Developing Games That Can Create Real Heroes on Real Guitars: Using Acoustic Musical Instruments and the Human Voice as Controllers

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Abstract: Games, one of the most popular forms of entertainment for young people today, exhibit a number of promising traits for pedagogical practice. Game-based learning theory identifies elements of game play that encourage engagement and increased motivation. The acquisition of musical skills on a new instrument can be a slow and laborious process, requiring sustained effort and commitment. A strong alignment between many of the properties of game-based learning and the practice of learning to play a new instrument, especially at the early stages, is identified. After laying out the theoretical connection, a collection of new game design prototypes are described, designed with the goal of augmenting conventional skill-acquisition practice and increasing student motivation and engagement.

Introduction

Learning to play a musical instrument, as with any physical skill acquisition, typically involves thousands of hours of repetitive tasks in the form of etudes and studies. While this practice is considered very beneficial and leads to long-term rewards, the immediate experience is often mundane and students struggle to find the motivation to sustain the required time commitment.

Strong cases have been made for exploring video games as new interfaces for music education (Denis & Jouvelot, 2004). Games are lauded for their ability to immerse and engage players, increase motivation, improve the transfer of pedagogical knowledge, and increase accessibility to resources. Further, there is strong evidence that games foster the development of useful motor, cognitive, and social skills. Games such as Rock Band, Guitar Hero, and Wii Music already boast a modicum of musical, physical skill focus, albeit using specialized game controllers and highly constrained musical contexts. Can video games be leveraged to support musical skill acquisition on traditional acoustic instruments, encouraging long-term musical development?

We present here a preliminary study in music practice-based video game development targeting the early stages of instrument (or vocal) practice. Based on theories of game-based learning (GBL) we designed and created three interactive games aligning educational objectives with the strengths presented by game interactions. Unlike most musical video games developed to date we leverage the student's chosen acoustic instrument or voice as a game controller, ensuring that the motor skills are developed directly upon the instrument or voice of choice. The prototype games were then tested with a group of college students engaged in learning secondary instruments to better understand how these games function with regards to user engagement.

Game Based Learning

While the exploration of video games as tools for music education has been proposed (Denis & Jouvelot, 2004), much work remains to be done in this area. A fundamental challenge facing this exploration involves aligning the affordances of GBL with specific educational goals. We base our exploratory designs in theories of GBL, taking advantage of the opportunities presented by medium as we perceive mappings to existing pedagogical practices and objectives. Towards this end we ask: how do skill centered music education goals align with the strengths of GBL? We now present a number of acknowledged attributes and qualities of games and how we place them in our designs in order to encourage musical practice and development.

First, digital games are found to create meaningful problem-solving experiences, and promote learning-by-doing active and collaborative learning (Huang & Johnson, 2009). This is seen in the process of identifying winning game strategies, typically by learning from mistakes and the mistakes of peers. The improvement of appropriate skills occurs through problem-solving experiences explored by self-directed trial-and-error activities. In commercial games the problems solved rarely have a real-life extension, however in an educational game they could encourage skills that have meaning outside

of the context of the game. What if the problem requires playing a certain melodic passage, or improvising around a given scale or chord sequence? These types of problems map readily to game based challenges.

The development of fine motor skills, often to very high degrees, is seen in the repetitive use of popular video game controllers. One potential opportunity for music game developers is to replace the game controller with the student's chosen musical instrument. Even if the instrument is simply treated as a set of buttons (mimicking a game controller's functionality) the learner is now spending time with their instrument, a desirable educational goal. However, if appropriate use of the instrument is required in order to interface with the game (i.e. playing music, and playing it effectively), the player develops the targeted skills and the game can begin to lead the player through dynamic opportunities for the kinds of development typically confined to static etudes and studies.

If the player is using their own instruments to play the game, the safe spaces for play, experimentation, and failure that games create become of key importance. The "magic-circle" (Huizinga, 2003) surrounding game play encourages exploration that could have detrimental implications in other contexts. In a game there is always an opportunity to try again, and there are no permanent test scores or grades. Thus any failure becomes a step along the path to achievement. Music practice typically encompasses countless failures (missed notes, reading errors, intonation problems, etc.) with many such mistakes before mastery is achieved. We see a strong potential for encouraging productive mistakes and corrections in game-based music education learning. Unlike standard isolated practice settings, a game can offer the player feedback and reinforcement directly and immediately.

Games allow players to carry out actions autonomously in the process of completing game tasks. In other words, players have a great amount of control over what paths they take in order to resolve the problem or task at hand. This autonomy helps players develop a sense of ownership of decisions they make during the game play (Bennett & Warnock, 2007, Crawford, 1982).

In order to encourage engagement with the game, leading to increased musical engagement (i.e. more practice time), the problems and challenges in the game must be perceived as achievable yet somewhat unpredictable, and thus interesting. Ideally these challenges will stretch and flex the player's existing knowledge or skill levels (Pivec et al., 2003), only minimally exceeding the learner's potential capacity to overcome the obstacles (otherwise the learner may experience frustration (Bennett & Warnock, 2007, Crawford, 1982). This is a fundamental problem in all game design and also familiar to educators through Lev Vygotsky's notion of a *zone of proximal development*, and in a musical setting is compounded by the need to balance both in-game problem difficulty with the proficiency of the player's musical capabilities. Yet this simultaneously implies a game progression that starts with entry-level basics and culminates in master level concerti.

Interactivity is a fundamental component of video games, encouraging engagement and immersion, and rewarding experimentation and theory formation leading to meaningful game play (Ang, 2008). While games have been shown to enhance motivation (Pivec et al., 2003), interacting through a musical instrument could simultaneously encourage increased engagement with the instrument, both during and after the game play session. Interactivity might also lead to new models for teaching music theory, allowing the learners to intuit musical rules and properties at their own pace. Additionally, game play seems well suited to modeling and encouraging improvisation (Denis & Jouvelot, 2004), one of the National Standards for music education, both due to the dynamism of the interaction and games' ability to foster a sense of freedom and playfulness.

Competition is a defining characteristic of games (Csikszentmihalyi, 1991) encouraging both engagement and achievement. Players both compete with themselves, through measures of their increasing accomplishments, as well as with other players. This also directly parallels the competitive attitude of the contemporary music market, from solo competitions and opera auditions to college applications and orchestral job opportunities.

Through game play, learners are able to gain first-hand experience practicing a methodology to solve both artificial and real challenges. This is enforced by the rules of the game, which are applied uniformly and constantly to all participants (Crawford, 1982). In a musical context this is analogous to

having a music instructor that fairly and untiringly stops on every mistake. At the same time this instructor also consistently and even-handedly rewards every achievement.

While musical achievement typically has no end goal (but may encompass many short-term goals), games fundamentally contain goals and winning conditions. Achieving those game-based goals is accomplished through sequential task completion. This model fits well with musical instruction that necessarily requires sequential practice towards skill acquisition targets (i.e. one must hold the instrument, then learn to make sound, then produce each tone, then play a simple melody, etc.).

Three Games

In our approach to exploring the application of skill oriented GBL applications in music education we constructed three families of prototype games each addressing specific learning goals, where each family consists of a number of incremental design choices around the same game play themes. The identified learning goals are taken from introductory lesson plans as taught privately and in-group instrument classes. These are: pitch-altitude metaphor acquisition, tone production and sustain, and pitch matching. The first involves learning that pitches with faster frequencies are ``higher'' than notes with slower frequencies. Good tone production is important to all instruments and a common practice technique, especially for wind instruments, is the sounding of long tones—sustaining a given note as evenly as possible for as long as possible. Finally, pitch matching is a common aural skill that requires the student to accurately repeat a pitch (or pitch sequence) played by an instructor.

The games were implemented in Unity 3D and Max 5. Real-time pitch detection is performed in Max and the resulting data is transformed into a control stream for the game. Continuous pitch, loudness, brightness, and noisiness are all employed to give a general sense of timbre and dynamics in addition to melodic content. Thus any voice or instrument capable of acoustic tone production may be employed as a controller for these games.

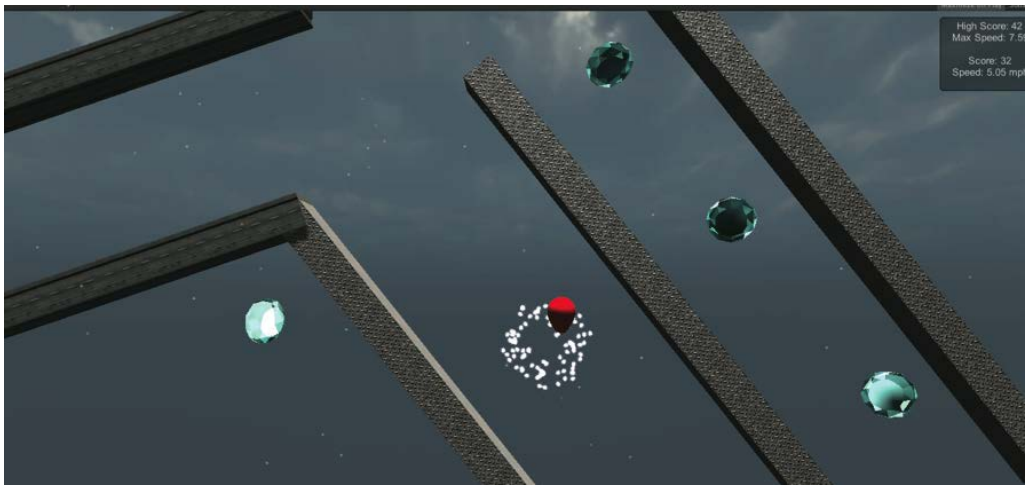

***Figure 1*: *Balloons* game play session in progress.**

Balloons

This game family involves playing a melodic passage in order to navigate a balloon through a series of obstacles (see figure 1). However, this is not stated explicitly, rather the player is presented with the ability to inflate and deflate a virtual balloon based on the pitch they play, which encourages the balloon to rise (for higher pitches) or fall (for lower pitches) and move from left to right on the screen (in conventional "side-scroller" style). Obstacles are placed throughout that require the player to sound a specific pitch sequence in order to progress. By the time the player reaches the end of the level they have played a short piece of music.

A meaningful challenge is provided to the students through the production of a piece of music presented in an abstract fashion. The notes that comprise the *piece qua level* are only visible as a path through the game space, and thus experimentation encouraged and required in order to discover

the melody. Failure and errors, through playing the wrong notes, causes the balloon to collide with obstacles and lose momentum, suffering a temporary setback. The balloon then floats aimlessly until the proper inflation level (correct pitch) is achieved and progress through the piece resumes. A score is awarded based on the time the player took to complete the level, which is intended to encourage competition and additional challenge as the learner seeks to improve upon their previous attempts.

The layouts (i.e. levels or musical pieces) implemented in the prototype explore both constrained melodic possibilities (i.e. only a single melody can solve the challenge) as well as open pathways (allowing many different successful pitch sequences). The latter are additionally augmented with special collectible objects in the game that count towards a high score, rewarding the player for seeking out more difficult paths/melodies (i.e. requiring more musical dexterity). Also, the more open levels explicitly encourage melodic exploration and improvisation, enabling a number of permutations to solve the same game play challenge.

The Long Tone, Long Jump

Sustaining long tones is typically a key developmental target for the beginning instrumentalist. Towards this goal we appropriated the metaphor of a long jump, in which the player must sustain a note evenly in order to achieve the longest jump and thus the highest score. When the player first articulates a note a colored ball is launched from the left side of the screen, moving rapidly towards the right. As long as the player sustains the tone, with minimal pitch, dynamic and timbrel variation, the ball continues to hurtle forward, moving through clouds. When the player finally loses the tone, or 'cracks,' the ball falls to the ground, producing a tangible measure of the length of the tone. The game traces the path of the ball on the background and places a visible mark at the touch down point, simultaneously announcing the player's achievement as measured in virtual meters.

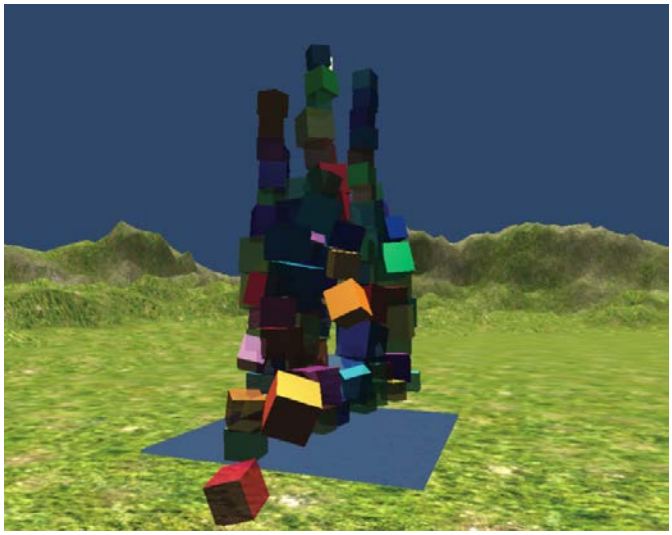

***Figure 2*: *Musical Towers* game play session.**

The explicit extra-game challenge here is to sustain a tone as evenly as possible for the greatest duration, driven by the in-game challenge of flying for the longest attainable distance. Elements of competition are present in the athletic metaphor of the game and the primary challenge is one of educational merit. Failure simply resets the player to the start to try again, and the player may choose any note they desire. The musical metaphor of “high” and “low” pitch is again incorporated, here reflected in the nominal flying altitude of the ball.

Musical Towers, Musical World

The final design family focuses on the aural musical skill of pitch matching: hearing and reproducing a given pitch. Two different visual metaphors are employed for the same educational goal, one that is based on constructing towers of greater and greater height (see figure 2), the other on building a bigger and bigger ball (or *world*). Periodically, a block appears on the screen and a tone is heard. The player then has a few seconds to match the pitch of the tone with their instrument (or voice), causing the block to become a permanent part of the scene. If the player fails to produce the given pitch the

block explodes, disturbing nearby blocks that may have been acquired previously. Blocks, which are drawn from simple solid shapes, operate within a physical simulation, falling to rest (in the Tower version) or being attracted to nearby blocks (in the World version). The objective is to build the tallest tower or biggest world possible, by correctly matching each tone as quickly as possible and avoiding the disruptive detonations.

The game begins with a basic level of difficulty, and allows the player to try as many notes as they desire in order to locate the correct one (the block changes color to indicate a successful match). However, as the player acquires more blocks (successfully matching more notes) the blocks appear more quickly, intensifying the game play and requiring progressively more accurate pitch matching. This is a classic game design technique that effectively sweeps across the range of targeted skill levels, allowing each player to locate a comfort zone and then encourage them to achieve further. Awarding high scores based on the height of the towers or radius of the worlds again encourages competition and provides an indirect measure of each player's competency at matching pitches on their chosen instrument.

The notes chosen in the game are selected from a preset scale and mode, which can be chosen by the player (or instructor) before the game starts. The pitches are chosen at random in the current implementations, but including more intelligence and the ability to choose pre-loaded melodies is a development target.

Evaluation

In order to better understand the motivational characteristics of our games a small user study was conducted with undergraduate music students enrolled in secondary instrument classes (i.e. studying instruments on which they have no, or limited, prior experience). The participants employed their secondary instruments to play the games, and occasionally elected to sing (none of the participants had extensive training on the voice). The games were set up and introduced to the students as a group, after which they were allowed to play the games in an ad-hoc fashion. This setting was constructed in order to provide initial observations about the group interactions afforded by the interactive games. Detailed results from this study are forthcoming, however some anecdotal results are presented here.

As anticipated, study participants were able to quickly understand the musical controls of the games and, in almost all cases, play successfully independently of instrumental competency. The Long Tone Long Jump was initially confusing, as the connection between steady tone and ball speed was not readily apparent. While overly sensitive audio processing and game mechanics caused the ball to crash frequently and in a disappointing fashion for some players, other participants were able to reach the “kill screen,” successfully flying past the end of the level. Overall, the Long Tone Long Jump appeared to be successful at fostering a sense of friendly competition, encouraging the participants to compare their jump lengths with others (something we hope to further encourage with the addition of high score charts).

Musical Towers seemed to excite some participants more than others, and primarily lead participants to sing (rather than play on their instruments). Additionally, one participant tried their *primary* instrument and found the game enjoyable, indicating a significantly higher required degree of proficiency. While successful, the participants typically sang the pitch in an alternating rhythm with the game, resulting in a slower speed than their actual pitch recognition. This resulted in bigger blocks and a more unstable tower, ultimately leading to an early defeat. While this may be deemed a feature (some participants found this game “soothing”), a more unpredictable game rhythm that more explicitly rewards rapid response will be incorporated and tested in a future version.

The Balloons game proved varyingly difficult for the players, with some being able to navigate the scenes much better than others. In one extreme case a beginning trumpet player, who could only produce three pitches, was quickly frustrated as the game design relies on the production of a full octave. This lead to plans to introduce an adjustable input range, allowing a breadth of competencies from the three note beginner to the four-octave professional.

Conclusion

We have presented many of the primary features of GBL and how we perceive mapping to music education practice in these specific design prototypes. Further, our three preliminary game designs

seem to align well with these features and provide a platform for testing and evaluation of both the designs and the potential for GBL in skill-based music education. Evaluative work is underway with user testing of the prototype games and future development is planned to incorporate the testing results in improved designs.

There is strong potential for the incorporation of GBL music games in conventional educational settings, in both private and group practice. The rapid feedback afforded by games such as the ones described here may have significant impact in private practice, where the student is typically the sole listener, being required to produce the music and critique it simultaneously. While expert musicians can do this fluently it is an extreme challenge for the beginner, and often results in the incidental acquisition of undesirable habits which require significant effort to relearn. An automated music tutor, integrated transparently in the form of a game, could alleviate these problems.

Group and private practice demands a high degree of commitment from students, due to the large number of required hours, and motivation is always at a premium. Games thrive on competition (Csikszentmihalyi, 1991) and this can also be a significant motivator for many students (as exhibited by the widespread practice of annual regional music competitions and auditioned "all-state" ensembles). GBL may be able to instill an atmosphere of fun engagement through competition, allowing students in a class to go "head to head" in meaningful yet harmless challenges. This mode of play is foundational in the success of games such as Rock Band and Guitar Hero and leveraging the same in a music class setting could be significant.

Finally, GBL presents a strong potential for the discovery of new modalities of music education, fostering new practices around these new tools. Game play may also lead to new ways of imparting theoretical knowledge, enabling a more discovery-oriented model that is typically unavailable in conventional text book-based modes of scholarship. The possibility of student's appropriating these types of games and constructing their own “practice” regimen (i.e. play time) could have wide reaching effects. What could happen if student's invested their game play time, on average 20 minutes a day (Fullerton et al., 2008, with many cases being much higher) into practical, musical games? We believe the results could be transformational.

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