

# Developing Games For The Purposes of Rote Learning for Keyboard and Piano

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**Abstract**— This paper describes the development of a set of three video games designed to reduce the high drop-off rates associated with learning to play the piano/keyboard by gamifying rote tasks that require monotonous practice. By defining our own understanding of what musicianship is and creating a custom framework for assessment through the use of existing curriculum, we have chosen specific areas which require the most rote learning and are critical to developing motor skills and to building an understanding of music; these include learning and practicing scales, keeping in time with tempo and the basics of hand coordination and fingering styles. Existing solutions that attempt to resolve the issue of high drop off rates observed with beginner instrument learners use elements of gamification in order to enrich their learning experiences and also help increase motivation. These approaches do work but in most cases they offer short term solutions; a key issue is retaining users over long periods of time and ensuring that they practice consistently and regularly. We developed solutions which offer a way for learners to practice in an engaging and entertaining way, with the intention to reduce the drop-off rates and lower the barrier for entry to learning piano/keyboard.

**Keywords**— piano, keyboard, gamification, musicianship, rote, learning, retention, pedagogy

## I. INTRODUCTION

Statistics from ABRSM [1] demonstrate that a large number of adults in the UK have never attempted to learn an instrument, and also that out of those that attempted learning, a significant amount dropped out shortly after starting. ABRSM polls claim that the reasons behind why adults stop learning include a loss of interest, financial issues or they found lessons were not necessary; they wanted to just have fun. There is a desire for adults and children to play an instrument but the current methods of teaching and financial pressures unfortunately mean that a large majority of these potential learners will never attempt to learn/discover the wonders of music.

In the current market, there is a large variety of music applications; from games which are purely an enjoyable experience to professional music applications, such as digital audio workstations. The applications which attempt to teach users how to play an instrument draw upon the professional side with detailed lessons and exercises, whilst also utilising elements of gamification (e.g. badges, and leader boards etc.) in an attempt to enrich the educational experience and motivate users to keep learning and practicing. These learning applications do work on some level and are used by millions of users [2], but user reviews and opinions reflect the fact that

they lack specific elements of gamification plus struggle to combine these elements. This leads to beginners enjoying the first few sessions and eventually dropping off due to lack of fulfilment, motivation and, most importantly, enjoyment.

Although no tangible evaluation data has been collected yet for the development work presented in this paper, a comparative review was conducted, which compared current musical learning applications. We defined specific comparative criteria and analysed the use of gamification in each application in order to determine their relative success. Using the paradigms of typical video game design and via the setting of simple, yet effective learning objectives defined through the use of our own framework for learning the piano, we developed a series of games with specific learning objectives. The purpose of these games is to determine whether practice can be achieved and some knowledge can be transferred through playing a video game.

Using consumer research conducted at ROLI (a music instrument manufacturing company who are currently developing new musical learning methods [3]), specific user groups were defined; a) novices, i.e. absolute beginners who have a passion for music but have no technical knowledge; b) instrumental learners, who seek to improve their current skills regarding their instrument; c) lapsed, this group had learned an instrument but gave up due to various reasons and wish to relearn.

The end goal is not to teach an entire curriculum of piano through the act of playing video games but to use them as tools in conjunction with other learning methods, such as traditional lessons, and to help determine musical aptitude within beginner students.

## II. BACKGROUND

### A. Defining Musicianship

Defining the core skills of musicianship and, as an extension, skills that make up learning the piano/keyboard, is provided partly by West [4]. ‘The Big Five’ focuses on internalizing what is being heard and played, which is defined as the skill of audiation. West further defines instrumental abilities in five areas of musicianship: rhythmic ability (maintaining a steady tempo), tonal ability (being able to play ‘by ear’), notational ability (reading and writing music on a staff), creative ability (the application of such knowledge to create original sounds) and, finally, executive ability (physical attributes e.g. posture at the piano etc.). While this framework of musicianship provides specific objectives of learning, it is important to note that becoming a competent musician is not

solely based on mastering these elements but, as West states, audiation is crucial; a musician can not only read the music but can feel and hear it [4].

### B. Piano Pedagogy

Pedagogy is defined as any method or practice of teaching within any given subject. It encompasses teaching styles and theories related to teaching and how feedback is given. For a large part of this research, we focus on using behaviourism (working with Pavlov’s [5] interpretation); rewarding correct behaviours and punishing incorrect ones. We also take into consideration theories of cognitivism (such as Bloom’s Taxonomy [6]); placing student’s understanding of a subject as the primary concern.

A key contribution towards specific teaching styles relating to music and instrument learning was proposed by Gordon [7]. In this work, a synthesis/analysis/synthesis approach is provided; the first level of synthesis is an introduction to establish familiarity about a given topic, analysis consists of a detailed study of the topic before returning to synthesis, where students can apply all topics of understanding. Other music learning theories share similar characteristics in common with Gordon’s; such as rote-first methods offered by Suzuki [8], where students build a solid foundation of musicianship through repeating tonal patterns and rhythms.

### C. Gamification

Gamification can be summarised as human-focused rather than function-focused design; most emphasis for it is placed on human motivation in the process. Using Chou’s Octalysis framework [9], we can analyse each learning application featured in this paper to understand how it uses elements of gamification. Chou’s Octalysis offers eight points of gamification. The eight points include: 1) meaning, a narrative and a call to play; 2) accomplishment, a sense of satisfaction when completing a level; 3) ownership, exchangeable points or a level based on experience; 4) scarcity; 5) avoidance, fear of missing out; 6) unpredictability, random prizes and multiple choices; 7) social influence, leader boards; 8) empowerment, reaching a milestone and receiving feedback for actions.

There is evidence to support the fact that gamification can help increase motivation and engagement; for example, in Game of Tones [10], which showed that participants who used the gamified experience were more motivated and had higher levels of accuracy compared to typical practice. This study, and others that are similar to this, use small sample sizes over short periods of time; however, a key problem is retaining users over longer periods of time with consistent rates of practice.

### D. Existing Solutions

To gain an understanding of the breadth of the musical applications on the market a review of popular music applications was conducted. We found that each application could be based around five core concepts; enjoyment (using Fu’s definition [11], which comprises of concentration, immersion, goal clarity, challenge and feedback), educational benefit, skill required, complexity plus, finally, time spent. The actual ‘musical learning applications’ are designed to try and meet the needs of each one of the core concepts outlined; they are rich in educational value, require little skill to begin, are based on simple ideas and the use of gamification helps make them engaging. However, as figure 1 demonstrates, it is

clear the musical learning applications meet the needs of particular concepts well and struggle with other areas.

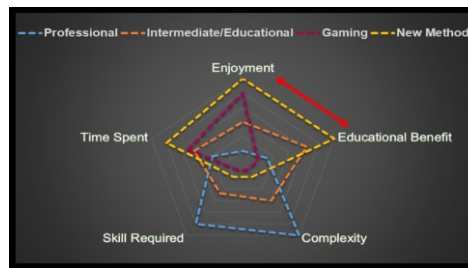


Fig 1. Core concepts; the solutions created for this project should cater to all criteria with a focus on educational benefit and enjoyment

### E. Hardware Considerations

The placement company which is partly sponsoring this work, ROLI, have recently developed a fully illuminated, RGB keyboard, dubbed LUMI [12]. Therefore, the main hardware for this project, and the controller of each game, will be the LUMI and as a consequence, games developed fit within the color schemes of the keyboard; using theories of cognitivism to reinforce learning through the use of color.

## III. METHODOLOGY – DEVELOPING NEW SOLUTIONS

Several prototype games were developed where the core mechanics are driven by the learning objective (e.g. practicing scales drives the mechanics for a game where playing corresponding notes destroys hazards). We defined key learning objectives relating to keyboard/piano which are associated with high drop-off rates and require substantial amounts of rote learning. Drawing paradigms from gamification, game theory and current applications on the market, we attempt to develop video games which are relatively original in their nature and can also impart some knowledge or create an engaging environment for practice. In order to strike a balance between a video game and a gamified learning experience, we have created several games that fit in this spectrum.

### A. Case Study One – Note Typer

This game intends to teach learners about hand coordination skills, basic rhythm practise and help reiterate notes and chords within any given scale. The extensions developed for this game also extend the learning objectives; helping to practice playing with two hands together.

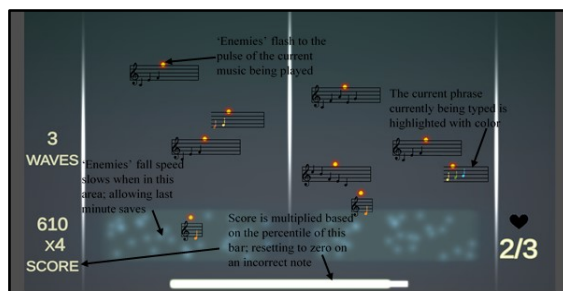


Fig 2. Note Typer Screenshot

The core loop of Note Typer is to prevent ‘enemies’ falling below the screen. Phrases (enemies) fall from the top of the screen. If they fall beneath the screen then the player loses a life (with three lives available in total). To destroy an enemy, players must play out each phrase (a ‘close call’ score is added depending on how close the enemy is to the bottom of the screen). The enemy phrases appear in waves and increase in

quantity and speed with each wave. Each ‘phrase’ is designed to help improve fingering skills at the keyboard; using ‘thumb under’ techniques, improving ‘five finger position’ etc.

Player actions are reinforced with positive feedback loops; playing a note in each phrase omits a friendly chirp sound in the pitch of that note (reinforcing audiation) and destroying an enemy results in the phrase ‘exploding’ into smaller pieces. Rhythm has also been implemented; using the algorithm from previous prototypes players are rewarded extra points for playing with the tempo.

The positives for this game include:

- More akin to a typical video game as it is based around destroying enemies (i.e. it has a theme and offers the player a sense of meaning)
- The notion that the player has a ‘choice’ of which enemy to destroy first, choosing to collect extra points by destroying additional smaller enemies should provide the player a feeling of control and, as a result, increases engagement
- Interchangeable learning objectives; could be notes in a particular scale, or one hand could be chords whilst the other is simple phrases (two-hand coordination)
- Incorporates the idea of music since what users play is not just a note but a series of phrases, which eventually will make up a whole melody

The potential negatives for this game include:

- The idea of agency and pressure may lead to inaccuracy and poor practice
- It is based on ‘negative’ themes i.e. destroying enemies and having to defend a position
- There is a heavy reliance on the player to look at both the screen and the keyboard whilst playing

Initially, the game was designed with enemies falling at random positions. We introduced the concept of ‘two-hands mode’ as an extension for those that wished to practice similar concepts but with two hands. We made a split down the middle of the screen, notes that fell on the left side were to be played with the left hand and vice versa. Later, we introduced chords; either side could produce chords.

### B. Case Study Two – Note Stack

Due to the nature of the core mechanic and game design paradigms, the learning objective is still relatively simple but there is room for extending this. At a basic level, the game assists players with the practicing of scales and improves their overall sense of rhythm. Additionally, players could use it to learn simple concepts such as the familiarity of notation.

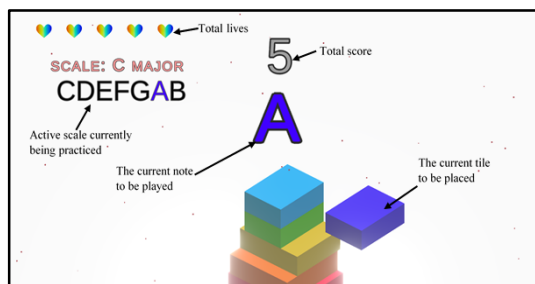


Fig 3. Note Stack Screenshot

This is a game based around the ideas derived from a similar mobile game, Stack [13]. The core loop in this game revolves around playing corresponding notes shown on screen (e.g. playing through a scale) in order to place moving tiles on top of one another in order to create a ‘stack’; the higher the stack, the higher the score.

If the user plays at the right time (either by using rhythm or by visuals), then the tile will match perfectly on top of the previous one. If three perfect tiles in a row are placed, then the size of the next tile increases slightly in size; making it easier to place, which can help a player who has fallen behind.

Feedback is offered in two forms; visually, the player will see a glow if they place a perfect tile or, if they do not place it perfectly, whatever part of the placed tile that missed the previous one will then be cut off, resulting in the next tile placement being a smaller target. The second form of feedback is auditory; a perfect placement results in a satisfying bell sound which increases in pitch (per perfect placement).

The positives of this game are:

- Basing this game around an existing mechanic which has proven to be engaging. The simplistic, yet satisfying nature of the game should encourage players to return and try to build a higher tower
- The mechanic is inherently repetitive, making this a great candidate for practicing specific areas of keyboard/piano learning which require repetition
- It incorporates elements of gamification such as avoidance (avoiding placing tiles incorrectly), social influences, and accomplishment (multiplying score)

The potential negatives of this game include:

- Whilst this is great for short bursts of practice, extended duration of play may eventually become dull, so efforts must be made to increase the engagement over extended play times
- The potential for fallacy lies behind the idea that users are simply playing a single note, regardless of whether they play in time or not, and this does not have a huge amount of application to playing an instrument

### C. Case Study Three – Crossy Notes

The core of the game revolves around playing repeating scales which change over time (players can input which scales they want to learn) as well as practicing with two hands. However, the nature of the mechanics and the idea of the game lend themselves to a broader range of learning objectives which have yet to be defined. One core concept is rhythm, which was later implemented; if players move with tempo then they should be able to continuously cross roads safely.



Fig Four. Crossy Notes Screenshot

This prototype is based on an existing popular game, Crossy Road [14]. The objective is to cross endless roads and avoid obstacles such as rivers and bushes as far as possible without being hit. Players must time their movements to cross each lane without being hit by a car. The camera constantly moves and if the player falls outside of the camera's view frustum then this will result in game over.

Feedback is offered by rewarding the player with score on each successful forward direction and additional points can be acquired by playing chords scattered throughout the game. In our version, players must move forward by playing an ascending scale and can play previous notes to move back.

This was the first game to make use of more than two octaves; by joining two LUMI keyboards together (which the hardware allows), the keyboard increases to forty-eight keys. Keys on the lower side are used to play chords and move left/right, whilst higher notes are used to play through the scale. Playing an incorrect note results in the screen flashing red and an off-putting sound being produced.

Positives for this game include:

- An attempt at bridging the gap between a casual video game and a gamified learning experience whilst maintaining a key learning objective
- It is based on existing paradigms which have proven to be exceptionally engaging
- Relates to musical concepts and audiation; each successful note played results in a successful chirp sound which is in the pitch of the key the user played
- Uses core concepts found in both theories on gamification and game design, such as meaning (feeling lucky when you narrowly miss an obstacle), accomplishment (the chirp sounds), unpredictability (car speeds etc.) and avoidance

Negatives for this game potentially include:

- Additional learning objectives need to be defined, otherwise it feels more like an actual game experience
- The idea of the camera constantly moving forward and forcing the player to play leads to added pressure and, possibly poorer, practice conditions
- Although a simple concept, it is not entirely transparent what the player must do to play and succeed; perhaps a solution is clearer instructions and showing each scale on an on-screen keyboard

Currently, the game increases in difficulty the further the player travels. Difficulty is measured by a few facets; the scale itself (the key/mode of scale), the rate at which cars spawn and their average speeds. Eventually, the player will lose and the incentive to play again is based around the need to beat their previous score or their personal best. Future directions may include implementing 'levels' in which players must reach a goal rather than seeing how far they can go and this should help provide the player a greater feeling of accomplishment.

#### D. Feedback and Additional Concepts

Additional concept prototypes were developed and attempted to set clearer learning objectives for future testing purposes. These concepts include ideas based around existing popular game genres such as infinite runners (i.e. propelling

the player forward on each successful note hit in a scale/next chord in a progression), puzzle, in which players must answer questions based around pitch (higher or lower etc.) and also ideas that revolved around free play and improvisation. Finally, using the pre-existing software developed at ROLI, 'mini-games' were integrated into the learning application currently being developed alongside 'LUMI'; games in which notes 'fall' from the top of the screen and users must play each note when it hits the 'play head'. These mini-games work because of their inherent simplicity and help to reiterate particular lessons within the learning companion application.

#### IV. CONCLUSION

In this paper we have outlined specific learning objectives related to the piano/keyboard which are associated with high drop-off rates and require rote learning. Through an analysis of current learning applications on the market we observed that a key issue is retaining learners and maintaining consistent levels of their practice. Therefore, we developed a series of prototype games with the purpose of creating an experience where a learner could play through an engaging activity and also retain valuable information. Using these games, a pilot study will be conducted, where interviews will take place in order to determine educational value and overall enjoyment; critiques of each game will be made based on the results of the interviews. During the second phase of development, we will consider using additional technology such as, potentially, virtual reality to create even more engaging experiences and cater our games to other learners.

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