I express my ideas, feelings, or mood through music? • How can I use the elements of music (e.g. melody, harmony, rhythm, timbre, texture, and expressive devices) to convey my ideas and intent? Responding • How do we perceive, interpret, and engage with art? • How does knowledge and experience influence interpretation? • How do style/genre/subject matter/media influence how you feel about the work? • How is music different from noise? • Why do we listen to music? • Why do we like the music we like? How can we be open to liking music we do not understand?

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• The music to which one has been exposed influences one's musical preferences. • Listening to music evokes emotions, whether or not one has chosen to listen to it. • All music contains a tonal and metric context and uses unity/variety and tension/release, and these elements can be aurally identified.	
• *Students will know…* • The basic functions of the computer program GarageBand (e.g. create a new track, edit a track, locate the track edit functions, etc.). • The meanings of the following terms as applied to manipulating & clarifying sound: *timbre, panning, volume, track automation, stereo imaging.*	*Students will be able to…* • Create a unique instrument using the software instrument edit functions in GarageBand. • Demonstrate an understanding of how basic audio engineering techniques effects timbre through creation of unique instrument sounds. • Demonstrate how basic audio engineering techniques allows multiple instruments that are played simultaneously to be heard clearly in their mix. • Listen to, analyze, and describe how they and others manipulate timbre by using basic audio engineering techniques. • Evaluate their use and others' use of basic audio engineering techniques to manipulate timbre in terms of musical effectiveness and personal taste.
Stage 2—Assessment Evidence	
Performance Tasks: Students will use basic audio engineering techniques including, panning, volume & track automation to create a two-dimensional image that allows for each instrument to be clearly heard in the mix. Students will listen to their own and others' arrangements and critique them using music terms.	
Key Criteria: Students' arrangements will be evaluated on the following criteria: following basic guidelines of the assignment, use of track automation, use of panning & volume. Students will listen to their own and others' arrangements with an ear to analyzing and evaluating its effectiveness in achieving the stated goals. Students will verbally share analysis and evaluation of others' arrangements.	
Other Evidence: Teacher check in-progress work of individuals. Students listen to each others' projects and offer advice.	
Stage 3—Learning Plan	
Learning Activities: *To be developed by individual teacher.*	

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