Redesigning Music Education Through Laptop Ensembles

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ABSTRACT

Today, artists have access to powerful and portable equipment which enables 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 It is critical for music education to address these emerging tendencies to avoid fostering students with outdated skill sets.

This paper describes how laptops and computer music could enhance contemporary music programs by providing an environment in which students focus on developing real-life knowledge and skills through artistic exploration and growth. This was demonstrated by designing a system around computer music performance and laptop orchestra models in which students could learn by composing, rehearsing, and playing. These dynamic settings were essential to encourage the application of critical thinking, teamwork, and problem solving skills in an active learning environment.

1. INTRODUCTION

This paper outlines the *Laptop Performance Training for Young Artists* project, a user study created to demonstrate that computer music could enhance artistic creation while developing 21st century skills, such as collaboration, improvisation, programming, critical thinking, and creative problem solving.

This user study explores how laptop orchestras have become stimulating environments for art creation and intellectual exchange. Although they have been implemented in higher education programs for the most part, these ensembles 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.

2. BACKGROUND

2.1 Why the Laptop?

Computers have become important tools in contemporary education because they can provide various benefits that will positively impact the learning process. They offer a wide array of materials and tools to make learning more interactive, challenging, and rewarding, which enables experiential learning and allows for deeper understanding and creativity.[1] Through them, students have access to highly personalized education in a cooperative environment, which is conducive to increased engagement and reinforcement.[2]

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 to collaborate with peers or people with similar interests. It also provides access to learning materials and paperless resources, which increase productivity and improve learning results at a reduced cost.[3]

To this end, laptops enable students to have an identity within global learning environments through efficiency, exploration, and expression.[3] Evidence of this can be found in the efforts that countries like Peru, Thailand, Uruguay, and the United States are making to integrate laptops and other digital technology into their educational systems.[4][5]

2.2 Why an Electronic Ensemble?

It is important to consider that electronic ensembles are not completely different from traditional band and orchestras. Their purpose as a collective music making experience offered to students is 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.[6]

2.2.1 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 the Princeton Laptop Orchestra (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 [7].

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, 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.

2.2.2 Interfacing with the Laptop

Computer music has changed the dynamics of ensemble performance. Computers enable performers to go beyond the acoustic instrument paradigm of a single gesture per acoustic event, by facilitating the creation of complex musical systems that integrate multiple events and triggers.[1]

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 staying away from the computer. Spectators find this appealing because the sounds they can hear are being caused by electronic instruments or contraptions.[8]

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, trackpad interaction, and even microphones and webcams. [8][9]

Fiebrink, Wang, and Cook [9] have integrated instrument design and performance in PLOrk through native laptop input and 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 1). This configuration allows performers to play notes and chords with one hand, while operating a different controller with the other one.

Figure 1. 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 2).

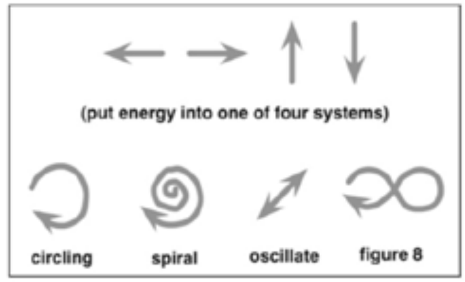

Figure 2. Trackpad bowing motions

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 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. USER STUDY

The *Laptop Performance Training for Young Artists* user study attempted to integrate electronic ensemble performance with effective teaching strategies to support meaningful and authentic learning experiences.

A group of students was selected for a learning module 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 specific concepts and skills. Successful implementation of this educational model was then measured through surveys, observation, and evaluation of the acquired data.

3.1 Instructional Design

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.

3.1.1 Music Sequencers

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 proficiency with music sequencers is essential for professional and aspiring musicians.

3.1.2 The P5 Sequencer

Designing an instrument for a real teaching 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 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[1] 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 learning progression. This did, however, present an interesting avenue for future work.

Various frameworks and libraries were considered as potential design tools, including: (1) Web Audio API eXtension (WAAX)[2]; (2) Gibber[3]; and (3) EarSketch[4]. 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 3. So far, WAAX seemed to be the most appropriate tool for a browser-based interface.

Figure 3. Custom User Interface in WAAX

WAAX offered various user interface controls, called MUI Elements, which were convenient from a programmatic standpoint. Early trials with students determined that it was easy for them to understand 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[5], a JavaScript library created by Lauren McCarthy and supported by the Processing foundation [10], was one of these options. Although it was developed for creative coding on the web, additional libraries can make it easy to access HTML5 objects, including Web Audio. Just like in Processing, the popular Java framework in which P5.js was inspired [11], 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.

The P5 Sequencer's graphical user interface (GUI) was designed to be clear and easily understandable. To allow beginners 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. Therefore, the core of the instrument was limited to the most basic elements found in hardware sequencers.

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

[1] 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/
[2] Available at: http://hoch.github.io/WAAX/
[3] Available at: http://charlie-roberts.com/gibber/gibber-lib-js/
[4] Project page available at: http://earsketch.gatech.edu/landing/
[5] Project page available at: https://p5js.org

keep the online instrument as close as possible to the sequencers that inspired it, such as the Arturia BeatStep[6] and the Korg Volca[7] family. Also, instruction was focused on fundamental music skills, so adding unique or advanced features was beyond the scope of the lessons.

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 important to encourage best practices and reinforce key concepts through the GUI and user interaction.

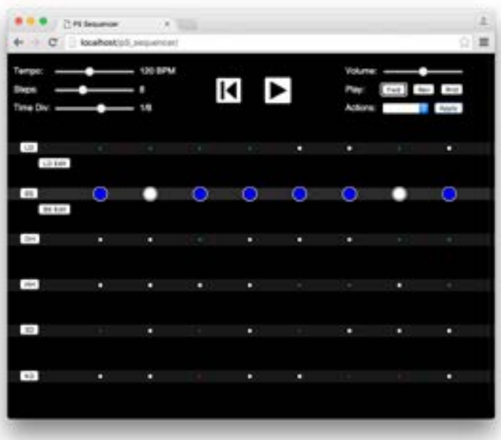

Figure 4. P5 Sequencer – Graphical User Interface

The P5 Sequencer's GUI, as seen in Figure 4, was designed to look like common hardware and software sequencer layouts to enhance the user experience; and visual cues, triggers and familiar computer interface components were included to highlight the interactive elements. These design considerations reinforced and accelerated learning by using familiar knowledge.

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.

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 5 , 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.

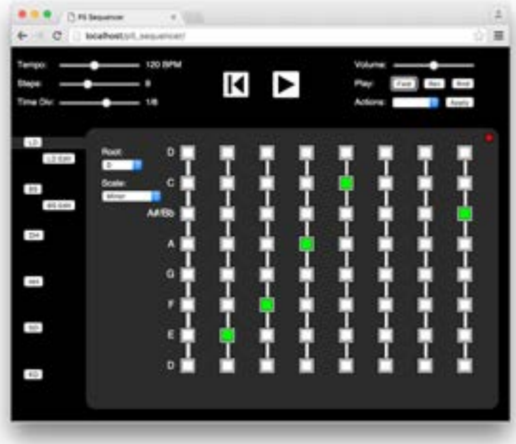

Figure 5. P5 Sequencer – Melody and Bass Editor

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 would have been interesting to explore concepts like velocity, probability, presets, and external tempo sync with other sequencers or devices; but it was necessary to prioritize a simple and clear interface to reinforce student understanding.

3.2 Selected Study Group

The CalArts Community Arts Partnership (CAP) 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.[8]

Children enrolled in the CAP music technology courses were between the ages of 12-17, and they all had previous experience in instrumental performance and music theory. Some 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 most of them had 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 range and skill level, it was highly unlikely for parents to be willing to invest in expensive digital audio workstations (DAWs), software instruments, or libraries, even if they could afford them.

The goal of the user study was to teach electronic ensemble performance skills through continuous observation

[6] Available at: https://www.arturia.com/products/hybrid-synths/beatstep

[7] Available at: http://i.korg.com/volcaseries

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

and assessment, and to evaluate the results. Two groups of 13-15 CAP students in the Music Technology and Production courses attended one 60-minute-long session every week throughout the spring cycle, which ran for approximately 3 months; and they participated in the user study during the last month of the course. They were selected 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.

3.3 Learning Process

The goal of this learning module was to teach students essential concepts and skills in ensemble performance using music sequencers.

3.3.1 Introductory Tutorial

The first phase of instruction introduced the *P5 Sequencer Online Tutorial* (Figure 6), which was designed to prototype the learning process through an interactive interface. Using a mix of direct instruction and controlled interaction, students could actively learn about music sequencers and go through the lesson content at a comfortable rate.

Figure 6. P5 Sequencer Online Tutorial

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 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.

3.3.2 Live Performance and Recording

The next phase of the user study followed a project-based learning (PBL) structure to reinforce meaningful learning through performance tasks and creative ensemble work. Students had to create a short composition with their group and then 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 as evidence of learning at the end of the course.

The performance and the CD represented a fruitful learning experience in which students had something to show for all their work.

3.4 Assessment

The initial evaluation stage assessed the overall comprehension and learning of the essential sequencer concepts. Students were encouraged to construct responses through a series open-ended questions. The first set included the following items:

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.

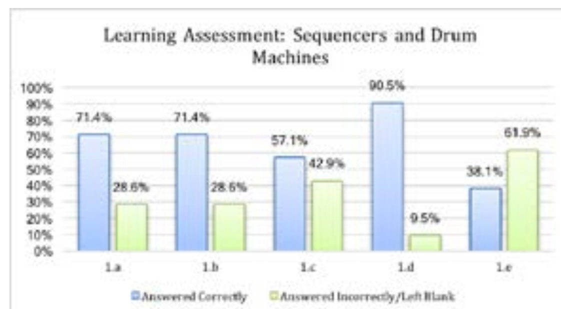

Figure 7. Learning Assessment Results

As seen in Figure 7, the first three questions revealed that most students had a good understanding of the new content; and question 1.d showed that they were comfortable associating it with familiar concepts such as tempo. However, the last question made it clear that there was a learning gap, and students stated that they were not so familiar with rhythmic figures. Results like these present an opportunity to reinforce any identified weaknesses throughout the learning process.

The second evaluation phase sought to determine if the students considered that the experimental learning process helped them throughout the user study. 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.

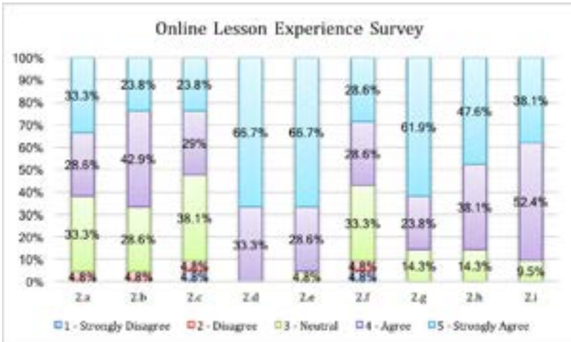

Figure 8. Student Experience Survey Results

Figure 8 shows that the overall satisfaction level of students was above "neutral", with the combined positive responses of "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.

4. FUTURE WORK

Although there is potential in encouraging students to explore laptop performance, we believe there is a greater opportunity in enabling them to create at higher levels of thought by learning to program or to design their own software instruments. We intend to continue researching and developing educational tools that could facilitate this.

Furthermore, mobile devices such as smartphones and tablets have become increasingly popular, and it would be interesting to find strategies to integrate them into electronic ensembles.

Finally, we are convinced that it is essential to find a way to make industry standard software more accessible for students, so it would be exciting to get major software developers to support formal music programs that are interested in using their products to teach ensemble courses.

5. CONCLUSION

This user study revealed that there is considerable potential in an educational model that combines laptop ensembles with project-based learning. The results showed that this process promoted self-motivation and curiosity by giving students clear goals and teaching them to learn independently. Approximately 60% of the students said that they were prepared to make music with the online sequencer, and 90% said that they were interested in exploring more laptop instruments and interfaces.

Furthermore, students were highly receptive to being involved in group work and collaboration. Nearly 90% of them said that they enjoyed participating in an electronic ensemble and making music with their classmates.

Finally, this work showed how the innovative model of a laptop orchestra challenges the creativity of students, without requiring high proficiency in laptop music. By providing the right tools and fostering the necessary skill sets, music educators could employ laptops to transform contemporary music education.

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