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Gamifying Music Education: An Appealing and Engaging Method of Practice for Teenagers

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ABSTRACT

Music interventions have been proven to have positive effects on educational processes and development of children. But music education has been in jeopardy for the past 3 years due to the Covid-19 pandemic and overall has been inaccessible due to exorbitant costs, social stigma, and lack of engagement. Under these conditions, this paper seeks to answer the question of whether gamification makes music practice more effective and appealing. To accomplish this, a mobile game is designed to utilize a fantasy narrative with interactions triggered by the sound from an instrument This game, named *Octavion*, features a captured princess who escapes with movement dictated by notes played on a musical instrument. Music notes appear on screen at certain times, which emulates sight reading sheet music. Qualitative and quantitative user experiments are conducted to understand the impact of the game on users' instrument playing aptitude and engagement. The results from playtests show that playing the game does improve the testers' sight-reading speed. In a larger context, this experiment indicates that a game of this structure can be appealing and effective to help teenagers read and play music.

Introduction

Video games are played all over the world. The only thing that is required to play them is a phone or a computer. On the other hand, music lessons starkly differ in accessibility. While video games are often free, music lessons on average cost about 40 dollars per 30 minutes session [2]. Not only the cost, but the COVID-19 Pandemic has caused a lapse in music lessons. Without being able to meet face-to-face, music lessons around the world have been delayed due to the fear of COVID infection since early 2020. There is an urgent need for music education to catch up as people are less motivated to practice and can't get feedback without a teacher. Mobile games can motivative provide feedback to the user. To help improve the reach and engagement of music learning, a game in this paper is developed that plays like a narrative driven fantasy game in which the main mechanic is playing the music notes that appear on screen with an instrument. The experience appeals to the target player group and ties in with the musical practice aspect.

In this paper, the design concept is explained in the Mechanics-Dynamics-Aesthetics (MDA) framework [3], a common framework to analyze games. The narratives, along with the character dynamics and the choice of the music in each scene, are illustrated. Then, the overview of technical design and implementation is provided to describe the mechanics that support the game experience. Finally, to measure the learning effect, an experiment is designed and performed on the target user group. Surveys were conducted at the end of the experiment to collect user feedback. The experiment's results were analyzed to assess the impact of the gameplay on music sight reading speed. The results demonstrated that teens who played the game had shown improvements in the sight-reading test. The contribution of the paper is two-fold: (1) it presents a game design that combines a narrative and direct feedback from a music instrument. (2) it provides empirical evidence of the game's positive effects on music education.

Review of Literature

Even before the COVID-19 pandemic, the importance of playing an instrument is understated in society. According to a study conducted by the Portland Chamber Orchestra, “the hippocampus, involved in learning and memory, increases neuronal connection and neurogenesis during development when the child is involved in musical training. This leads to improved learning and memory activity” [4]. Similarly, in a study conducted by the Harmony Project in LA, a music program dedicated to underprivileged kids, stated that “students that were actively engaged (twice per week) in the interactive music class scored higher on reading tests and showed larger improvements in their brain’s ability to process speech. In addition, 93% of the seniors from this program go to college unlike the 50% dropout rate of peers in the neighborhoods where the children were raised” [4]. The intelligence and interest in college are both clearly stated to have risen when a student has active engagement in playing an instrument. Aside from intelligence, instruments have also shown to increase the well-being of the player. In a study conducted by Spotify UK with a sample size of 400 stressed individuals, “almost nine in ten adults reported that playing a musical instrument had a positive impact on their mental health … over a third reported that playing music gave them ‘a sense of purpose in life.’” [5]. These studies show that playing instruments have a positive effect on an individual’s mental health and intelligence.

However, statistics and studies have shown that “beginning at age 15, teenagers abandon their musical practice at increased rates, with almost 50% doing so by age 17.” The explanation for this has been puberty, which explains why “students might have tried out various leisure time activities and may settle for a specific one (e.g., athletics) while at the same time neglecting others (e.g., music).” [6]. From the same study, they concluded that “The older children grow, the more important other leisure activities become … music lessons or group music making has to compete with other activities.” Social pressure is another reason teens stop playing music. The aforementioned study by Ruth and Mullensiefen showed that instruments were getting dropped during the ages of 15 through 17 “with one explanation being that boys sometimes regard musical activities as “feminine” [6]. With these factors, the benefits of playing an instrument are at risk of being abandoned by this age group.

The concept of using a game to educate teens, however, is not new, and is largely proven in the field. Education can be made more appealing through gamification. For example, Kahoot, an app that allows students to participate in a class wide multiple-choice quiz, has been a major competitor and trendsetter of the aforementioned field. A literature review on the effectiveness of Kahoot “suggests that there is a relationship between engagement, motivation, and having fun and learning outcomes and classroom dynamics.” Another popular gamified learning tool is Duolingo, an app that gives tests and goals to practice and certify a foreign language of the user’s choice. It leverages the Octalysis framework of game design which is an eight-stage framework that analyzes the ways that games could harness human motivation to build an engaging experience for a user [7]. From the success of these applications, it is evident that the gamification of education has shown to be effective in encouraging people to learn.

Built on the success of this gamification concept in education, the main mechanic for the game in this paper is inspired by traditional instrumental/rhythm games such as Guitar Hero, that have reached mainstream success. Another example of a game like this that also utilizes a narrative component is the Crypt of the NecroDancer (Figure 1).

Necrodancer utilizes the dungeon escape story to enrapture the player and incorporates musical elements as a means of progressing the story and moving the main character. Guitar Hero differs from the Crypt of the Necrodancer by being less narrative driven and more mechanic heavy. It uses a custom controller that takes the shape and feel of a guitar (Figure 2 and 3) and has notes coming down a lane as the call to play.

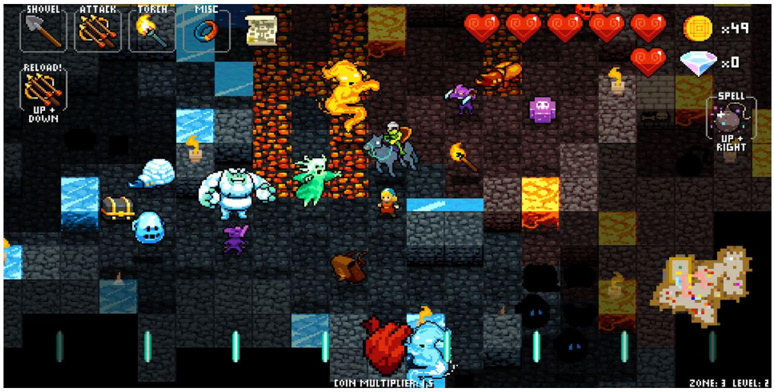

Figure 1. Crypt of Necrodancer, and rpg setting and premise that utilizes clicking on beat to move the character to the correct position.

Figure 2: Guitar hero controllers [8]

Figure 3. Guitar Hero 3 is played through the fire and the flames. [9]

The Guitar Hero franchise was immensely successful: by 2008 it had surpassed 1 billion USD in sales within the span of 24 months. This grand success demonstrated that a well-designed game can attract and engage users to play music.

Guitar Hero mimics the fun of playing a guitar, but the controller replaces the guitar strings with a few buttons. The game in this paper takes the successful and proven premise of a rhythm game and applies it further by replacing the rhythm mechanics with actual instrumental feedback. Through gauging the effectiveness of learning an instrument with a mobile game, this game is the first to combine narratives and direct feedback from an instrument.

Octavion, the game to enhance music education

Inspired by trending action role playing games centered around fantasy narratives in popular games such as Tower of Fantasy and Terraria, a game was created called “Octavion” (Figure 4). The narrative design is simple and intuitive. This narrative is integrated with the players’ experience with the mechanics of the game, which involves a music instrument, notes, and tempos.

Figure 4. The splash screen of game when the player completes the tutorial

Narrative, Movements and Music

Octavion is a fantasy adventure game where the main character is the princess of the kingdom of Octavion. The princess is captured and held prisoner by the goblins of the forest. The prayers of the king and queen summon a spirit of the gods, and this spirit takes the form of a glowing bright blue note. The bright blue note is named Muse, and is introduced in an explosion of light (Figure 5).

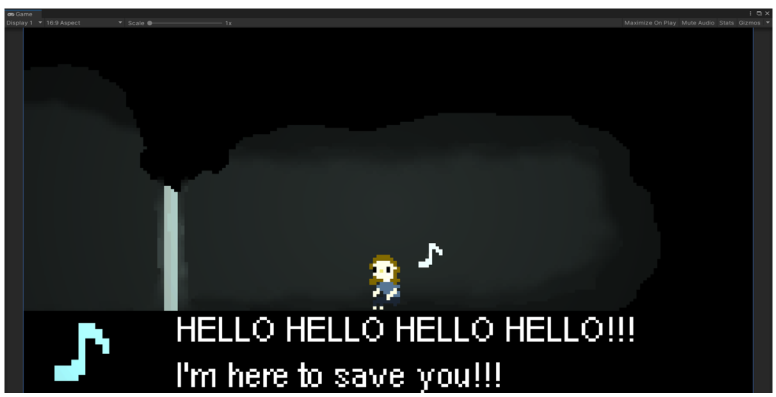

Figure 5. First time Muse is introduced, the fictional spirit sent to the player

The one condition for Muse to help the princess is that it must possess the princess in order to take control of her body to get out of the dungeon. Once Muse takes control of the princess, it requests that the player uses music to guide it through the dungeon. Three levels are designed to engage players with different experiences with integrated music, movements and narrative illustrated in Table 1. Songs were chosen to fit the theme of each level. They were edited with a music composition software Musescore and tempos were adjusted to fit the difficulty of the levels [10].

Dynamics and Mechanics

The primary game dynamic is designed to be intuitive, straightforward, and simple enough to allow players to understand what roles the instrument has in playing the game. It progresses the narrative through incentives when a correct note is hit such as rewards and goals which motivate players. The narrative context around the rescue mission situates activity and establishes rules of engagement, while the learning content revolves around the music notes, tonality, and striking the right note on an instrument that is relevant to the narrative plot and interactive cues that prompt movements and provide feedback.

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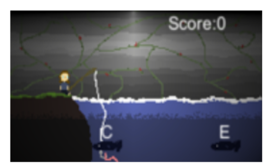
Table 1. Aesthetics of three levels

	Narrative	Movements and Music	Picture
Tutorial	The adventure is breaking out. The princess must escape a prison cell by destroying the cell bars. To accomplish this the player must play the notes that appear above the prison bars.	The main level consists of the character moving forwards and backwards. When the character gets near the prison bar the user must play the correct note on the instrument which is signified above the prison bar. An original composition is played in the background for purely ambient purposes.	
Level 1	Once out of the prison cell the player must guide Muse through the forest to a nearby lake as Muse's vessel is becoming weak from dehydration. At the lake the player must fish where notes are above the fish. Correct notes yield fish, and the player needs 30 fish to pass the level.	The notes move towards the character. The song that plays in the background is Gymnopedie No 1 by Erik Satie, a slow song that is meant to make the scene feel peaceful. It was also chosen because the notes in that song are meant to be more beginner oriented. The tempo is slow: at bpm is 35 BPM, the user can have time to hit the notes when they touch the character.	
Level 2	The game features several formidable enemies, including bounty hunters who disrupt fishing and goblins who shoot arrows corresponding with notes that must be played correctly. The final foe, the Goblin King, presents a challenge (the Can Can) incorporating the skills from all previous levels.	Level 2 is similar to level 1 in mechanics but the premise and music are completely different. The character is fishing and notes show up in the form of fish. The song chosen was The Blue Danube by Johann Strauss II. It's a waltz, a dance music to fit the idea of fish running up a stream in a bouncy style. The song is more difficult to play than the one in level 1 and it is faster. The tempo is a slow/walking tempo (80 BPM). The time signature is ¾. The level makes the user feel joyful and gliding. The user should hit the notes when they touch the fish hook.	

The high-level concept is illustrated in Figure 6. A user plays an instrument to generate the right note to trigger the next move. The sound is sampled and processed via the microphone on a phone device or a computer. The game is developed in C# on the Unity platform, the popular game development platform that can build applications across mobile, desktop, console, TV, VR, AR, and the web.

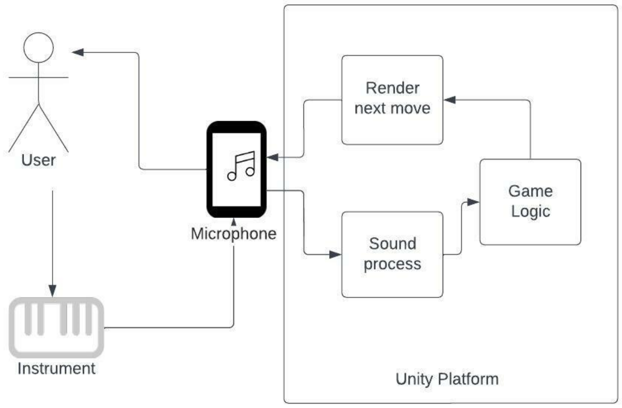


Figure 6. Concept Diagram of Octavion Game

The technical mechanics intersect with the narrative through the timing of the character's actions. The main character is seen at the same spot on the screen all the time, but their animations are dictated by whether or not the right note is played. On the screen, there are incoming notes towards either the character or the objective desired which have to be played when the note hits the objective area.

A mechanism is needed for players to use their instruments in the game: an instantaneous tuner. This currently has no previous examples in the Unity game engine. In order to do this, a tuner was developed that can output a public string indicating what note was being played on the microphone. The coding of the tuner required the development of a few key concepts: Fourier transform, filtering, Harmonic Product Spectrum, and animation (Figure 7).

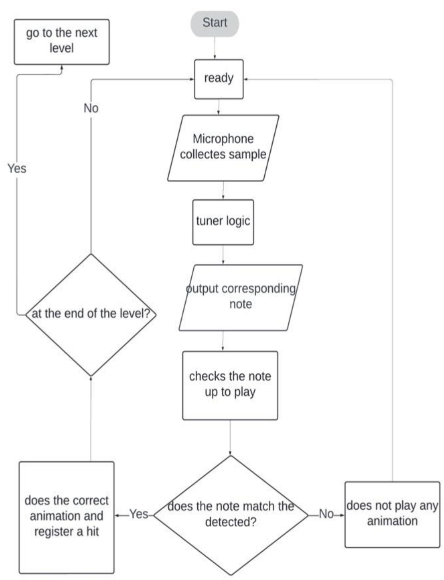


Figure 7. Game flow chart of the backend technical note recognition. "Does the correct animation and registers a hit" means the character will do an action that puts them closer to the objective. E.g. taking a step forward, catching a fish, etc.

The tuner utilizes Unity's scripting APIs that obtain the frequency information of a defined sample size from the user's microphone [11]. Then, the Harmonic Product Spectrum is used to filter out the excess frequencies playing in the background to get the fundamental frequencies of the notes being played by the instruments in real time [12]. The following formulas are used to convert frequencies to their letter note counterparts by looking up the note in (1) with the index calculated with (2) [13].

$$allnotes = [\text{"A"}, \text{"A\#"}, \text{"B"}, \text{"C"}, \text{"C\#"}, \text{"D"}, \text{"D\#"}, \text{"E"}, \text{"F"}, \text{"F\#"}, \text{"G"}, \text{"G\#"}] \quad (1)$$

$$index = \left\lfloor \left(12 * log_2\left(\frac{frequency}{440*(-4.75)^2}\right)\right) + \frac{1}{2} \right\rfloor \quad (2)$$

From this, a note can be identified to decide the next action in the game logic. Figure 8 illustrates the logic flow of the tuner algorithm. Algorithms are implemented in C# (the coding language that Unity uses).

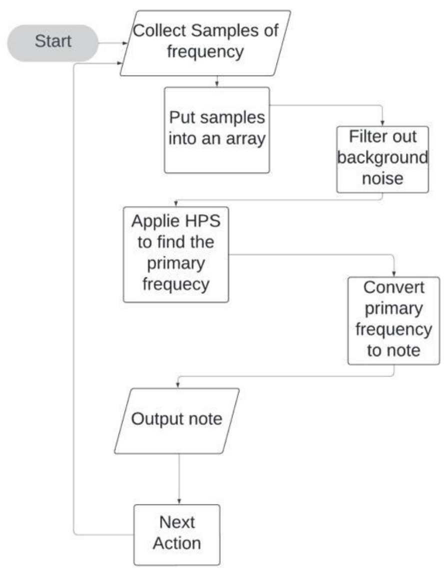


Figure 8. How the tuner works, HPS stands for Harmonic Product Spectrum.

Aseprite and paint.net were used to design the visuals of the game. To animate, Aseprite is used and to make most of the assets I used the 213x126 resolution to emulate older games, more recognizable games, such as those played on an old Nintendo console. Paint.net was used to edit the drawn images and to write text for the logo and text bubbles that appear throughout the game. All visual effects were then put together with Unity's built-in animator to time the different drawings with their corresponding different functions and text bubbles to create game-like cutscenes.

Experiments

Experiment Design

A formative evaluation was conducted to test if the game had an effect on the players with two devised tests. Both tests were using Google Docs with a string of 64 notes in letter form, with 4 letters on each line (Figure 9). A playtest of the games' levels 1 and 2 was placed in between playing tests.

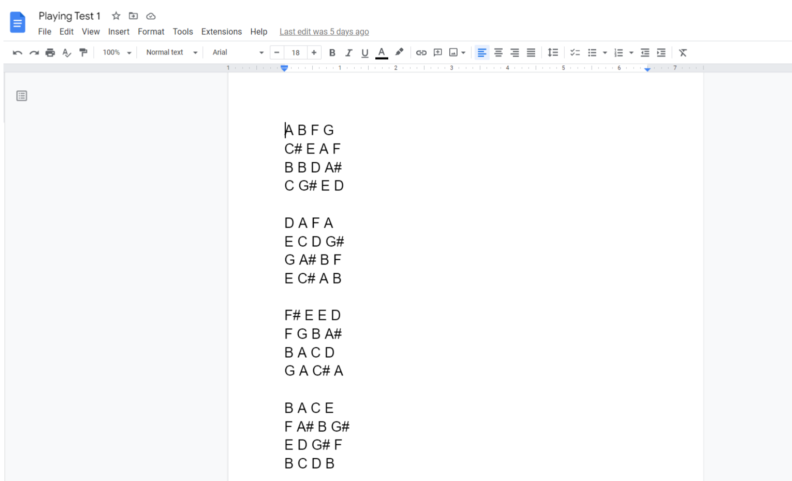


Figure 9. The concept of playing test. Players play the notes on the paper with an instrument while being timed.

For the first test, participants were told that they would play the notes on the sheet while being timed and whenever they hit a wrong note, they would have to go back and correct it. They were also told to try to finish the test as fast as they could. When they finished, the time recorded was documented as a pre-game timing for each participant. After the pre-game test, participants watched the tutorial cutscene. Then they played the entirety of level 1 and level 2. After having them play both levels, they repeated the pre-game test with equal difficulty and length, but with different notes. Once they were done with the test, the timing of it was recorded as a post-game timing for each player.

At the end of all the tests, the participants were asked to fill a Likert scale survey and were prefaced with the plea for honest feedback for the integrity of the study. The survey asked 11 questions on the Likert scale (Table 2) [14].

Table 2. The questions asked in the Likert scale survey

1. This made me better prepared for the sheet music at the end of the test
2. I feel more confident about where to put my fingers
3. I am inspired to play my instruments after this game
4. I want to share this with my friends
5. I would play this again if it was done
6. I feel happier after playing this
7. This game was very challenging
8. This fantasy world feels immersive
9. I know what’s going on in the story
10. The game mechanics are easy to learn
11. I know what to do for every level

Experimental Settings

All participants were recruited at a high school dining hall. The group was composed of 5 girls and 7 boys, spread throughout ages 15 and 17. All participants were tested at the same location where there was a grand piano. The same computer was placed on the top of the grand piano on the foldable stand. Earbuds were worn so the earbud’s microphones could catch the instrument audio. Within this test group, there was one guitar player who worked with a piano finger chart on the side while playing the game, and one who played the game using a violin.

The tests took about 10-15 minutes each, and the environment volume was variable due to the uncontrollable nature of the student commons. The pre-game test on average lasted about 1 and a half minutes; on average the tutorial cutscene took about 2 minutes; the first level took about 3 minutes; the second level took about 4 and the post-game test ran about 1 minute to complete. The survey at the end would take about 4-5 minutes.

Lots of positive feedback were shared by the participants such as “This looks awesome!” or “can't wait to play this one (once) the game is done”.

Experimental Results

The comparison of time to finish the test pre- and post-game is the core metric to measure the effectiveness of the game. The raw data is illustrated in Figure 10.

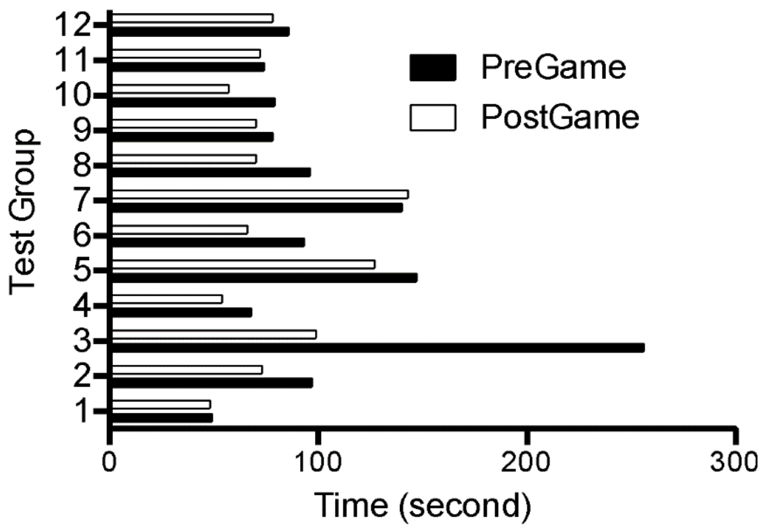


Figure 10. Octavion shortens testing time among students.

The recorded testing times showed that out of the 12 participants, 11 were able to play the test of the same difficulty and length faster than before they played the game. There was an outlier from tester 3 that may skew results; it was removed for the data analysis.

In general, the participants improved the time to finish the test after they played the game (see Table 3).

Table 3. Comparison of mean time to finish the test

Experiment	N	Time	Std. Dev
Pre-game	11	91.6	29.18
Post-game	11	78.16	29.92

From a paired t-test performed on the results, there was a significant difference between the time pre- and post-game with $p<0.05$ (Figure 11). With the average finishing time that is lowered from 91.6 seconds to 78.16 seconds (overall 14.6% improvement). It can be concluded that the game helped the testers improve their speed to play music notes on an instrument.

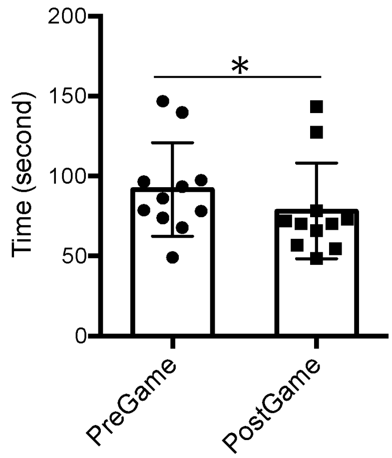


Figure 11. Octavion helps improve sight reading time among students significantly (n=11). Statistical analysis was performed with student paired t-test (*p<0.05).

Moreover, from the results of the Likert scale surveys, positive feedback was shown for approachability of the mechanics and the story. For all of the questions that addressed the aforementioned concerns, the survey recipients answered neutral and above. These results indicated that the testers would play this game again if it came out; the results also showed that the participants were able to learn the rules of the game easily (Figure 12).

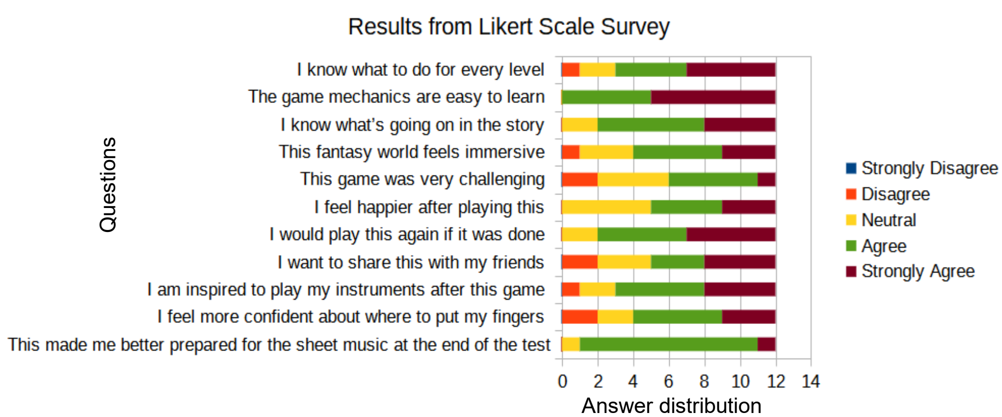


Figure 12. Results are displayed from the Likert scale surveys among the testing group.

Conclusion and Next Steps

In this paper, the Octavion game is designed to combine fantasy narratives and interactions triggered by sound of a real instrument to improve music skills. It enabled players to associate the keys on an instrument and music notes through playing a game. Qualitative and quantitative user experiments provided the evidence to measure impact on users' interest and ability playing instruments. Results showed that the game improved the players skills in recognizing notes and hand positions.

In general, sight reading is hard to improve in a short amount of time; hence, the improvement seen in the user test using Octavion is encouraging and promising. For the next steps, adding additional core drivers in the higher levels such as unpredictability and empowerment based on the aforementioned Octalysis framework is expected to be beneficial to the players. Based on the results, gamifying music education with direct instrument input does engage high school students, and playing improvement through this more appealing medium is highly probable and games like Octavion should be pursued in the future.

Acknowledgements

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