The Air Guitar: Developing a Cost-Effective Digital Guitar

(Technical Paper)

Nontraditional Methods of Music Education

(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction: Developing a Cost-Effective Digital Musical Instrument for Application in Music Education

Music stands to be one of the most influential aspects of modern education providing students with opportunities no other class can provide. Glenn Schellenberg of the University of Toronto shows in a 2011 study that playing a musical instrument often results in positive cognitive behaviors including goal setting, self-motivation, and even a higher IQ (Schellenberg, p.297). Music education, spanning from orchestra to band, equips students for success in academics, work, and in adult life. Despite the benefits, it has been a perennial struggle for public schools to encourage and economically support music education. The lack of economic support in public schools leads to lower-income students losing access to music education and its cognitive benefits. (Bates, 2018, p.73). Moreover, there is no guarantee that students will prioritize music education over other extracurricular activities such as athletics or a job. While the outlook on school funding and student participation may seem bleak, nontraditional music education has become increasingly accessible and popular as computers have become common in the classroom (Williams, 2012, p.139). Nontraditional music uses computer software applications that simulate and overlay instrument sound bites and vocals to produce songs in a wide range of genres.

Given the state of music education, my capstone group plans on designing a digital guitar that would be used in nontraditional classrooms. The digital guitar will provide a cost-effective alternative to formal music instrument lessons with the added benefits of easy digital production integration. The STS approach will consist of researching the status of music education in western education institutions. Specifically, in Albemarle County, Virginia. This local community has made leaps and bounds in nontraditional music education at Murray High School—a public charter

school affiliated with Albemarle County Public Schools (ACPS). I am seeking to understand the effectiveness of this program in engaging nonengaged learners in the traditional classroom.

STS Topic: Nontraditional Methods of Music Education

Traditional music education in western education includes concert band, marching band, orchestra, chorus, and even guitar classes. Each of these classes offers valuable life skills and engages students in ways that differ from math, science, English and history classes. From a study conducted on adults with and without a musical background it was found that, "Musical training may promote the development and maintenance of certain [executive function] skills, which could mediate the previously reported links between musical training and enhanced cognitive skills and academic achievement" (Zuk, 2014, p.1). Executive functions are the brain's ability to operate independently spanning traits like inhibition, problem solving, cognitive flexibility, and a working memory (Zuk, 2014, p.1). It is well established that music education is linked to high academic achievement through the production of executive functions. The issue lies in that over 80% of students are not engaged in music education (Williams, 2012, p.134).

A majority of students ignore or cannot afford the opportunity to grow as a student through music education. Some of the lack in music participation is due to strategic budget cuts in the arts. Long time athlete and musician John Gerdy (2015) explains, "When program cuts are necessary, priorities must be set and difficult choices made. Traditionally, one choice has been between fielding elite athletics programs and maintaining enriching programs in the arts—with the arts usually being the first to suffer" (Gerdy, n.p.). Due to a lack of funding, kids face economic barriers in accessing music education. Musical instruments are expensive and if neither schools nor a student's family can afford an instrument, they will not be able to participate in music in school (Russel, 2016, n.p.). Even more than the time and economic

constraints that students face, there is a general apathy towards participation in music education. Popular musicians do not usually rely on standard music notation, so students are less inclined to want to participate in classical music or marching bands (Williams, 2012, p.132). Students are either too busy, cannot afford, or are disinterested in traditional music education.

Nontraditional methods of music education pose an exciting, cost-effective, and modern alternative to traditional music education. Nontraditional methods include digital music production programs like GarageBand, Logic, or DJ software. As music changes, music education should change with it. Students who show apathy towards traditional music classes may find nontraditional music classes, that appeal to their music tastes, more attractive. Williams' (2012) study suggests, "students who are academically unmotivated or prone to creating discipline problems in other classes find TBMCs [Technology-Based Music Classes] rewarding" (Williams, p.142). Research suggests that technology driven music classes have made music education more appealing to even unmotivated and quarrelsome students (Williams, 2012, p.137). Figure 1 below shows the demographics of students who are enrolled in nontraditional music classes. It is notable that 82% of students enrolled in nontraditional music classes do not participate in ensembles (Williams, 2012, p.138). TBMC's appeal to a demographic of students that otherwise do not participate in traditional music education.

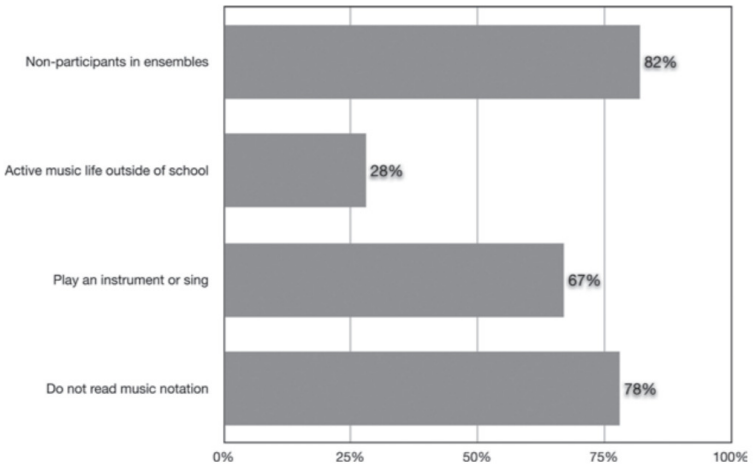

Figure 1: Survey data taken by students who participate in technology-based music classes. 82% of students do not participate in a musical ensemble. This suggests that TBMC's are successful in engaging students who do not participate in traditional music classes. (Williams, 2012, p.138)

I will continue to research nontraditional music education in order to understand the implications of digital technology in music education. The context for my research will be drawn from my local community in Albemarle County, Virginia. Murray High School will serve as a model for my case study into nontraditional music education in engaging unengaged students. Murray High School has a rich history in nontraditional education stemming from the school's original charter in 1987. The charter states that Murray High School will provide, "Educational programs which are designed to offer variation of traditional instructional programs and strategies for the purpose of increasing the likelihood that students who are unmotivated or unsuccessful in traditional programs remain in high school and obtain a high school diploma" (Friedman, 1987, p.1). Murray high school was developed under the values of engaging the unmotivated students since its opening in 1988. More than twenty years later, Murray High School still seeks to engage unmotivated students using technology-based classes. The nontraditional classroom has the ability to engage students like never before and through my STS

research I hope to analyze how students are motivated by technology-based classes at Murray High School.

Technical Topic: The Air Guitar: Developing a Cost-Effective Digital Guitar

Since the birth of the guitar in Spain in the mid-1500s, the guitar has played an integral part in music production and culture (Hartmetz, 1998, n.p.). Musical trailblazers, such as Jimi Hendrix and the Beatles, played the guitar in revolutionary new ways to bring about a whole new genre of music. Over the next 50 years, music has been bent and molded by new digital technologies developed with the processing power of smart phones and computers. GarageBand, Logic, and other digital music production programs are widely used to make music on computers and smartphones. Using prerecorded sound loops in the GarageBand library, producers of any age and skill level can make beats and rhythms (Wang, 2019, n.p.). Moreover, users can make their own melodies and beats with a keyboard, drum, or guitar simulator and sing lyrics over their own beats. Now, more than ever, music production is accessible to the masses. Andrew Perrin (2019) of the Pew Research Center found that, "81% of Americans say they go online on a daily basis" (Perrin, n.p.). Whether on a smartphone or computer, a vast majority of Americans have the ability to make music.

The technology behind digital music production applications is based on digital signal processing to replicate analog sound waves. Most digital music production applications use MIDI sound files to simulate a musical note. These files work well simple music and sound production, but as sound quality becomes more important, MIDI files can be lacking without complex signal processing. Between analog and digital production, you lose sound quality. The analog has a distinct warm sound to it due to dynamic compression in recording (Barlindhaug, 2007, p.78). For some musicians, aesthetic is everything, so while digital may offer a cheaper

avenue, you lose the specific sound analog brings (Barlindhaug, 2007, p.78). Even in the 21st century consumers choose to listen to a song with the warmer sound of a record player than on Apple Music. If sound quality and aesthetics are important to an artist or listener, there is little that cheap digital music can offer.

While digital musical production applications offer accessible music production to anyone with a smart phone or laptop, they are often too simplistic, low quality, and not user friendly. Music producers are limited by the software they use and the funds that they have. If a producer would like to use a higher quality software, it will be fairly expensive. At $200, Logic, a higher quality production software, is fairly expensive compared to the cost of a beginner's guitar (Wang, 2019, n.p.). On the other hand, an instrument like the guitar is a high cost for a hobbyist or expressive outlet. High prices for better quality appear to be the ceiling for musical expression, whether musicians are using high quality digital production or playing an instrument.

Since it is known that over 81% of the US population has access to a smart phone, using a smart phone as a musical instrument would be a cost-effective solution to the high costs of high-quality digital music programs and instruments (Silver, 2019, n.p.). Knowing the accessibility of a smartphone, my capstone group and I will develop an app that simulates playing a guitar. To simulate holding down strings on a guitar fret we will use a smartphone application that displays 6 guitar strings. The other portions of the Guitar will consist of sensors, filters, and computer logic. The three main sections for the Air Guitar are drawn out in Figure 2 below.

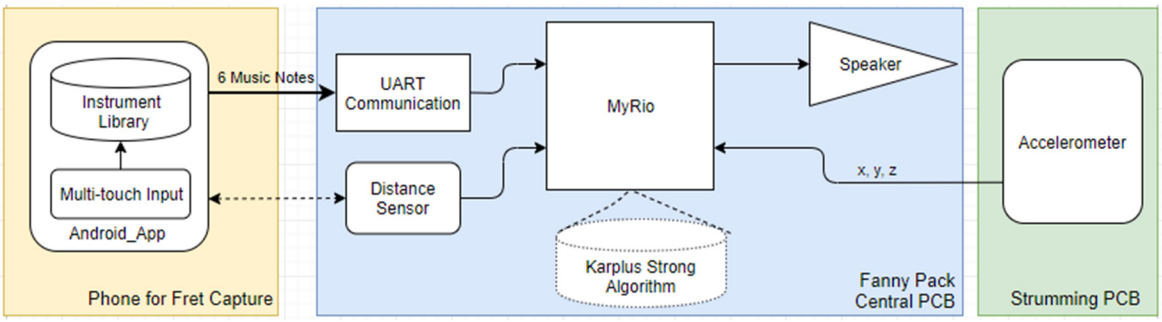

Figure 2: Air Guitar design block diagram. Maps out each subsystem which provide a voltage or signal source for the microcontroller to process. The microcontroller will then produce a guitar sound through the speaker with a pitch based on the phone and distance sensor data. (Created by Author)

Using accelerometers to measure movement, the guitar sounds will trigger when the accelerometer circuit board is moved. Based on the finger placement on the phone and the distance sensor equipped at the user's hip, the logic will use the Karplus-Strong algorithm to output a guitar sound at the needed pitch. Karplus-Strong takes in a noise source, then filters and adds a time delay to that noise for pitch selection (Jaffe, 1983, p.57). The Karplus-Strong Algorithm produces a wide range of sounds from the pluck of a harp to the strum of an acoustic guitar. With the technology in place, the last requirement is to produce a playable guitar that replicates playing an acoustic guitar. From beginners to professionals, the air guitar will provide a fun, portable, and cost-effective alternative to playing a guitar.

Conclusion

With the modern development of digital internet capable devices, music has become increasingly accessible. Smart phones and computers have revolutionized the production and distribution of music. Digital music production applications have set the grounds for developing the Air Guitar: A handheld electronic guitar. The Air Guitar will consist of a smart phone app simulating guitar fingering and an accelerometer board to simulate strumming a guitar. The smart phone app and accelerometer will be integrated in a microcontroller where the Karplus-

Strong algorithm will produce an acoustic guitar sound. The Air Guitar will bridge the gap between the accessibility of digital music software and the high cost of a musical instrument. The STS research has led to new discoveries about music education. Research has shown that music education produces positive cognitive behaviors that are seen in high achieving students. Moreover, a general apathy for classical music education has led to a rise in nontraditional music education. This is seen at Murray High School where students who are not motivated by traditional education are engaged by technology-based music classes.

Word Count: 1916

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