Composing Music With Computers: Good Art or Bad?

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This curriculum unit is recommended for:
General Music / 5th Grade

Keywords: artificial intelligence, music composition, virtual music, musical engineering

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis:

Upper elementary music students are ready to begin assimilating the essential elements of music they have been learning about since kindergarten. They are beginning to move beyond showing their responses and understanding with their bodies and voices, and are becoming equipped to engage in higher level discussion about the music they hear, to interpret musical notation on their own, and to begin some level of guided musical composition. In this unit, students will have the opportunity to increase these musical skills through the vehicle of learning about the exciting advancements at the crossroads of artificial intelligence and music, especially music composition. There are a lot of interesting articles and videos documenting both good and bad results and reactions to this sometimes controversial intersection. This is the kind of thought-provoking information that students preparing for success in the 21st century marketplace can clearly benefit from. The activities developed will give students a better understanding of what musicians and composers have been doing for centuries, as well as create some exciting glimpses into the rapidly expanding possibilities of problem solving and creating as we look to the future, both in music, and in a myriad of other subjects!

I plan to teach this unit during the coming year to 120 students in Music/Grade 5.

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Composing Music With Computers: Good Art or Bad?

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Rationale

As a Music Teacher in the year 2014, I see myself with 3 basic purposes. The first is to help each student become a *musician*; growing in the musical knowledge and skill necessary to achieve the objectives expected of them at their grade level, understanding that after leaving me, each will be on a personal path that will lead to a wide variety of experiences and levels of development. No matter where each child's path leads, my hope is that each one will have at least learned to understand and appreciate the art and culture of the music that touches his or her life. The second purpose is to use the enjoyment and impact of music to help students learn about a variety of valuable subjects as well as to *learn how to learn* by teaching them to exercise skills such as observing, analyzing, applying, and creating. My third purpose is to help them to become better human beings by paying attention to meanings of lyrics, the emotions and moods emanating from the melodies and rhythms, the importance of values and skills such as listening, cooperation, perseverance, risk-taking and respect while working with other musicians and peoples in the classroom and around the world. I believe that exploring the world of music composed and analyzed by artificial intelligence with the help of the people who invented it can help me accomplish all three purposes.

Most children like to listen to music, but not too many have aspirations to create it. The biggest reason is that music composition seems difficult and intimidating. It's something that professionals do, right? Elementary music classes only meet once a week, usually for approximately 45 minutes, and it is a challenge for many students just to remember the names of the notes on the music staff and how many beats each note gets, let alone putting them together correctly in an order that actually sounds good. I am always looking for new ways to provide my students with the guidance and tools that make this creative task a lot more fun and a lot less intimidating. I think that showing short videos about how computers create music using artificial intelligence, and asking questions about the quality of music created versus music composed by "real" intelligence, will whet their appetites for giving composition a try. Using music composition games and activities, both on the computer and off, will give them the guidance and comfort needed to increase their success.

Teaching our students to be both problem solvers and creative thinkers is a double-barreled weapon that will go a long way in preparing them to be successful in today's continually changing technological and informational landscape. That intersection of both the right and left brains is stronger than either side functioning on its own. Artificial intelligence and engineering shouldn't be considered foreign to the arts, but rather friends

in the common quest for advancement. I think AI can give artistic expression a greater degree of order and power, and conversely, the Arts give AI the opportunity and challenge to develop sensitivity and expression.

Introduction

"Music seems to be such a human thing, and, although it does follow mathematical patterns, a computer couldn't ever write good music could it? And if it could we're miles off, right? Think again."[1]

The reviews are mixed, but computers are doing amazing things in the realm of musical composition! Current research also includes the application of AI in music performance, theory, and digital sound processing, as well as music therapy and psychology. I believe that my students will be inspired and empowered by the thought that they can collaborate with a computer to compose music. I also hope they will be inspired to remember the importance of the uniquely "human" qualities we are teaching our computers to emulate.

Content Background

Artificial Intelligence or AI is "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings."[2] Since the development of the digital computer in the 1940's, computers have been programmed to carry out very complex tasks, such as discovering proofs for mathematical theorems, playing chess, making medical diagnoses, acting as search engines, interpreting languages and recognizing handwriting. However, even though the abilities of digital robots and computers have increased greatly in recent years in correlation with increased processing speed and memory, can we really call them *intelligent*? "Psychologists generally do not characterize human intelligence by just one trait but by the combination of many diverse abilities. Research in AI has focused chiefly on the following components of intelligence: learning, reasoning, problem solving, perception, and using language."[3]

The first work of any substance in the field of artificial intelligence was done in the mid-1900's by the British logician and computer pioneer, Alan Mathison Turing. He gave what was likely the earliest public lecture in 1947, London, that mentioned computer intelligence saying, "What we want is a machine that can learn from experience", and the "possibility of letting the machine alter its own instructions provides the mechanism for this". Though he never published it, in 1948 he introduced many of the central concepts of AI in a paper entitled "Intelligent Machinery", and in 1950, Turing gave pause to the ongoing debate concerning the definition of intelligence with the introduction of the Turing Test. This practical test for computer intelligence involved 3 participants: a computer, a human interrogator, and a human foil. If the interrogator

can't figure out which answers come from the computer, and which answers come from the human foil, "the computer is considered an intelligent, thinking entity." [4]

Although the goal of getting a computer to pass the Turing Test has inspired progress in the achievement of strong AI – "artificial intelligence that aims to duplicate human intellectual abilities"[5], it is by no means a satisfactory determinant of whether or not the computer is actually intelligent. Is being able to perform a task as well as or more flawlessly and impressively than a human really what makes a computer intelligent? The problem of defining intelligence is that "intelligence is simply our name for any problem-solving mental process that we do not yet understand."[6] As soon as one summit is reached, it no longer seems to be the goal, but rather just another step on the journey to an ever-elusive destination.

Even more relevant to the development of this curriculum unit, are the advances in a computer's ability to intelligently generate or compose new music. "Virtual music represents a broad category of machine-created composition which attempts to replicate the style but not the actual notes of existing music (Cope 1993)."[7]

Virtual music in some form has existed for centuries. During the Baroque period of music history (1600-1750), composers and performers used notated music (figured bass), period style constraints or rules, and performer choice or improvisation "to produce a diversity of results and yet adhere to a composer's style".[8] In the eighteenth century, one of the first formal types of algorithms in music history is an example of virtual music called *Musikalisches Wurfelspiel*, or musical dice game. The idea of this sophisticated game requires "composing a series of measures of music that could be recombined in many different ways and still be stylistically viable—virtual music."[9] The dice is rolled and the measures placed within the numbered matrix are combined to make a "new" composition. The measures had to be designed by the composer to successfully connect with those in the column to their immediate right. However, their apparently arbitrary arrangement made the outcome seem quite amazing when played in an eighteenth-century parlor. Several composers of the Classical period used these combination techniques to construct minuets, concertos, and symphonies. Composition and performance of popular music today has some real essential similarities to that of music from the Baroque period, although the musical styles are radically different. They still have a given part, a derived or implied rules part, and a free part, though popular music uses a melody instead of a bass line and note names of chords instead of Arabic numerals indicating inversions.

In the past sixty plus years, pioneers of musical composition by computer have made significant advances. Their virtual music compositions are the result of a variety of mathematical models, algorithmic construction, recombination, neural nets, and backpropagation techniques. Two of the most significant figures that have emerged at

the forefront of AI and music composition in recent years are David Cope of the United States, and Francisco Vico of Spain.

In 1987, David Cope's computer program named "Emmy", short for Experiments in Musical Intelligence, passed a variant of the Turing Test. "The audience, full of musical and academic luminaries, was polled on which pieces were Bach's and which were Emmy's. They couldn't tell the difference."[10] Amazingly, Emmy was able to compose over 500 chorales in half an hour, which is 15 times more than Bach composed in his entire lifetime! In the 1990's, Cope created a program that used only the output of "Emmy" as a source database for its musical choices. By encouraging and discouraging this "composer", known as "Emily Howell", Cope, Dickerson Emeriti Professor at the University of California at Santa Cruz where he teaches theory and composition, and Honorary Professor of Computer Science at Xiamen University, China, "attempts to teach it to compose music more to his liking." Emily Howell's newest MP3 album, "Breathless", is available on Amazon.

Francisco Vico and the team he has assembled at the University of Malaga, Spain, have used their heralded computer program, Iamus, to generate over 1 billion songs of a multitude of genres, including symphonies composed for the London Symphony Orchestra. His start-up company, Melomics Media, adapts Iamus' technology to create and sell royalty-free versions of its immense repertoire for around $2 a song as well as a suite of apps which adapt music to the consumer's moods and activities. Although many people think that music created by a computer is without a message and doesn't mean anything, Vico believes that, "In the future, we could add that layer of feelings, of intentionality…This will be very, very easy compared to what we have already done."[11]

Background

The students I teach attend Barringer Academic Center, a K-5 elementary school in the Charlotte-Mecklenburg School District. It is a National Magnet School of Excellence, and proudly Exceeded Growth on standardized tests in North Carolina this past 2013-2014 school year. Enrollment is around 630 students, and we have a diverse population of African American, Asian, Caucasian, Multi-race, and Hispanic students.

BAC is a partial magnet school, with three different programs: Horizons is for the highly gifted with students who perform two to four years above their grade level. Potential students and their parents fill out an application, complete a series of tests and attend an interview to see if they qualify. Learning Immersion is a magnet program for our K-2 students, and during their second grade year, all students can be tested to see if they qualify to move on to the Talent Development program for gifted students in grades 3-5. The gifted programs are very popular, but most of those students have to travel from outside of our zone to attend Barringer. The majority of our students are from the

surrounding neighborhoods and receive free or reduced lunch. Most do not qualify for the gifted programs and so they are participants in our Academy program. Several are working below grade level and benefit from our dedicated Exceptional Children staff and the hard work of their classroom teachers.

Every student gets to attend Music Classes once a week. We have 36 kindergarten thru 5th grade classes at Barringer, and each Special Area teacher teaches six periods each day. In order to fit all classes into the five day rotation, one class from each grade level is dispersed among the other classes of the same grade. This means that music classes range from 20 to 30 students in size. Three days a week, all Special Area classes are 45 minutes long, and 2 days a week, they are 60 minutes in length, with the extra time built in to allow a restroom break. Our class curriculum in Charlotte-Mecklenburg is up to the individual music teacher, but it is consistently aligned to the North Carolina Essential Standards for grades K-5. I use the music curriculum of two different publishers along with a number of supplemental materials that I have developed myself or purchased with the help of our PTA. 4th and 5th graders can audition for the BAC Chorus which meets one morning a week before school.

In 5th grade, I focus on strengthening my student's rhythm and note reading skills in the first semester including writing notes, games, puzzles, and other group activities, singing a variety of songs and playing rhythm instruments so that they are prepared for at least 8 weeks of recorder or xylophone playing from the end of January thru mid-March. This unit is followed by 2 weeks spent studying Italian music as part of our school-wide emphasis on world cultures. After that, I have typically focused on musical elements and style, often doing a Jazz unit since jazz music encompasses so many different styles from Ragtime in the late 1800's, all the way to the Jazz Rock of today. This year, I will replace that unit with this Artificial Intelligence and Music Composition Unit for 7 weeks in April and May, and end the school year with an emphasis on musical instrument identification.

I have a nice-sized music classroom with five tables and chairs for up to thirty students. I have a good quality sound system, and just this year I got an LCD projector. I don't have a computer to hook up to it yet, but I can connect my iPad. Last year we got two carts of iPads that can be reserved for classroom use. I can also reserve our school's computer lab for a class period so that the students can access desktop computers.

Objectives

One of our North Carolina Essential Standards in Musical Literacy is to "create music using a variety of sound and notational sources". The purpose of this unit is to give fifth grade students with varying degrees of capability and understanding, multiple opportunities to practice composition skills with the degree of help and guidance that each students needs in order to learn and grow in their skill and comfort level. My fifth

graders should already be aware of the essential elements needed in music composition; such as the music staff, treble and/or bass clef, time signature, meter, measures, bar lines and notes. They should all be able to use whole, half, dotted half, quarter, and eighth notes and their corresponding rests in 2/4, 3/4, and 4/4 meter. Higher level students will be able to handle working with more advanced rhythms (dotted quarter note/eighth and sixteenth note patterns) and melodies that include ledger line notes. All students should be able to recognize a harmony or accompaniment part. Students at all levels should be encouraged to reach their potential.

One of the fifth grade music objectives is to create compositions and arrangements within specified guidelines. My students will create compositions within specified guidelines by spending time during five weeks of the unit with iPads or computers. They will learn how to compose with the help of three different computer programs in this unit: through the *Mozart's Dice Game* app on the iPads, and both *Scratch* and *Quaver Music* on the computers in our computer lab. These applications will provided an opportunity to create rhythmic compositions using notation for whole, dotted half, half, and quarter notes; whole, half and quarter rests; and beamed eighth notes in duple, triple, and common time and which are arranged using a variety of sound sources. *Quaver Music* provides a musical composition program for kids, which guides them to design their own musical composition by deciding which measures and instruments to choose and constructing them into a complete composition. So even though we don't have a professional drum set, percussion, bass, keyboard, synthesizer and brass instruments for each student, they can still meet the objective of using instruments to perform rhythmic, melodic, and chordal patterns accurately and independently.

I also want my young musicians to have some experience describing and explaining personal preferences for specific musical compositions and style using musical terminology. As always, I will encourage my students to use musical terms and related vocabulary, so that instead of saying "This song is cool!" they will learn to say, "This song has some interesting rhythms in it.", or, "I like the tone colors the composer chose." They will be able to use at least some of the tempo, dynamic, and articulation vocabulary displayed in the classroom. This activity will fulfill our mission to fulfill the objective that asks fifth grade music students to use music terminology in explaining music, including notation, instruments, voices, and performances. To facilitate this, students will have an opportunity to listen to music on the internet composed by both human and computer and compare them verbally and in writing. Some of these compositions of "Emmy" (Experiments in Musical Intelligence) are based on works by famous Baroque and Classical composers such as Bach, Vivaldi, Mozart, Chopin and Beethoven. We will also listen to some new music created by computer composers "Emily Howell" and "Iamus". I will ask the students to especially listen for hints of expressiveness.

Beyond just the musical aspects, I want my students to have some understanding of the 21st century connections between math, science, music, and technology by learning

about the strides in the development of AI. Short videos will be shown over the course of six weeks such as "Iamus/Melomics Documentary", "Artificial Intelligence and Music: Bryan Pardout TEDxUChicago", "Music and Creativity" from Science Nation, "Tech Closeup: Music Professor", "Pat Metheny – Orchestrion – EPK", and "Pat Metheny 'Improvisation #2' – excerpt – from the Orchestrion Project". These videos will help give the students a better understanding of how computers have been programmed to compose and what they are able to do as a result. They will be given the experience of creating through the lens of a computer programmer by doing some simple programming themselves as they work on their composition skills through the online program, *Scratch*. I also want my students to have a basic understanding of what algorithms are and their importance in problem solving and AI. The students will participate in activities designed to help us think like a computer programmer by finding answers to some musical problems using relevant data and trial and error.

This unit will reinforce fifth grade Common Core Literacy Standards in Speaking and Discussion. My music students will be called on to share their opinions and the reasoning behind them as they discuss the answers to questions about artificial intelligence in relation to composition and artistic expression. They will have the opportunity to share how any new facts they have learned about in this unit reinforced or changed their opinions, and will be required to follow the rules of discussion at their tables and with the whole class.

Some of their Common Core Literacy Standards for Writing will be supported as well. Each lesson, they will be asked to take a few minutes to write down their opinions about the question or questions asked. In music class, they will usually do this at the beginning of class, based only on their previous knowledge. After watching a video about AI and music composition in our lesson, each opinion should either be confirmed or challenged. On those days, when music class is over, I will send their packets with them as they return to their regular classroom. The classroom teacher will then give them an opportunity to express in writing how the video impacted what they had written previously and to give the reasons for their newly informed opinion along with a concluding statement.

Strategies

Questions and Discussion

Each lesson in this curriculum unit will include at least one of the following probing questions to get the class focused and thinking: *What is artificial intelligence? Can machines be creative? How is music created by artificial intelligence different or the same as music created by a human brain? How do machines learn to compose? Can computers make good music? Do computers help or hinder human creativity? Why is using computers to compose music fun? Scary? Easy? Hard? Can a computer show expression? Can a person overcome a weakness or disability with a computer?*

Whether created by human or computer, what do we want music to do? We will begin our discussion about artificial intelligence and music that will continue over the course of the unit. Sometimes we'll discuss our thoughts as a class and sometimes I will choose a facilitator to give each person at their table an opportunity to share their thoughts, and a spokesperson to share some of the best discussion from their table with the class. Some questions will need to be asked again when the students have received information or understanding that might change their answers.

We will also do a group activity that will require partnering with other students and comparing their rating of a variety of popular songs in an effort to better understand machine learning and get to know more about our classmates' musical tastes in the process. Early in the school year, I asked my students several questions about themselves, and one was, "What is your favorite song?" This will give me a source of songs that I know my students care about and will make the activity and the resulting discussion more engaging for them.

Talking Stick

In many Native American tribes, people used a "talking stick" to make sure that each person had a turn to share his or her ideas and opinions with the rest of the group. The person holding the stick had the right to speak. Everyone else was expected to listen with respect. When a person finished talking, he or she passed the stick to someone else. We will use this strategy when students are talking at the table. The facilitator that I choose at each table will be someone who I can trust to make sure that the stick gets passed quickly enough to give everyone who wants to a chance to share at least once. The stick will be passed to the left or clockwise since my students have seats that are numbered one thru six around their rectangular tables.

Journaling and Note Taking

I will prepare individual student packets with a basic outline or agenda for each lesson, including one or more of the questions above, with room for students to jot down their thoughts and make some notes to themselves as needed. They might want to make some notes about how they want to structure their composition or icons they want to click on when working online. The packet will also give them a structure for journaling their progress through the unit and help them remember what they've learned and accomplished. Some fill-in-the-blank notes will be included to help them catch all the great information the various videos contain.

Demonstration

You can't just talk about music composition, you have to bring it to life! Short videos demonstrating or explaining music created with artificial intelligence will be used to pique student interest and help to answer the questions I have posed.

A fifth grader at our school, who is a fabulous pianist and has won a composition contest, has agreed to share her composing experiences and maybe offer a little demo with some advice. I believe her classmates will be very interested in hearing about the composition process from one of their peers!

When I work with the students in the computer lab, I will make use of the Smart Board in order to help them see step by step what to do as they work through the steps for programming a composition online. As I am explaining and soliciting their help, I will be able to show them exactly what we're doing as we create a composition in both *Scratch* and *Quaver Music*. We will also be able to benefit from the online animated guide; a young man named "Quaver", who is very encouraging and helpful.

Listening

An extremely important component of music education is developing listening skills. My classes will definitely enjoy listening to both computer generated music and human composed music in the blind and trying to decide which is which. They will be asked to identify instruments and/or voices, and they will be encouraged to use good descriptive and content appropriate vocabulary when describing the music or explaining their reasoning and preferences. Some of these musical terms will be posted on the Musical Word Wall, a pocket chart where I place important musical terms that we have discussed, and others will be included on a list in their packet.

Technology

All students will have the opportunity to go to the computer lab and use the *Quaver Music* website to compose in *QGrooves*. They will learn to maneuver through the program and make a multitude of choices. Technology provides the benefit of being able to immediately listen to and share what they've composed without requiring all the expensive instruments and qualified musicians on hand. They will also learn some basic computer programming skills with a program called ***Scratch*,** giving the students the opportunity to compose an eight to sixteen measure song by programming one command at a time in order to achieve the desired outcome. We will also use a class set of iPads in order to compose a song using an 18^{th} century musical dice game. Using the computers and these programs will help students begin to develop their composition chops in a non-threatening way, and begin to see the connection between music composition and the computer programming that created the software!

Differentiated Learning

This takes many forms and constant vigilance by the teacher. Sometimes it just means that those students who quickly demonstrate success in an activity are appointed as teacher helpers who assist the other students at their table. Sometimes it means that I should prepare both an easier and a more difficult version of the same basic activity, or just leave an activity out, so that we have more time to spend on another one. When working with *QGrooves*, students with less musical aptitude or experience may just finish adding the parts for a couple of instruments, and those with greater aptitude and experience will be able to take advantage of all the instrument combination possibilities, but both will still experience success. The same ability to differentiate learning will naturally occur in the *Musical Dice Game*, and during our programming of a composition in *Scratch*. Those students who are more adept at technology and/or at figuring out how they want their composition to be put together will be able to finish a longer, more complex project, but the a student who needs more time to figure out each step can still complete a rewarding composition effort, since a shorter song is still a song! As the teacher, I need to notice if students have chosen an activity that challenges their abilities, and sometimes make a recommendation that will help a student grow at the pace they are capable of. Some students and classes need more modeling by their teacher and more explanation and repetition of instructions. Something written needs to be read aloud to a student who has difficulty reading, and sometimes higher level students should be required to go another step in the process and figure out what to do on their own so that they continue to grow and stretch.

Rubrics and Reflection

Achievement tends to increase when excellence in outcome is explained. When working on our computer composition projects in *Scratch* and *QGrooves*, we will use a rubric that specifies what is expected in order to achieve scores of 1 thru 5 in order to aid individual and teacher assessment. We will also take time to talk with classmates about our personal and group failures and accomplishments, and how to improve. The packets I referred to above in the journaling and note taking section will provide my students with a place to write as they reflect on how their perception and understanding of composition both real and artificial has changed after being given more information. They will also be able to see how their thoughts about artificial intelligence and creativity have evolved over the course of this unit.

Classroom Activities

Lesson One: Can Machines Be Creative?

Our first lesson will begin by listening to the last minute or so of Beethoven's *Fifth Symphony, First Movement*. At its conclusion, I will ask my students if they would consider the composer of this piece, Ludwig van Beethoven, to be creative. They should

answer "yes". Then I will ask, "What made him creative?", and take two or three answers. While handing out their packets with the "IAMUS/MELOMICS Documentary" Part 1 Fill-In-The-Blank Sheets inside, I will say, "Let me ask you a question that is central to our study of Artificial Intelligence and Musical Composition, *"Can machines be creative?"*. After giving the class a few minutes to answer this question in the blanks provided, I will give them a few minutes to turn and share their thoughts with the others at their table. One designated student at each table will be the facilitator and give each student the opportunity to speak using a "talking stick", and another student will be the spokesperson and share what their table said with the rest of the class. Then, I will show them the first half (9 minutes and 2 seconds) of the You Tube "IAMUS/MELOMICS Documentary". As they are watching, they can follow along on their fill-in-the-blank sheets and provide the missing words. As soon as the students have heard the information in question #6, I will stop the video, and allow the students a few minutes time to fill in the blanks provided with the answer to the second question, *"Can a computer create expression and feeling?"* This time the students will be given a few minutes to share with others at their table, again using the facilitators, while I roam the room listening to discussion. I will share a few of the thoughts I heard, and then we will resume the video.

When we come to the 9:02 mark on the video, and the end of our fill-in-the-blank pages, we will stop it for the day, and pass out iPads. As I demonstrate on the screen in the front of the room, everyone will find the app for "Mozart's Dice Game" on iTunes. If we can't all get on iTunes, I will have different students roll the dice and we'll compose together on the large screen. This app is based on the reference in the documentary to the musical dice game, *Musikalisches Wurfelspiel*, created by composer Wolfgang Amadeus Mozart. This game will allow students to create a musical piece, a minuet and trio, out of 272 different musical measures in the style of Mozart. The player rolls two six-sided dice for each measure in the minuet, adding the numbers of the dice together. The resulting sum is used to select the measure of music from a table. This is a great demonstration of a machine-like algorithm used over two centuries ago in music composition. If there is time, I will encourage the students to share their composition with their "neighbor", and maybe with their teacher or someone at home as well.

Lesson Two - How Do Machines Learn to Compose?

Today's lesson will begin with the You Tube video: "Artificial Intelligence and Music: Bryan Pardout TEDxUChicago". Before starting the video, I will have a student read the definition of artificial intelligence from our Vocabulary Sheet: <u>Artificial intelligence</u> - *the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings*. Bryan Pardout documents in this short video how he worked to develop computer software that could correctly identify the type of sound a musical instrument was making by teaching it to recognize a "tinny" sound using numerous audio readings of recorded sounds. He asked a number of people to listen and

identify what they think is a tinny sound, and then he entered that data into his program. This is one specific example of one of many little pieces of information that must be entered into a computer program in order to give it the ability to compose using interesting sounds that can communicate with the listener. At the completion of the video, the students will have the opportunity to answer question number three in the unit packet, *"How do machines learn to compose?"* I will ask them to back up their opinion with some information they gained from the video. After giving students a few minutes to write, I will solicit two or three answers from the class. If they have difficulty, these follow-up questions might be helpful: "What was Professor Pardout trying to teach his computer?", "How did he go about doing it?", and then, "Why is this computer knowledge important to musical composition?" Again, I will solicit answers from the class for each of the three questions, and make sure they understand the importance of this type of research.

Following our brief discussion about Bryan Pardout's research and its implications, I will give each student a list of ten popular songs from different genres, and have them give each song a rating: -5, I strongly dislike this song, -3, I don't really like this song, 0, I don't know this song, 3, I like this song, and 5, I really like this song. When everyone has completed his or her own ratings, each student is instructed to poll three to five other students, depending on time, and multiply his or her own individual ratings for each song with those of each classmate polled (i.e. -3 x 3 = -9 or 5 x 5 = 25), and then total the results. When they are done, I will ask, "What do your scores tell you?" Hopefully, they will have discovered that the classmate whose ratings multiplied with theirs produced the highest total is the one who most closely shares their own tastes in music, and should be a good person to ask for music recommendations. This is an example of machine learning where entering their data can tell them who has the most similar musical tastes, similar to what iTunes does with the info they gather about your musical tastes as you listen.

Lesson 3 and 4 – Composing and Programming, Step by Step

Our third lesson will begin by spending some time listening to a fifth grader who has some actual composing experience. Olivia will share one of her compositions with us and talk to us about the process she goes through when writing a musical composition. I will give my students a chance to ask her a few questions, then I will ask her and the rest of our students, *"Do you think computers help or hinder human creativity?"*, and *"How is music created by artificial intelligence different or the same as music created by a human brain?"*

We'll have class in the computer lab today, so that the students can begin some experimentation with *Scratch***.** I will share with them how this online computer program can give them some helpful assistance as they learn to compose. Each student will make some notes in their packet about the musical elements they can choose for their song, such as tempo, rhythms, dynamics, tone colors (instruments), meter, key and melody, for

the eight to twelve measure tune they will be creating. I will help guide them as needed as they are making notes by pointing out their possible choices on the various charts in the music room or on my whiteboard. I will demonstrate how to compose a few measures of music by "programming" step by step with my compositional choices on the Smart Board. When the students are choosing their pitches, they can hear the notes they pick by clicking on the keys of the little keyboard that appears on the screen. The note values are entered as whole numbers or decimals (i.e. 2=half note, .5=eighth note), so rhythmic options are limited. Then, I will allow them some time to try to compose at least one measure of music so they can get used to finding their way through the process. Scratch is designed as a fun and creative opportunity for children to learn coding skills as well as strategies for solving problems, designing projects, and communicating ideas. Each step chosen by the student appears as text in a little interlocking colored block. When the child clicks on the cat icon, the steps in each block are played back in chronological order. After finishing a measure or two of music, we'll have to call it quits for the day. However, the students are welcome to experiment with this free online program at home or at the library before we meet again in order to get more comfortable with it.

I will send the students' packets with them to their classroom so that they can write down their opinions and reasoning in regard to the questions I asked them at the beginning of the lesson today.

This lesson will continue into next week, when we will spend the entire class working on our *Scratch* compositional projects. Each student will receive a printed rubric that we will review so that they can clearly see what is expected of them by the end of the period. I will check in with every student at least once during the class period to see how they are progressing, and if anyone finishes early, they can assist students who are struggling.

Lesson 5 – Computer or Human Composition?

Our fifth lesson will begin with "Tech Closeup: Music Professor". This short YouTube video will give the students information about the important work of David Cope in the creation of virtual music. The students will find out about the creation of his first computer composer, "Emmy" (Experiments in Musical Intelligence) and how he teaches his newest computer composer, "Emily Howell" to compose music that is similar to his musical tastes. At the conclusion of the video, I will give my students a little history about the Turing Test, and Emmy's ability to fool musical and academic luminaries. Then I will give my students the same opportunity to listen to music composed by both programs, including a little musical listening quiz to see if they can tell the difference between music composed by Johann Sebastian Bach and Bach-like music composed by *Emmy*, similar to what Cope asked his audience to do back in 1987. We'll continue our listening quiz and comparison with music by Vivaldi, Mozart, Chopin, and Beethoven as well as music composed by *Emmy* in the styles of each of these famous composers. I will

use musical compositions by *Emmy* and *Emily Howell* found on David Cope's University of California Santa Cruz faculty website, included in the Website List for Classroom and Student Use at the end of this unit. Students will mark which pieces of music they think are the ones composed by the human composers and which they think were composed by *Emmy*. There will be space designated in their packets for the students to analyze and reflect on their decisions, right or wrong, and what made the music seem either "more human" or "more machine-like" to their ear.

Next, we will finish the IAMUS/MELOMICS Documentary on YouTube, from 8:40-19:23. I will have the students complete another set of fill-in-the-blank pages as they are watching. At the end of the video, they will be given a second opportunity to answer the question, *"Can a machine be creative?"* This time they should be able to back up their answers with some rationale. As before, the students will write the answers in their packet. They can also use the information from the video to help examine answers to the following questions: *"Can a computer show expression?", and "Whether created by computer or human, what do we want music to do?"*

Lessons 6 and 7 – Robot Bands and Computers That Compose!

Our last lessons will stretch over the course of two class periods as we spend some more time in the computer lab. We'll begin the first session with the fun You Tube video, "Pat Metheny, The Orchestrion – EPK". The students will see and hear a brief history of automated instruments starting with the player piano, to how today, legendary jazz guitarist and composer, Pat Metheny, can command the instruments of the whole band from his guitar. The question of the day is *"How is using computers to compose music fun? Scary? Easy? Hard?"* The students will record one answer for each question in their book, and then I will choose four volunteers, one to answer each question out loud.

Next, we will spend some time getting acquainted with *Quaver Music*, a free online music resource for kids. The student accounts need e-mail approval from a parent or adult whose computer they can use outside the school, so I will need to send home a request for the e-mail address each child should use well in advance. If needed, I can buddy some students together. I'll take the kids through the registration process, giving them a chance to create their log-in ID and password. Once they're in the site, I'll show them how to compose using the *QGrooves* application on the big screen. I will allow the students to make style, instrument, and musical loop and combination choices for me as we compose together on our own computers. I'll also show them how you can load a play-along track, a song already stored on *Quaver Music*, which can be "played-along with" by adding one or more tracks to give it a thicker, more interesting texture.

To begin our last session of this unit, I will play the You Tube video, "Pat Metheny 'Improvisation #2' – excerpt – from the Orchestrion Project" so they can see more of the final product of Pat Metheney's experiment with robotic instruments. From time to time,

I will stop the video and draw the students' attention to exactly what Mr. Metheny is doing in this amazing electronic improvisation and composition process. He improvs for a set number of beats on one of the instruments in the orchestrion by playing that part on his guitar. As he begins to improv a new musical phrase, he initiates the recording of that phrase by stepping on a pedal with his foot. Then that part plays repeatedly as he records a phrase on another instrument. This is called looping. He continues to layer instrument after instrument by "commanding" it with his guitar as we watch the real instruments play without an actual touch from a human musician. Finally, he adds a wonderful solo melody over the top, actually played in real time on his guitar. He taps a pedal with his foot, and some of the instruments drop out of the mix. The seamlessness of the performance is truly awe-inspiring!

Now it's my students' turn to compose on the *Quaver Music* application, *QGrooves*! The great thing about *QGrooves* is that a child (or adult) who doesn't have all the musical know-how and talent of a Pat Metheny can still put together a reasonably good sounding composition and learn something about composing in the process! Everyone will review the *QGrooves* composition process by going through it step by step with the animated guide, "Quaver". "Quaver" demonstrates how to drag and drop "loop tiles" into the numbered boxes or measures. Then he guides each student composer in how to choose instrument sounds, change chords, select 2-beat or 4-beat patterns, and the musical style. The students will fill in the tracks for 5 parts: keyboards, synth/brass, drums, percussion, and basses. These five tracks can stand on their own, or they can be added to a song already stored on *Quaver Music*. Students can also experiment with the volume fader, and set the largo, moderato, or presto setting on the "metronome". My young composers will have the ability to hear a track solo or mute one or more tracks as needed. There are even more options available if a parent puts money in their child's *Quaver Music* account, but we will just be using what is available for free. My students can even title their compositions and save them. Once they have all gone through the step by step process with "Quaver", I will allow the students to work on their own for the rest of the class as I work my way through the room to encourage and help where needed. Most students should be able to complete at least eight measures. They are able to save their compositions and continue working on them at home, where they can access them with their user name and password.

We'll log off our computers in time to watch a short closing You Tube video from Science Nation, entitled "Music and Creativity". The students will see a professor from Georgia Tech who teaches students to become Music Engineers. His research includes the study of the impact of creating music, especially improvisation, on the human brain, and the development of technological tools that support musical learning. He has created the popular iPhone app, "La Di Da", that enables someone with minimal music talent to record their voice, and through the "magic" of technology, make it sound much improved, adding back-up rhythm tracks that make it sound almost professional. This is to remind my students, that one of the benefits of technology, and musical engineering

specifically, is that it makes music more accessible to everyone so that professionals and amateurs alike can benefit from the joy music provides!

The unit will end with the following question contained in the title: *"Composing music with computers: good art or bad?"* I believe my students will see and hear that composing music with computers has come a long way and will certainly only get better, but just like music composed by humans alone, it can be good art ***or*** bad!

Vocabulary

Algorithm - a step-by-step problem-solving procedure, especially an established computational procedure for solving a problem in a finite number of steps.
Algorithmic Composition - the use of formal procedures to make music without human intervention, either through the introduction of chance procedures or the use of computers.
Artificial Intelligence (AI) - the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.
Backpropagation - a common method of training a neural net in which the initial system output is compared to the desired output, and the system is adjusted until the difference between the two is minimized.
Baroque - the period called "Baroque" in music history extends roughly from 1600 to 1750. Baroque music is tuneful and very organized and melodies tend to be highly decorated and elaborate. Conflict and contrast between sections in a piece and between instruments are common, and the music can be quite dramatic.
Biology – the study of living organisms, including their structure, functioning, evolution, distribution, and interrelationships.
Classical – the term "classical" is often used to describe music that is not rock, pop, jazz or another style. However, there is also a Classical era in music history that includes compositions written from about 1750 to 1825. Music from this period is orderly, balanced and clear. Its form is very important as is its harmony and tonality—that is, the musical key in which a piece was written.
Composition - the art or act of composing a musical or literary work, or a work of music, literature, or art, or its structure or organization.
Computer-generated music – this term is generally used to mean a kind of music which could not have been created *without* the use of computers.
Creative – having the ability or power to create.
Evolution - a progression from a simpler or lower to a more advanced, mature, or complex form or stage.
Expressive – effectively conveying a feeling, idea, or mood.
Genome – the total amount of genetic information in the chromosomes of an organism, including its genes and DNA sequences.
Improvisation – the composition of music while simultaneously singing or playing an instrument.

Loop – a repeating section of sound material. Short sections of material can be repeated to create ostinato patterns. A loop can be created using a wide range of music technologies including digital samplers, synthesizers, sequencers, drum machines, tape machines, delay units, or they can be programmed using computer music software.
Music Engineering - the process of recording and reproducing music. Music engineering is a big part of the music industry and there are many types of music engineers in the music industry, from those who provide live sound in performance venues to those responsible for designing the audio equipment used at these venues.
Musicalisches Wurfelspiel – (German for "musical dice game") was a system for using dice to randomly generate music from precomposed options. These games were quite popular throughout Western Europe in the 18th century.
Neural Nets – a real or virtual device, modeled after the human brain, in which several interconnected elements process information simultaneously, adapting and learning from past patterns.
Orchestrion – a generic name for a machine that plays music and is designed to sound like an orchestra or band. It may be operated by means of a large pinned cylinder or by a music roll, and less commonly, book music. The sound is usually produced by pipes as well as percussion instruments, and sometimes a piano.
Recombination - a method for producing new music by recombining existing music into new logical successions.
Solenoid - a coil of insulated or enameled wire wound on a rod-shaped form made of solid iron, solid steel, or powdered iron. Devices of this kind can be used as electromagnets, as inductors in electronic circuits, and as miniature wireless receiving antennas.
Strong AI - artificial intelligence that aims to duplicate human intellectual abilities.
Turing Test - This practical test for computer intelligence created by British logician and computer pioneer, Alan Mathison Turing, involved 3 participants: a computer, a human interrogator, and a human foil. If the interrogator can't figure out which answers come from the computer, and which answers come from the human foil, the computer is considered an intelligent, thinking entity.
Virtual Music - represents a broad category of machine-created composition which attempts to replicate the style but not the actual notes of existing music.

List of Materials for Classroom Use

Class set of computers
Class set of iPads
Letter about Quaver Music to send home before the unit begins requesting a parent's email so that they can give permission for their child to use the site
Pencils
Packet of lesson materials

- A question sheet for each lesson with room for the student to answer the question(s) either once or twice and the You Tube video shown
- 2 fill in the blank sheets for IAMUS/MELOMICS Documentary You Tube video – Part I and II
- Table for “Musical Preferences Match”, Appendix 2
- Vocabulary List of artificial intelligence and music composition terms
- Musical terms for describing music listened to
- List of websites for the various videos and online activities

Projector and/screen or Smart Board
Rubrics to be made for *Scratch* and *QGrooves* compositions

Website List for Classroom and Student Use

"Artificial Intelligence and Music: Bryan Pardo at TEDxUChicago." YouTube. June 6, 2013. Accessed November 23, 2014. http://www.youtube.com/watch?v=AwcpkGPSUYw.
Bryan Pardout, head of the Northwestern University Interactive Audio Lab, gives a TED talk on how he trained a computer software program to identify and reproduce a "tinny sound".

Cope, David. University of Santa Cruz. Accessed November 21, 2014. aftsites.usc.edu/faculty/cope.
Biography, Bibliography, Music, Scores, Software, and EMI. Includes recordings of EMI's compositions.

"IAMUS / MELOMICS Documentary." YouTube. January 15, 2013. Accessed November 23, 2014. http://www.youtube.com/watch?v=ETGDbWvWCbM.
Video documentary by Melomics Records about the invention and development of the compositional computer program, "Iamus", by Professor Francisco Vico and his team at the University of Malaga, Spain.

"Mozart's Dice Game." App Store. Accessed November 24, 2014. https://itunes.apple.com/en/app/mozarts-dice-game/id311413994?mt=8. Application based on Mozart's musical dice game, "Musikalisches Wurfelspiel".

"Music and Creativity - Science Nation." YouTube. May 12, 2011. Accessed November 23, 2014. http://www.youtube.com/watch?v=t3UKvQggFpM.
Video and transcript about professor Parag Chordia from Georgia Tech who teaches students to become Music Engineers. His research includes the study of the impact of creating music, especially improvisation, on the human brain, and the development of technological tools that support musical learning. Created the popular iPhone app, “La Di Da".

"Pat Metheny - Improvisation #2." YouTube. September 10, 2012. Accessed November 23, 2014. http://www.youtube.com/watch?v=6dzxlr9LPDY.
A 4 1/2 minute excerpt from "Improvisation #2" on the Pat Metheny Orchestrion Tour.

"Pat Metheny - The Orchestrion EPK." YouTube. November 1, 2010. Accessed November 23, 2014. http://www.youtube.com/watch?v=9VymAn8QJNQ.
Pat Metheney gives a little history of orchestrions, and then shows how he composes and performs with his amazing robot band.

"Quaver's Marvelous World Of Music." Quaver's Marvelous World Of Music. Accessed November 24, 2014. https://www.quavermusic.com/Default.aspx. A virtual world of music creation where a child can create a free account. Contains the QGroove application among many others.

"Scratch - Imagine, Program, Share." Scratch - Imagine, Program, Share. Accessed November 24, 2014. http://scratch.mit.edu/. Click on *Create*, then click on *Sound* under the *Scripts* tab in the center and you are ready to code your own song!

"Tech Closeup: Music Professor." YouTube. May 14, 2007. Accessed November 23, 2014. http://www.youtube.com/watch?v=yFImmDsNGdE.
Is it Mozart or Professor David Cope? Many of the world's experts can't tell. See how this music professor uses his own software to make beautiful music.

Annotated Bibliography for Teachers

Bosker, Bianca. "Life As Francisco Vico, Creator Of The Incredible Computer-Composer Iamus." The Huffington Post. January 13, 2013. Accessed November 23, 2014. http://www.huffingtonpost.com/2013/01/13/francisco-vico-iamus-melomics_n_2457374.html.
Interview with Francisco Vico about Iamus, the computer program he created to compose music, his startup company, Melomics Media, and how music will continue to change.

Caplan, Theo. "Artificial Intelligence Composers: Can Computers Write Music?" The AfterMatter. December 2, 2012. Accessed October 25, 2014. http://www.theaftermatter.com/.
Discussion of David Cope's work in AI and music composition as well as the controversial human vs. computer composition.

Cheng, Jacqui. "Virtual Composer Makes Beautiful Music—and Stirs Controversy." Ars Technica. September 29, 2009. Accessed November 22, 2014. http://arstechnica.com/science/2009/09/virtual-composer-makes-beautiful-musicand-stirs-controversy/.

Concise story of what led music professor and composer, David Cope, to develop EMI (Experiments in Musical Intelligence) and later, computer program, Emily Howell.

Cope, David. University of Santa Cruz. Accessed November 21, 2014. aftsites.usc.edu/faculty/cope.
Biography, Bibliography, Music, Scores, Software, and EMI, Includes recordings of EMI's compositions.

Cope, David, and Douglas R. Hofstadter. *Virtual Music Computer Synthesis of Musical Style*. Cambridge, Mass.: MIT Press, 2001.
Focuses on the author's "Experiments in Musical Intelligence" computer music composing program. Includes a historical background.

Cope, David. *Computer Models of Musical Creativity*. Cambridge, Mass.: MIT Press, 2005.
An original and provocative study of computational creativity in music that's not too technical.

Copeland, B.J. "Artificial Intelligence (AI)." Encyclopedia Britannica Online. November 2, 2014. Accessed November 22, 2014. http://www.britannica.com/EBchecked/topic/37146/artificial-intelligence-AI.
Very helpful overview of artificial intelligence in general.

Da Voce, Viola. "Could a Computer Program Replace Human Composers?" Contrapuntist RSS. January 25, 2013. Accessed November 22, 2014. http://www.thecontrapuntist.com/2013/01/25/could-a-computer-program-replace-human-composers/.
Discusses professor and entrepreneur Francisco Vico's vision for helping amateurs to become successful composers.

Fortnow, Lance. *The Golden Ticket: P, NP, and the Search for the Impossible*. Princeton, New Jersey: Princeton University Press, 2013.
Provides a nontechnical introduction to P-NP, its history, and its algorithmic implications.

Kavner, Lucas. "Musical Metacreation: Can A Computer Write A Song That Moves You?" The Huffington Post. June 20, 2012. Accessed November 22, 2014. http://www.huffingtonpost.com/2012/06/20/musical-metacreation-can-_n_1610195.html.
How the Musical Metacreation project and other computers programmed to create music have progressed.

"Melomics." Melomics. Accessed November 21, 2014. http://melomics.com/.

A huge repository of online music composed by a computational system for the automatic composition of music.

"Musical DNA." Idea Explorer. Accessed November 21, 2014. http://www.radiolab.org/story/91515-musical-dna/.
About Professor and Composer, David Cope, and his computer program named EMI (Experiments in Musical Intelligence).

O'Brien, Miles, and Marsha Walton. "Engineering and Music: A Powerful Duet for Art and Science - Science Nation." Nsf.gov. August 16, 2010. Accessed November 22, 2014. http://www.nsf.gov/news/special_reports/science_nation/musicman.jsp.
An article and video about the combined research of an engineer with a love of music and a musician who likes technology.

O'Brien, Miles, and Marsha Walton. "Music and Creativity - Science Nation." Nsf.gov. May 16, 2011. Accessed November 22, 2014. http://www.nsf.gov/news/mmg/mmg_disp.jsp?med_id=74374.
Video and transcript about a professor from Georgia Tech who teaches students to become Music Engineers.

Stricker, Jacquelyn. "Artificial Intelligence and the Arts." Createquity. October 24, 2012. Accessed November 22, 2014. http://createquity.com/2012/10/artificial-intelligence-and-the-arts/.
A thoughtful piece on the ability of computers today to replicate creativity, and the question of whether they will ever have feelings or exercise intentionality.

Van Buskirik, Eliot. "Robot Band Backs Pat Metheny on Orchestrion Tour | WIRED." Wired.com. January 28, 2010. Accessed November 22, 2014. http://www.wired.com/2010/01/orchestrion/.
Article and video about dozens of robotic band members that back up jazz guitarist Pat Metheny on his latest album, Orchestrion, and will join him on his upcoming international tour.

Wut, Tim. "TechZulu • Liquid Notes | Using AI to Add Intelligence Back Into Music." TechZulu Liquid Notes Using AI to Add Intelligence Back Into Music Comments. November 3, 2013. Accessed November 22, 2014. http://techzulu.com/liquid-notes-using-ai-to-add-intelligence-back-into-music/.Discussion of music, technology, and business with Roland Trimmel, the head of operations for Re-Compose, the developers of innovative music composition and production software, Liquid Notes.

Appendix 1: Implementing Teaching Standards

Common Core ELA Standards – Literacy

Speaking and Listening *SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 5 topics and texts, *building on others' ideas and expressing their own clearly.*
Discussion of the questions posed daily about artificial intelligence in relation to composition and artistic expression is a key component of this unit.

Writing W.5.1 *Link opinion and reasons using words, phrases, and clauses* (e.g., *consequently, specifically*).
Students will be asked to record in writing their opinions and thoughts on each of the important questions posed about artificial intelligence and music composition.

Essential Standards – Music

Musical Literacy *5.ML.1.3 Use instruments to perform rhythmic, melodic, and chordal patterns accurately and independently on classroom rhythmic, melodic, and harmonic instruments.*
Students will playback melodic and harmonic instrumental music parts they have composed.

5.ML:.3.2 Create compositions and arrangements within specified guidelines.
Students will compose while following the guidelines of the computer composition programs.

5.ML.3.3 Create rhythmic compositions using notation for whole, dotted half, half, and quarter notes; whole, half and quarter rests; and beamed eighth notes in duple , triple, and common time and which are arranged using a variety of sound sources.
These rhythms are chosen and played by the students as they compose.

Contextual Relevancy 5.CR.1 *Understand the relationships between music and concepts from other areas.*
Artificial Intelligence being used in music composition, illustrates music's relationship with math, science, and technology.

Musical Response *5.MR.1 Use musical terminology in explaining music, including notation, instruments, voices, and performances.*
Students will describe the computer and human compositions using the appropriate terminology.

Appendix 2

Musical Preferences Match

Name of Song	Your Rating	Person 1	My Rating X Yours	Person 2	My Rating X Yours	Person 3	My Rating X Yours	Person 4	My Rating X Yours

Notes

[1] The aftermatter.com

[2] Britannica.com

[3] ibid

[4] Brittanica.com

[5] ibid

[6] ibid

[7] Cope, *Virtual Music* (2001)

[8] ibid

[9] ibid

[10] Theaftermatter.com

[11] Thecontrapuntist.com