Construction and Design of the Simophone
(Technical Report)

The Impact of Music Games on Music Education
(STS Paper)

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By
Kidus Fasil

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Technical Team Members:
Brendan Grimes
Kaden Hoversten
Mohamed Mahmoud
Charles Monsell

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.

ADVISORS

Joshua Earle, Ph.D, Department of Engineering and Society

Adam Barnes, M.S., Department of Electrical and Computer Engineering

Introduction

My technical project incorporates the design, construction, and implementation of a self-playing xylophone that takes in Musical Instrument Digital Interface (MIDI) files, which contain different channels that have notes and tempos, as input and feature a “Simon Says” mode in which the xylophone will play a sequence of notes and the user is expected to play it back. My STS topic investigates the impact of games focused on gameplay involving interactions with music and how this genre impacts music education.

Two questions arise when performing research on this topic. How do music games impact music education? Are there any cognitive benefits to people who play music games compared to those who do not? These questions are important not only because of their relevance to the technical project’s practical applications but also the impact on society that music games could have. The goal of my technical project is to assist beginners, musicians, and hobbyists in learning how to play the xylophone. Thus, my technical project at a larger scope could be viewed as a game related to music that would help the user learn musical concepts such as tempo, pitches, sightreading, and dynamics. Preliminary studies have shown that musical skills have cognitive benefits such as intelligence, visuospatial abilities, processing speed, executive control, attention, and episodic and working memory (Budson, 2020). This is why it is important to look at different methodologies, such as music games, to improve music education.

I will outline a comprehensive research plan that uses established frameworks and methodologies from STS. This plan aims to pave the way for answering the research questions discussed earlier, shedding light on the intricate interplay between music games and music education. In doing so, I hope to not only advance the technical project but also contribute

valuable insights to the larger discourse on the intersection of music, technology, and education in our society.

Technical Project: Construction and Design of the Simophone

The Simophone features a self-playing xylophone capable of dynamically generating random tunes sourced from a vast library of MIDI files. The user's objective is to hone their listening skills and musical memory by listening to the melody produced by the Simophone and then repeating the melody by striking the correct notes on the xylophone. The Simophone captures the user's performance in real-time through a microphone, analyzing each note played. Subsequently, the system compares this live recording to the original MIDI file, delivering instantaneous feedback to the player using an LCD screen. Success hinges on the player's ability to accurately replicate the tune, fostering an engaging challenge that encourages memory enhancement and musical skills. In the Simophone, we have seamlessly merged the worlds of music, technology, and cognitive stimulation, offering a combination of entertainment, learning, and musical expression.

The first core feature of the Simophone is the ability to store and play MIDI files. To do this, 32 individual solenoids, which are a type of electromagnet formed by a coil of wire, will be placed under each bar of the xylophone, and will be actuated to strike whatever note needs to be played from the MIDI file. The selected solenoid has a DC resistance of around 40 Ohms and needs around 300 mA of startup current to produce the rated 5N of force. This means that the power supply to drive the solenoids will be 12 volts (Mouser). To hold the solenoids in place underneath the xylophone, 80/20 aluminum extrusion will be used. In this case, the extrusion will be mounted under the xylophone and 32 custom 3D printed parts will be produced to mount each solenoid to its respective key.

To actuate the solenoids at the correct time to play a MIDI file, a microcontroller will be used to control each solenoid individually via the pins of the microcontroller. That is, the microcontroller will activate the pin controlling the solenoid corresponding to the correct note at the correct time according to the MIDI file. However, since the pins are not capable of driving a solenoid by itself, a transistor, which is at a high level an electrical switch, will be used to control the current through the solenoid with the pin controlling the voltage on the base of the transistor.

The next core feature for the project is the implementation of “Simon Says”. Since this project is oriented around music, this feature will revolve around teaching the user parts of a song or scales. For this to work, a tempo will be set by the system and will be relayed to the user via flashing an LED. This LED will remain flashing for the entire game to help the user keep tempo. Once the tempo is set, the Simophone will begin to play something for a defined block of time. After the Simophone is finished playing, a different colored LED from the one keeping the tempo will begin to flash. This will be coordinated with the tempo LED to count off to the entrance when the user is supposed to play. The user will then attempt to play back what was played and if correct, the Simophone will play something slightly more difficult. If not correct, the game ends and the user will be prompted to start over.

To determine whether the user played the correct set of notes, a microphone will be used to record what the user plays. To perform this comparison, the frequency contents of what the user plays will be analyzed using the Fast Fourier Transform (FFT) algorithm and mapped to one of the notes on the xylophone if it is one of the defined frequencies of a note on the xylophone. This sequence of notes will be compared to the sequence of notes the microcontroller has stored and played. This means that the Simophone can determine what frequencies were played at a given time to enable the comparison of the recorded sample. The Simophone will be a crucial

device that will assist users with learning music and playing the xylophone, which would be benefical to musical education.

STS Project: The Impact of Music Games on Music Education

Over the past 3 decades, video games have significantly increased in popularity. With increased popularity, there is increased controversy. There is a misconception that games negatively impact education in adolescents, which many parents or legal guardians use to discourage their children from playing games (Drummond and Sauer, 2014). While this study has shown that games do not negatively impact education, it generalizes all genres of video games and does not show if there are benefits to music education. There is one example in which music games catalyzed the rise to fame of a well-known band: The Warning. The Warning is a hard-rock band composed of the three sisters Daniela, Paulina, and Alejandra Villarreal Velez who started out their careers by learning how to play rock songs through the Rock Band video game series. The Rock Band series is a set of rhythm games that allow players to play songs on the lead guitar, bass guitar, keyboard, and drums. After learning these songs, they uploaded their performances on YouTube which gained traction. (Dodwell, 2019) The Rock Band series massively contributed to their success in music because it taught them how to keep tempo, play the notes at the right time, and basic music theory (Harmonix Music Systems). While this is one example of music games directly benefiting musicianship, the goal of this paper is to examine whether this example was anomalous.

Research Question

My project will be centralized on the study of the impact of music games on music education rather than the impact of all genres of games on education. My research questions on this topic are how music games impact music education and whether there are any cognitive

benefits to people who do play music games compared to those who do not. These questions are especially relevant to social groups such as students, musicians, and beginners of music theory because people learn music in diverse ways. However, these research questions might not be as important to professional musicians because they are already experienced in the field and do not need music games to assist them with learning. One way that music games help people learn is by imitation (Bluestone, 2000). For some beginners, it is easier to repeat a sequence of notes played rather than having music theory explained directly. This way, they have a better understanding of tempo and pitches, and they could then translate that when reading sheet music. People may want a more flexible way to learn and give them the opportunity to express themselves, treating music as if it were second nature (Wooten, 2013). Music games ideally would be able to close this gap. It is important to the social groups mentioned because they could become the next era of musicians and could vastly influence the musical atmosphere.

Methodologies

I will use methodologies such as ethnography and case studies to perform research. The people crucial to this study are elementary school educators or members of the community involved in fine arts. For elementary school educators, I will ask how they employ technology in their music curriculum and what methods they have experimented with when teaching music through either a survey or an interview. For people involved in the fine arts community, I will ask what their inspirations were for joining fine arts and how they initially learned how to play music. This would be a survey or interview. Furthermore, I will talk to professors in the department of music at UVA, more specifically the Learn to Groove (MUSI 2340) professor and other Musical Performance (MUPF) professors on how they integrate technology into their lesson plans. For case studies, I will look at pedagogical studies and literature that investigate the

success rate among different methods of teaching music and the cognitive effects of music games. I will also investigate the motivation of the companies who published these music games and the user groups they catered their product towards. There have already been preliminary studies that have investigated the impact of music games on music education. Games like Rock Band 3 have shown to increase engagement across students and potentially cognitive benefits (Cassidy & Paisley, 2013). On the other hand, games like My Note Games!, which teaches music in a more traditional manner, are found to be not as engaging and are no better than traditional music theory (Hein, 2014). This suggests that some music games benefit music education and others do not help at all. As a result, I will also look at other games that incorporate music and/or rhythm like Rock Band such as Guitar Hero, Dance Dance Revolution, Space Channel 5, and DJ Hero and see how the impact of those games have had.

Timeline

My timeline for performing research will stretch out over a couple of months. Research will begin near the end of the semester when considering the external considerations, customers, and benefits of my technical project. This will be directly connected to the research question because the technical project is one example of what a music game should be. Then, surveys and interviews would continue for the next couple of months asking different educators and members of the fine arts community the questions specified above in hopes of getting an acceptable sample size. Throughout those months, case studies on different methods of teaching music and the cognitive effects of music games would be investigated asynchronously. I will get proper access to these resources in advance, ideally before the end of the semester, such that there are no roadblocks when performing research.

Conclusion

My technical project's main purpose is to help learn the xylophone. To a further extent, the self-playing xylophone could potentially benefit music education. The implications of music games benefiting music education could encourage educators to make the method of using music games in their lessons become more widely used. This would also provide another opportunity for students, beginners, and hobbyists to learn more about the fundamentals of music rather than trying to pick up sheet music and learn music theory from scratch. My prospectus provides a comprehensive research plan to investigate how music games impact music education and its potential benefits over other methods of teaching music.

Key Texts

While doing research the most important sources to my STS project were the *You've been warned: How the warning went from video game players to rock band Musicians - Guitar Girl Magazine* by Michael Dowdell, *Music Games in education* by Eric Hein, *Music as a language* by Victor Wooten, and *Music-games: A case study of their impact. Research Studies in Music Education* by Gianna G. Cassidy and Anna M. J.M. Paisley.

The primary source from Micheal Dowdell was an interview with the band, The Warning. When they were young, they played the game Rock Band quite frequently. As a result, they were able to pick up the guitar and drums and uploaded their performances on YouTube which gained traction. This is relevant to the project because it is an example of how music games had a practical application to gaining musical skills. It shows that music games have helped in the past which would emphasize the relevance of the research question.

The primary source from Gianna G. Cassidy and Anna M. J.M. Paisley. as well as Eric Hein both cover case studies with music games in an academic setting. While the Cassidy and Paisley piece focuses on Rock Band 3, the Hein piece does cover Rock Band 3 but also mentions games such as iGotGame and My Note Games!. It has been shown from the study that there is increased engagement in music and cognitive benefits from Rock Band 3. Conversely, My Note Games! has shown that there is little to no engagement due to the similarities between that game and traditional music theory. While there is still more research that has to be done, this implies that some music games help with music education, but others do not.

Finally, the primary source from Victor Wooten suggests that a more free-form and expressive approach should be used to learn music, like how you learn a language. Music games can be an example of how someone can learn music while expressing themselves.

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