INTEGRATION OF LAPTOP ORCHESTRAS IN SECONDARY PUBLIC SCHOOLS: A FEASIBILITY STUDY

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DEDICATION

For my husband, Shane Hamilton, and my family and friends, thank you for reminding (commanding) me to be awesome.

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ABSTRACT

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The purpose of this study was to investigate the feasibility of integrating a laptop orchestra into the curriculum of a secondary public school. Participants (N = 33), directors (n = 11) and members (n = 22) of laptop orchestras at U.S. colleges and universities, completed surveys addressing curricular and physical resources required to support the ensemble. Responses indicated that the student learning outcomes of university laptop orchestras were in alignment with current national and state standards for music education. Survey results also revealed that directors of laptop orchestras would need specialized training in music technology and computer science, along with an abundance of time to dedicate to rehearsal preparation. Reported physical resource needs varied, depending upon ensemble goals, with estimated equipment costs ranging from $100,000 to $750,000, but far less if students owned their own laptops. Many participants predicted that, with the continued growth of music technology, technology-based ensembles would become standard in secondary schools.

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CHAPTER I

INTRODUCTION

Historically, advances in music technology have prompted composers and performers to add and embrace new and improved instruments to musical ensembles. With recent advances in computer technology, electronic music has become more accessible with performers synthesizing sound on their laptops, tablets, and mobile devices. New electronic ensembles, known as laptop orchestras, have developed as a response to these new instruments.

Laptop orchestras have been gaining popularity at the collegiate level. Each performer plays a "meta-instrument," which is composed of a laptop computer, a rack of audio equipment, and a hemispherical speaker, which can produce the same sound in all directions or different sounds in each of six directions. In addition, various interfacing input devices can be used with the meta-instruments for increased expression. Most of these ensembles use the software system "ChucK," which enables performers to code music in the midst of live performances. These ensembles employ a do-it-yourself approach, as the hemispherical speaker and instrument inputs are typically manufactured or "hacked" together by the performer.

CHAPTER II

REVIEW OF LITERATURE

The laptop orchestra is a product of 21st-century technology and combines elements of computer science and music. Therefore, literature about laptop orchestras is primarily from the last two decades and is available from diverse sources. Due to its recent development, few research studies have been conducted on this type of ensemble. Articles range from general descriptions of laptop orchestras to publications detailing the components of a meta-instrument.

Overview and Development of Laptop Ensembles

The majority of the literature surrounding laptop orchestras contains an overview of the development of the ensemble. Trueman, Cook, Smallwood, and Wang (2006) documented the founding and first year of the Princeton Laptop Orchestra (PLOrk). The motivation for establishing the orchestra was to extend the use of spherical speakers, which had recently been developed and used in smaller ensembles, to a larger group setting. The researchers expounded upon the equipment they used, including set up diagrams; the ensemble, with a diagram of the layout; the software and patches used, including ChucK, Max/MSP, SuperCollider, and custom applications written in Java; communication and networking, using the software over a wireless LAN; compositions, including a list of pieces with descriptions; and some of the problems the ensemble encountered--namely network errors.

Similarly, Bukvic, Martin, Standley, and Matthews (2010) provided a description of the Virginia Tech Laptop Orchestra (L^2Ork) and presented research on how to enhance

the affordability and flexibility of the ensemble. Their research was based on operating software in a Linux-based system to avoid interference with preinstalled software on the computer. In addition, the research team worked on a summer research project to bring the setup cost per meta-instrument to below $800. Given their cheaper and streamlined meta-instrument, the researchers mentioned the need for further research regarding the feasibility of incorporating laptop orchestras into K-12 curriculum.

Wang, Trueman, Smallwood, and Cook (2008) discussed the logistics of operating a laptop orchestra at the university level but did not address the curriculum and student learning objectives. They provided an overview of the activities during a typical week of the PLOrk ensemble, including in-class instruction, as well as studio work outside of class. The curriculum they reviewed included learning and playing pieces, live performance, programing, an assignment example, student works, and listening; results and evaluation of assignments; and the movement from a classroom-oriented computer music class to an integrated classroom with live performance.

Coding Language

"ChucK" is the computer music software used in the composition of music for laptop orchestras. The software is free and open-source, and different from other programs in that the performer has precise control over duration and timing. The software allows for sound synthesis, physical modeling, gesture mapping, algorithmic composition, sonification, audio analysis, and live performance (Wang, Cook, & Salazar, 2015). ChucK can be used in conjunction with other computer music software including EspGrid, which provides a network for connecting instruments in an ensemble (Ogborn, 2014). The EspGrid software was designed to be neutral and hybrid in order to interface

with various types of computer music languages. The software was generated based on the need for compatibility in laptop orchestras in which participants used their own, varied laptops instead of a standard set owned by an institution.

Applications of Laptop Orchestra Technology

Technological advances have enabled computer scientists to transfer the concept of laptop orchestras to mobile phones, tablets, and virtual reality. Professors at Stanford University took the software and principles of the laptop orchestra and extended them to mobile devices (Oh, Herrera, Bryan, Dahl, & Wang, 2010). In these mobile phone ensembles, members wear a glove with an attached speaker on the hand holding the iPhone, leaving the other hand free to control the screen and interface elements. Preeminent in the faculty members' motivation for creating the Mobile Phone Orchestra (MoPhO) was the innate mobility combined with computational power of mobile phones. In the beginning stages, the MoPhO ensemble used the Nokia N95 smart phone and its built-in speaker for their performances (Wang, Essl, & Penttinen, 2008).

Serafin, Erkut, Kojs, Nilsson, and Nordahl (2016) conducted a study of the application of technology to virtual reality instruments and provided guidelines for instrument designers. They proposed the creation of immersive experiences for the musician with virtual reality headsets, whereby the performer could be a piano or play a city with a saxophone. Their goal was to expand the visual element of music performance using these devices, yet admitted that there were limitations in that the audience could not receive the visual information. In response to advancements in technology, laptop orchestra directors have been researching ways to power their orchestras via solar energy to allow more flexibility in the performance venue (Cook & Smallwood, 2010). The

researchers provided information about development of laptop orchestras in conjunction with related solar art and sound design, including solar power setup, results, and implications. They admitted that the solar panels could increase performance time but that a fully charged battery is sufficient for a typical concert. The continued decrease in the cost of solar energy has been a catalyst for the researchers to persist in the project.

Composing for Laptop Orchestras

Because laptop orchestras are relatively new, studies indicate that there is a concern over the scarcity of repertoire. Smallwood, Trueman, Cook, and Wang (2008) chronicled the challenges, ideas, and methodologies surrounding composing for laptop orchestras. They discussed the unique sound design and spatialization that result from the hemispherical speakers. The use of hemispherical speakers in laptop orchestras is much different from other electric ensembles, which use stereo or surround sound speaker systems, making laptop orchestras distinct in how sound is used and designed. In addition, they review the different types of interfaces the PLOrk ensemble uses to control sound, including the standard interfaces equipped in laptops, motion sensors, and accelerometers. Networking of users and the role of the conductor are also discussed in regards to how the orchestra syncs beats together as an ensemble. An idea unique to laptop orchestras is the game piece. These pieces use the visual component of video games with the musical components of sound effects and background soundscapes. The researchers also included a list of PLOrk compositions that had been written to date of publication, with the number of players, software, and interface(s) used. Addition information about laptop orchestras, audio and video recordings, scores, and selected code can be found at the following universities' websites: Stanford University

(http://slork.stanford.edu/), Princeton University (http://plork.princeton.edu/index.php), Virginia Tech University (http://l2ork.music.vt.edu/main/), and Louisiana State University (https://emdm.music.lsu.edu/laptop-orchestra/).

Instrument Design

Digital musical instruments are designed and used by composers to create the sound desired for a piece. Instruments can take many different forms, from a midi keyboard to data gloves, known as "The Hands," worn by the performer (Torre, Andersen, & Balde, 2016). Their study focused on the documents pertaining to the sensor architecture, design, mapping strategies, and development of the data gloves. Developed by Michel Waisvisz and exhibited in 1984, these gloves blazed the trail for digital inputs used for performing music live. Lyon, Knapp, and Ouzounian (2014) studied the use of biosignals as a digital musical instrument. This case study observed the use of the Biomuse instrument in a chamber setting. The Biomuse uses sensors worn by the performer on armbands and waistbands that record the electrical activity of muscle contractions and accelerometers that measure acceleration.

The California Institute for the Arts has extended their digital musical instrument design to include robotic musical instruments within an ensemble of human laptop performers (Kapur et al., 2011). Their research details the design and production of seven robotic instruments, the aesthetic of the ensemble, considerations for the networking of computers during performance, and compositions in the repertoire. All of their robotic instruments have a separate Arduino- based USB control module with a power supply that either pluck, strike, or actuate a percussive instrument.

Research focusing on laptop orchestras is limited in its scope. Studies address the process of developing a laptop ensemble, the requisite coding language, availability of compositions, and applications to other electronic devices. A paucity of research has been conducted on the educational goals and student learning outcomes associated with laptop orchestras. Further, most of the literature addresses ensembles at the university level, while information about laptop orchestras in secondary schools is largely unavailable.

Purpose of Study and Research Questions

The purpose of this study was to investigate the feasibility of integrating a laptop orchestra into the curriculum of a secondary public school. To facilitate the adoption of laptop orchestras in middle schools and high schools, student learning objectives need to be in alignment with standards at the national and state level. Further, the schools must have access to the requisite technology, including computer programs and individual electronic devices, as well as a trained teacher. This study used intact university laptop orchestras as resources for determining curricular content, equipment needs, and teacher qualifications. With this study, the researcher hopes to find answers to the following questions:

1. Are laptop orchestras a viable option as an auxiliary ensemble in the secondary setting?
2. Do the student learning objectives for laptop orchestras differ from traditional ensembles?
3. Could a laptop orchestra sufficiently fulfill national and state music education standards?

4. Could laptop orchestras serve as an attractive alternative for nontraditional music students?

CHAPTER III

METHODOLOGY

Participants

This study utilized of two distinct surveys. One was sent to current and former laptop orchestra directors connected with ensembles at the collegiate level in the United States. A different survey was dispersed to current laptop orchestra student members by the participating directors. Email addresses of potential participants were extracted from an international database of laptop orchestras compiled by Woollard, Concordia University (G. Wang, personal communication, March 2, 2017). Due to the limited number of laptop orchestras, the pool of potential participants was relatively small. To ensure the directors and ensembles listed in the database were still active, affiliated school websites were searched and initial contact emails were sent. There were 19 directors contacted with an email request for participation. No emails came back as undelivered, leaving 19 successful contacts. Directors were sent a separate email containing a link to the student member survey with a request to forward that email to the current members of their ensemble. Eleven out of the 19 directors completed the survey, resulting in a return rate of 58%. Because the number of emails sent to ensemble members was at the discretion of the director, data on percentage of member participation is unavailable. The survey was open for 37 days. In order to minimize confidentiality risks, all data were anonymous and confidential. Participants (N = 33) included laptop orchestra members (n = 22) and laptop orchestra directors (n = 11).

Procedure

Two surveys consisting of 10 questions each were made, one for the directors and one for the members (see Appendix A and B). The researcher received approval from the university's Institutional Review Board prior to survey distribution (see Appendix C). Surveys were distributed electronically through SurveyMonkey. A reminder was sent every two weeks after the initial distribution, for a total of two reminders, in an effort to increase the percentage of responses. The questions were open-ended with a text box provided. Text responses were systematically analyzed and tabulated. The quantified data was then reported in categories in terms of frequency of response using a table format.

The survey questions were chosen to ascertain the overall goals and learning outcomes of laptop orchestras. The survey questions fell into broader categories, including musical background, technological background, field of study/career goals, student and teacher desire for the ensemble, student learning outcomes, and the time and cost of running the ensemble.

Potential questions were generated by the researcher and reviewed by university music faculty members and Dr. Ge Wang, founding director of the Stanford Laptop Orchestra and author of the "ChucK" music programing language. The survey questions were edited, based on input from faculty members, and a pilot study was conducted with undergraduate and graduate music students to establish validity.

Data Analysis

Data were collected via SurveyMonkey and were analyzed by the researcher. Data were presented using response, response frequencies, and percentage in table form. The number of respondents was adjusted for questions that did not receive a 100% response

rate. Due to the open-ended nature of the questions, some responses contained multiple items.

CHAPTER IV

RESULTS

Laptop Ensemble Members

The students surveyed had traditional Western music backgrounds with the primary instruments performed being piano (55%), guitar (27%), voice (23%), and percussion (23%; see Table 1). Correspondingly, the ensembles in which students had been members included wind band (45%), marching band (40%), orchestra (25%), and concert choir (25%; see Table 2). The students' majors centered on the use of technology and included music technology (27%), computer science (14%), math and computer engineering (9%), and music composition (9%; see Table 3). The student career goals were broad, with the top five categories including being happy/making and doing cool things (14%), software development (14%), music performance (14%), songwriter/composer (14%), and unsure (14%; see Table 4).

Student members had extensive knowledge in programming and scripting languages including Java, HTML, JavaScript, C, and C# (73%). Some members had taken college level coursework (50%) in alignment with their various computer science-related majors (see Table 5). When students were asked why they chose to join a laptop orchestra, many of their answers centered on the concept of expanding skills and knowledge. The top answers included expanding knowledge and understanding of electronic music (23%), desire to expand musical skills (18%), and interest and enjoyment in both computers and music (18%; see Table 6).

Although directors mentioned teaching some music literacy, music history, or music theory in rehearsals, members reported learning little to none of those topics (36%). Members elaborated that they had prior theory knowledge (9%), theory was helpful but not necessary (9%), they did learn about the history of electronic and experimental music (9%), and they also learned about common chord progressions (9%; see Table 7). Student members responded that through the laptop orchestra they learned about various elements of music technology including Max/MSP (24%), Ableton (14%), the interconnectivity of art and technology (10%), programming (10%), and how to deal with technical issues (10%; see Table 8).

Students were asked to elaborate on how their laptop orchestra experience changed their viewpoints on their musicianship. A few students answered that their viewpoints on their musicianship had not changed (14%). Those who noticed a change mentioned an increased value of and improvement in improvisational skills (19%); an expanded definition of music as sound and the nature of musical performance (10%); the fluid and exploratory nature of music and emotional freedom of expression (10%); and a raised appreciation for electronic and experimental music (10%; see Table 9). When asked if the student members planned to continue performing computer music after they left the orchestra, the responses were optimistic and included yes (50%), no (18%), maybe (9%), and they have plans to practice coding in order to perform in the ensemble again (9%; see Table 10).

Laptop Ensemble Directors

Directors primarily had an instrumental background with their primary instruments being guitar (55%), piano (27%), keyboard (27%), percussion (18%),

trumpet (18%), and electric bass (18%; see Table 11). The directors had participated in orchestra (45%), jazz ensemble/combo (36%), big band (36%), wind ensemble/concert band (36%), concert choir (27%), and rock band (27%); signaling more of a jazz and rock background (see Table 12). The training and qualifications for a laptop orchestra director at the university level were varied, with backgrounds including vocational knowledge (64%); other education, including online training and self-taught (45%); and music production software, such as Max/MSP and Ableton (45%; see Table 13).

When asked about their goals in creating a laptop orchestra, 45% of directors stated that they had obtained their goals which included creating a platform to explore modes of creating music with laptop mediation (27%); use as a pedagogical tool for creating and performing with technology (18%); large ensemble experience for students with a technologically based primary instrument, as required for music degree plan (18%); and a space to work on improvisation techniques (18%; see Table 14). The student learning outcomes put into place by the directors included performing with technology/exploring the intersection of music and technology (64%), creating meta instruments/electronic instruments involving coding (45%), composing/notating for nontraditional instruments (36%), and improvisation (36%; see Table 15). When asked if they taught music literacy, music history, or music theory in rehearsals, directors' most frequent responses were that they teach performance practice/musicality in performance (27%), concepts are discussed when they arise, depending on student background (27%), discussion of related works (18%), music notation/graphic notation (18%), history of electronic music (18%), and that they do not teach any of those concepts (18%; see Table 16). A significant portion of the laptop orchestra experience was composing and

improvising. All directors reported programming student compositions on concerts, with some using student works exclusively (see Table 17).

Responses from directors regarding the financial costs involved in creating such an ensemble varied, with some participants stating that while the equipment is expensive, cost is dependent upon the extant resources of the institution and the focus of the ensemble (20%). An equal number of participants (20%) reported that there is no significant cost as equipment is provided by students and/or borrowed and the software used is free. Ensembles that provided equipment estimated set up costs anywhere from $10,000 to $75,000 with yearly operational costs from $100 to $2,000. Several directors mentioned the cost-to-benefit ratio of providing equipment, as connectivity and maintenance issues arise more frequently with student-provided laptops (see Table 18).

The time investment was an area of concern for directors (27%), who stated that they spend anywhere from 5-100 hours creating and debugging each musical selection Additionally, directors (18%) reported that for 3 hours a week of rehearsal, they spend 3 hours setting up for rehearsal and 1-3 hours coding (see Table 19). Many directors commented on the growth of music technology and predicted that, eventually, technology-based ensembles would be standard in secondary schools. Specific areas that directors addressed included the experience level of the teacher/director (36%) and the accessibility of performing with technology on hand (27%; see Table 20).

Table 1

Traditional Instruments Played by Laptop Orchestra Members

Instrument	Responses	%
Piano	12	55
Guitar	6	27
Voice	5	23
Percussion	5	23
Trumpet	3	14
Violin	2	9
Drums	2	9
Tabla	1	5
Oboe	1	5
Analog Synthesiser	1	5
Woodwinds	1	5
Viola	1	5
Trombone	1	5
Electric Bass	1	5
Banjo	1	5
Mallets	1	5
Flute/Piccolo	1	5

A total of 22 participants provided 45 responses.

Table 2

Previous Ensemble Participation by Laptop Orchestra Members

Ensemble	Responses	%
Wind Band	9	45
Marching Band	8	40
Orchestra	5	25
Concert Choir	5	25
Jazz Ensemble	3	15
A cappella	2	10
Middle School Band	2	10
Early Music Ensembles	2	10
Vocal Jazz Ensemble	1	5
Grade School Band	1	5
Jazz-Rock Combo	1	5
New Music Ensemble	1	5
Punk Rock Band	1	5
Steel Drum Ensemble	1	5
Percussion Ensemble	1	5
Laptop Ensemble	1	5
DIY	1	5
Drum Corps	1	5

A total of 20 participants provided 46 responses.

Table 3

Laptop Orchestra Members' Major and Minor Field of Study

Major/Minor	Responses	%
Music Technology	6	27
Computer Science	3	14
Math and Computer Engineering	2	9
Music Composition	2	9
Discrete Mathematics	1	5
Electrical and Computer Engineering	1	5
Mechanical Engineering	1	5
Aerospace Engineering	1	5
Computer Engineering	1	5
Music Performance	1	5
Geosciences	1	5
Neurosciences	1	5
Music Engineering Technology	1	5
Music Engineering	1	5
Marketing	1	5
Music (Minor)	1	5
Business (Minor)	1	5
Electrical Engineering (Minor)	1	5
Computer Science (Minor)	1	5
Jazz and Commercial Studies (Minor)	1	5

A total of 22 participants provided 29 responses.

Table 4

Laptop Orchestras' Members Career Goals

Goals	Responses	%
Being happy/making and doing cool things	3	14
Software Development	3	14
Unsure	3	14
Music Performance Career	3	14
Songwriter/Composer	3	14
Studio Recording/Mixing Engineer	2	9
Producer/DJ	2	9
Touring Sound Engineer	2	9
Finding Employment	2	9
Earn Degree	1	5
Computational Finance-Quant and Analyst	1	5
Aid in sending astronauts to Mars	1	5
Program Management	1	5
Graduate School	1	5
Teach Private Music	1	5
Teach at the University Level	1	5
Own Recording Studio	1	5
Research	1	5
Build a foundation in the industry (Music Tech)	1	5
Event Production	1	5
Sound Engineer (General)	1	5
Sports Team Marketer	1	5
Work for Microsoft	1	5

A total of 22 participants provided 36 responses.

Table 5

Computer and/or Engineering Training and Experience of Laptop Orchestra Members

Training/Experience	Responses	%
Programming & Scripting Languages (Java, HTML, JavaScript, C, C#, SML, CSS, Python, Ruby, ChucK)	16	73
College Coursework (Computer Science, Engineering, Digital Composition)	11	50
Music Software & Technologies (Max/MSP, Digital Composition, Audio Mixing, Protools, MOTU, Logic/Reaper)	9	41
None	5	23
Vocational Training (Internships, Certifications)	4	18

A total of 22 participants provided 45 responses.

Table 6

Why Members Decided to Join a Laptop Orchestra

Reason for Joining	Responses	%
Expand Knowledge and Understanding of Electronic Music	5	23
Expand Musical Skills	4	18
Interesting - Enjoyment of both computers and music	4	18
Requirement-Computer Music Class	3	14
Desire to enhance technological skills	3	14
Fun/Open/Sweet Environment	2	9
Enjoyment of Electronic and Experimental Music	2	9
Desired Collaborative Experience with Faculty and Driven Students	2	9
Class Assignment	1	5
Gain Experience Improvising	1	5
Embrace Intersection of Computer Science and Music	1	5
Gain New Perspective	1	5
Coincides with Primary Instrument (Laptop)	1	5
Coincides with Major (Technology Performance)	1	5
Desire to be in an ensemble unlike any previously experienced	1	5

A total of 22 participants provided 32 responses.

Table 7

What Members Learned About Music Literacy, Music History, or Music Theory

Musical Concept	Responses	%
None/Little	8	36
Had prior Theory knowledge	2	9
Theory is helpful but not needed	2	9
History of electronic and experimental music	2	9
Chord Progressions	2	9
Historical origins of Laptop Orchestra	1	5
Beat Patterns	1	5
Keeping an open mind	1	5
Working with non- musicians/Anyone can make sound	1	5
Basic Theory principles for Composition	1	5
How to better verbalize musical ideas	1	5
Aural Skills-listening for niche during improvisation	1	5
Music Arranging/remixing	1	5
Musical Modes	1	5
Composers	1	5
Understanding of genre and interpretation	1	5
Layering	1	5

A total of 22 participants provided 28 responses.

Table 8

What Members Learned About Technology through Involvement in the Laptop Orchestra

Tech Concept	Responses	%
Max/MSP	5	24
Ableton	3	14
Interconnectivity of Art and Technology	2	10
Programming	2	10
Learned how to deal with technical issues	2	10
Possibility of Ensemble (no prior knowledge)	1	5
Understanding of how computers produce desired sounds	1	5
Programming generation of sound	1	5
Difficulty in synchronizing computers	1	5
SuperCollider language	1	5
VNC	1	5
Linux based audio pipeline (Jack, SuperCollider)	1	5
How to use technology to enhance, not replace, musical performance	1	5
Vast potential for electronic instrument making	1	5
General Computer Skills	1	5
Wiring/Hardware	1	5
Synthesis and Improvisation	1	5
Possibilities and limitations of technology	1	5
AM Synths	1	5
DSP	1	5
Motivated to learn Linux on own time	1	5

A total of 22 participants provided 30 responses.

Table 9

Changed Viewpoints about Musicianship by Laptop Orchestra Members

Area	Responses	%
Value and Improvement in Improvisational Skills	4	19
No	3	14
Expanded Definition of Music as Sound and the nature of musical performance	2	10
Fluid and exploratory nature of music and emotional freedom of expression	2	10
Raised appreciation for electronic and experimental music	2	10
Highlighted Human Expressiveness	1	5
Underlined the difficulty in creating random music	1	5
Exploration in the Composer/Performer relationship and collaborative process	1	5
Improve blend and balance with other performers	1	5
Adapting to new performance conditions	1	5
Group collaboration	1	5
Provided first hand experience with electronic music	1	5
Feeling of being a legitimate musician who can work in a group setting	1	5
Improve live DJ performances	1	5
Raised personal musicianship to meet the level of other ensemble members	1	5
Development of imagination, creativity, and compositional editing	1	5
More open to non-traditional instruments	1	5

A total of 21 participants provided 25 responses.

Table 10

Members Plans to Continue Performing Computer Music Either Alone or With Others after Leaving Laptop Orchestra

Plan to Continue	Responses	%
Yes/definitely/absolutely	11	50
No	4	18
Maybe/for leisure	2	9
Plan to practice coding alone, would perform in ensemble again	2	9
Incorporate skills into electroacoustic performances	1	5
Currently composing electronic music for self- performances	1	5
Wish to continue professionally	1	5

A total of 22 participants provided 22 responses.

Table 11

Traditional Instruments Played by Laptop Orchestra Directors

Instrument	Responses	%
Guitar	6	55
Piano	3	27
Keyboard	3	27
Percussion	2	18
Trumpet	2	18
Electric Bass	2	18
Harmonica	1	9
Violin	1	9
Clarinet	1	9
Voice	1	9
Accordion	1	9
Oud	1	9
Rubab	1	9
Saxophone	1	9
Drum set	1	9
Hand percussion	1	9
Woodwinds	1	9
Double Bass	1	9
Trombone	1	9

A total of 11 participants provided 31 responses.

Table 12

Laptop Orchestra Directors' Previous Music Ensemble Membership and/or Conducting Experience

Ensemble	Responses	%
Orchestra	5	45
Jazz Ensemble/Combo	4	36
Big Band	4	36
Wind Ensemble/Concert Band	4	36
Concert Choir	3	27
Rock Band	3	27
Brass Quartet/Quintet	2	18
Direct/founded laptop orchestras/mobile phone orchestras	2	18
Madrigal Choir	1	9
Church Choir	1	9
Ukulele Orchestra	1	9
Musica Sacra	1	9
Experimental group	1	9
Improv Collectives (acoustic and electric)	1	9
String quartet	1	9
Strolling string group	1	9
Founder - Create Ensemble	1	9
World Music groups	1	9
Sax Quartet	1	9
Tango Ensemble	1	9
Electro-country band	1	9
Free Jazz group	1	9
Modern Classical group	1	9
Marching Band	1	9

A total of 11 participants provided 43 responses.

Table 13

Laptop Orchestra Directors' Computer and/or Engineering Training and Experience

Training/Experience	Responses	%
Vocational Knowledge (Training, Professorship, Startup CTO, Researcher, Mechanical Engineer, Recording Studio, Mixing/Mastering)	7	64
Other Education (College Coursework, Online Training, Self-taught)	5	45
Music Production Software (Max/MSP/Jitter, General Music Technology, Ableton, SuperCollider)	5	45
Doctorate (Computer Science, Music Composition, Experimental Music & Digital Media)	4	36
Masters (Computer Science, Computer Engineering, Electroacoustic Music, Electronic Music Studies)	4	36
Programming and Scripting Languages (Fortran/Pascal, HTML/XML, SQL/PHP, C++/JavaScript/Java)	4	36
Bachelors (Electrical Engineering, Computer Science)	3	27

A total of 11 participants provided 32 responses.

Table 14

Director Goals in Creating a Laptop Orchestra

Goals	Responses	%
Yes, we obtained our goals	5	45
Platform to explore modes of creating music with laptop mediation	3	27
Pedagogical tool- Create and perform with technology	2	18
Large ensemble experience for students with a technological based primary instrument (as required by NASM for degree plan).	2	18
Work on Improvisation Techniques	2	18
Creating interesting projects for students and self	1	9
Create environment for collective performing and teaching of electronic music	1	9
Electronics as medium to explore aesthetic ideas	1	9
Research workshop and performing group	1	9
Collaborative Composition	1	9
Doing new things/making new music	1	9

A total of 11 participants provided 20 responses.

Table 15

Laptop Orchestra Directors Student-Learning Outcomes for Their Orchestra

SLO	Responses	%
Performing with technology/intersection of music and technology	7	64
Creating Meta-instruments, electronic instruments involving coding	5	45
Composing and notating for nontraditional instruments	4	36
Improvisation	4	36
Usage of Commercial devices	2	18
Software organization/development	2	18
Developing creativity in sonic exploration	2	18
Collaborative skills in small groups and ensembles	2	18
Appreciation for experimental music making/expanding concept of sound	2	18
Joy of collective music making (composing and performing)	2	18
Developing students as performers	2	18
Engineering	1	9
Rehearsal Techniques	1	9
Listening	1	9
Music performance for science/engineering students	1	9
Understanding real-time scheduling techniques (CS course)	1	9
Networking (CS course)	1	9
Music generation techniques	1	9
Learning to code	1	9
Developing students as interpreters	1	9
Performing with appropriate tone, technique, and musicality in primary medium	1	9
Performing at the highest possible level	1	9
Learning musical Aesthetics	1	9

A total number of 11 participants provided 46 responses.

Table 16

What Directors Teach About Music Literacy, Music History, or Music Theory in Rehearsals

Musical Concept	Responses	%
Performance practice/musicality in performance	3	27
Concepts discussed when arise, depending on student background	3	27
Discussion of related works	2	18
Music notation/graphic notation	2	18
History of electronic music	2	18
No	2	18
Scales	1	9
Keys	1	9
Rhythm	1	9
Improvisation Techniques	1	9
Musical Form	1	9
Sound Elements (Pitch, Duration, Amplitude, Timbre)	1	9
Arrangement/Orchestration	1	9
Origins of Laptop Orchestras	1	9
Philosophy and ethics of musical instrument design	1	9
Theory of how the technology works	1	9
Sound Design	1	9
Composition	1	9

A total of 11 participants provided 26 responses.

Table 17

Amount of Musical Works Improvised or Composed by Students in the Laptop Orchestra per Semester

Number of Works	Responses	%
One work composed per Student	2	18
10–20 pieces	2	18
All works on a concert are created by individuals, small groups, or the whole class	2	18
Split composing and performing into separate semesters	1	9
3–6 improvised pieces per student	1	9
One large class piece	1	9
8–10 Small group pieces	1	9
On a 6–7 work concert, 4–5 are directly created by students	1	9
3–4 works for large ensemble	1	9
5–7	1	9
8 small ensemble pieces and 8 full ensemble pieces	1	9

A total of 11 participants provided 14 responses.

Table 18

Costs Involved in Developing and Maintaining a Laptop Orchestra

Cost	Responses	%
Expensive, depends on resources and ensemble focus	2	20
Equipment is student provided and/or borrowed. Software is free - no significant cost.	2	20
Sanity	1	10
Financial cost vs. Time cost - expensive to provide equipment, but less time spent debugging student laptops	1	10
Initial cost $30,000–$500 per year to maintain	1	10
Equipment, time	1	10
Institution already owned equipment - spend a few hundred per year on cables, tables, etc.	1	10
Close to $10,000 (decade ago) for hemisphere speakers and laptops	1	10
Money for parts to repair speakers	1	10
Money to buy 2 or 3 new computers per year	1	10
Visiting artist fee	1	10
Controller/inputs ($100 each for 10 performers = $1,000)	1	10
$75K startup fund for 20 full stations.	1	10

A total of 10 participants provided 15 responses.

Table 19

Time Investment in Starting and Maintaining the Laptop Orchestra

Time	Responses	%
Piece setup 5–100 hours to create and debug	3	27
Maintaining Computers - Keeping synchronized	2	18
3 hours rehearsal, 3 hours setup outside rehearsal, 1–3 hours coding per week	2	18
High/significant - many hours per week to maintain	2	18
Setup and prep for rehearsal 30mins to 1 hour before rehearsal	1	9
1.5 full work day per week	1	9
Several weeks for initial setup (purchasing hardware, studying other groups, etc.)	1	9
Rehearsal 1.5 hours per week	1	9
Rehearsal 2 hours per week, approximately 13 hours outside of rehearsal work	1	9
Depends - Students already have some technological experience	1	9

A total of 11 participants provided 15 responses.

Table 20

Director Thoughts on the Future of Laptop Orchestras and the Possibility of Integration into a Secondary School Setting

Thoughts	Responses	%
Yes	7	64
Teacher will need a lot of experience	4	36
May be more feasible to perform with technology on hand	3	27
Technology based music is growing and will eventually find its way into secondary schools, but that may not be in the laptop orchestra format.	3	27
Preparatory time for school computers is high	2	18
Debugging and connectivity issues are high for student computers	2	18
Integration of live electronic performance with other skills (Singing, instrumental performance, composition, music production) may be a better route	2	18
Focus of electronic ensembles on developing musical creativity	2	18
Laptop Orchestras have a limited application outside the University setting	2	18
Laptop Orchestras are evolving for more portable devices	1	9
Schools will need the right resources/space	1	9
Wide range of places for laptop orchestra	1	9
Groups are currently for experimentation and research, could fit into schools with more codification	1	9
Electronic ensembles at the secondary level may need to be more director driven due to skill level of participants	1	9
A challenge is the lack of repertoire for the ensemble	1	9
They are a great vehicle for music making, social skills, improvisation, and technology/programming	1	9

A total of 11 participants provided 34 responses.

CHAPTER V

DISCUSSION

Research Questions

Research Question 1

Are laptop orchestras a viable option as an auxiliary ensemble in the secondary setting? According to this study, the answer is "yes," with the caveat that the director would need to have a firm background in computer science, music technology, and, if possible, hands on experience performing in a similar ensemble. Currently, finding a teacher who meets these requirements or is willing to acquire the skills needed may be difficult. Performing with music technology is still a new and developing concept; integrating it into the traditional music education degree plans at the university level may take time. If a director is interested in developing the skills to start a laptop orchestra, he/she would need to teach himself/herself and/or seek out assistance from electronic music composers and performers.

Potential laptop orchestra directors would also need to find creative ways to streamline the operation to work in a secondary setting. The time it takes to run such an ensemble was an area of concern for laptop orchestra directors. This issue would need to be addressed before laptop orchestras were added to the secondary level schools, in that lack of time is a problem that plagues many music educators. The directors surveyed noted that simplifying the operation with the use of Soundcool (www.soundcool.org), Web Audio API (Audenot & Wilson, 2017), and music applications may work better at the secondary level. Some directors mentioned that a general electronic music ensemble

might be more feasible, as schools can use technology on hand and are not confined to the laptop orchestra model.

Research Question 2

Do the student learning objectives for laptop orchestras differ from traditional ensembles? Yes, traditional ensembles offered in secondary public schools typically focus on teaching and preserving the performance practices associated with Western art music. Although learning objectives differ from teacher to teacher, traditional ensembles generally spend more time working on student proficiency on her instrument, music literacy in sight-reading and rehearsing, and performance etiquette. The four main learning objectives identified by laptop orchestra directors included: 1) performing with technology, 2) creating meta-instruments, 3) composing and notating for nontraditional instruments, and 4) improvisation. These objectives gravitate more towards individual student creativity in addition to performance.

Research Question 3

Could a laptop orchestra sufficiently fulfill national and state music education standards? Yes, in their current form, laptop orchestras fulfill the national music standards, outlined by the National Standards for the Arts (2014), which include creating, performing, and responding to music. The 2014 National Standards even have a separate section specifically addressing music technology classes at the secondary level. Laptop orchestras also fulfill the broad state music education standards for the state of Texas, outlined in the Texas Music Essential Knowledge and Skills for Fine Arts (2013), which include foundations: music literacy; creative expression; historical and cultural relevance; and critical evaluation and response. The only difference is that laptop orchestras deviate

from the Western art tradition, so the music literacy is based more on graphic notation than traditional Western notation.

In addition to fulfilling the national and state standards for music, many of the technological concepts covered in the ensemble could fulfill necessary requirements for a technology applications or computer science class. Because of the unique nature of having a laptop as the instrument, laptop orchestras are a hybrid music and technology ensemble. Universities surveyed were not uniform in which department the class was offered. Some offered the class as a music class; others offered it as a technology/computer science class; and others offered it as a music technology class in a department separate from the University's music department. With current educational interest in STEM/STEAM, the curricular implications of such an ensemble could have enormous potential at the secondary level.

Research Question 4

Could laptop orchestras serve as an attractive alternative for nontraditional music students? Yes. Although the students surveyed had some sort of traditional music background, many of them joined the ensemble because it was different from what they had experienced before and it combined computer science and music. A point of interest is how many of the student members played piano and guitar, instruments which usually do not have large ensembles associated with them at the secondary level. Another element to consider is the laptop itself being an instrument, and musicians in the laptop orchestra considering it to be their primary instrument.

If a student is making music with their laptop, what ensembles are available in which they can participate? This issue was brought up by the directors as a few noted that

they started the ensemble to fulfill the National Association of Schools of Music (2016) accreditation requirements by which music students must participate in large ensembles. While providing a large ensemble opportunity for all students is not a requirement at the secondary level, music educators are in a unique position to potentially provide music education to students who may not fit in a traditional ensemble. Additionally, the various inputs used in laptop orchestras could be modified for use with students with special needs. Currently, electronic music performers with physical disabilities are using music technologies, such as the EyeHarp. Incorporating these technologies into a secondary level laptop orchestra can provide more opportunities for students to participate in musical ensembles.

Musical Collaboration

Throughout the survey answers, a consistent concept that arose was musical collaboration. Directors viewed the ensemble as a place to explore new sounds through composition and improvisation. A few directors pointed out that the ensemble also serves as a research lab, a place where students can share ideas and actively collaborate in the composer/performer relationship. The students, when asked how the experience changed their viewpoints about their musicianship, reported that they gained improvement in improvisational skills, an expanded definition of sound, and more fluidity in expression.

When asked why they chose to join a laptop orchestra, the students expressed a desire to participate in a collaborative environment. A few members expressed their initial reason for joining was the unique setting that allowed them to actively collaborate with their professors and motivated students. Having a professor or faculty member in the position as both teacher and joint collaborator is rare in conventional ensembles.

Traditionally, the ensemble director only participates in performances visually through conducting and in rehearsals by dictating to the performers how they want the music to be interpreted. The laptop orchestra setting adheres to more of a master/apprentice model in which both parties work together on a project. This dynamic offers a refreshing alternative and extraordinary opportunity for motivated music students.

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APPENDIX A

Laptop Orchestra Directors Survey

Laptop Orchestra Directors Survey

1. Do you play any traditional instruments? If so, which ones?
2. List any other musical ensembles in which you have been a member or director.
3. Describe your computer and/or engineering training and experience.
4. What are/were your goals in creating a laptop orchestra? Have you obtained them?
5. What is the time investment in starting and maintaining the laptop orchestra?
6. What are/were the costs involved in developing and maintaining a laptop orchestra?
7. What are/were the student learning outcomes for your laptop orchestra?
8. Do/did you teach music literacy, music history, or music theory in rehearsals? If so, elaborate.
9. On average, how many musical works are/were improvised or composed by students in the laptop orchestra per semester?
10. What do you foresee as the future for laptop orchestras? Do you think this type of ensemble could be integrated in secondary public schools?

APPENDIX B

Laptop Orchestra Members Survey

Laptop Orchestra Members Survey

1. Do you play any traditional instruments? If so, which ones?
2. List any other musical ensembles in which you have been a member.
3. What degree are you pursuing? What is your major field of study? What is your minor field of study (if applicable)?
4. What are your career goals?
5. Why did you choose to join a laptop orchestra?
6. Describe your computer and/or engineering training and experience.
7. Has your laptop orchestra experience changed your viewpoints about your musicianship? If so, elaborate.
8. What have you learned about music literacy, music history, or music theory through your involvement in the laptop orchestra?
9. What have you learned about technology through your involvement in the laptop orchestra?
10. Do you plan to continue performing computer music either alone or with others after you leave the laptop orchestra?

APPENDIX C

Internal Review Board Exemption Letter

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378
email: IRB@twu.edu
http://www.twu.edu/irb.html

DATE: March 23, 2017

TO: Ms. Sarah Hamilton
Music & Drama

FROM: Institutional Review Board (IRB) - Denton

Re: Exemption for Integration of Laptop Orchestras in Secondary Public Schools: A Feasibility Study (Protocol #: 19514)

The above referenced study has been reviewed by the TWU IRB (operating under FWA00000178) and was determined to be exempt from further review.

If applicable, agency approval letters must be submitted to the IRB upon receipt PRIOR to any data collection at that agency. Because a signed consent form is not required for exempt studies, the filing of signatures of participants with the TWU IRB is not necessary.

Although your protocol has been exempted from further IRB review and your protocol file has been closed, any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any adverse events or unanticipated problems. All forms are located on the IRB website. If you have any questions, please contact the TWU IRB.

cc. Dr. Pamela Youngblood, Music & Drama
Dr. Vicki Baker, Music & Drama
Graduate School

APPENDIX D

Signature Page

TEXAS WOMAN'S UNIVERSITY

DENTON, TEXAS

November 16, 2017

To the Dean of the Graduate School:

I am submitting herewith a thesis written by Sarah Hamilton entitled "Integration of Laptop Orchestras in Secondary Public Schools: A Feasibility Study." I have examined this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts with a major in Music Education.

Vicki Baker, PhD, Major Professor

We have read this thesis and recommend its acceptance:

Carter Biggers, DMA

Paul Thomas, PhD

Department Chair

Accepted:

Dean of the Graduate School