

Learning Through Play; a Study Investigating How Effective Video Games Can Be Regarding Keyboard Education at a Beginner Level

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ABSTRACT

This paper describes the development of a set of video games designed to reduce the high drop-off rates associated with learning to play the 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 curriculums and learning applications, we have chosen specific areas which require the most rote learning, are critical to developing motor skills and to building an understanding of music; these include learning and practicing musical scales, keeping in time with tempo and the basics of hand coordination and fingering styles. We developed solutions which offer a new way for learners to practice in an engaging and entertaining way with the aim to reduce the drop-off rates and lower the barrier for entry to learning keyboard. Developing games requires an iterative process of development, testing, isolating key issues and solving them through further development. Therefore, through a pilot study (using observations, screen recordings and semi-structured interviews as data collection methods), we have observed that whilst this novel method of learning and practicing using video games is positively accepted by learners and teachers alike, the games themselves and the process of validation requires refinement in order to truly gauge each game relating to engagement, motivation and educational benefit. This paper describes the findings of this pilot study regarding the improvements and changes of each developed game as well how to improve future user studies.

CCS CONCEPTS

• **Human-centred computing**; • **Applied Computing**; • **Usability design and Evaluation methods**;

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KEYWORDS

Games, Study, Video Games, Dropout Rates, Users, Beginner, Keyboard, Students

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1 INTRODUCTION

In the current market, there is a large variety of music learning applications which attempt to teach users how to play an instrument, whilst also utilising elements of gamification (e.g., badges, and leader boards etc.) [1] in an attempt to enrich the educational experience and motivate users to keep learning and practicing. These learning applications do work to some extent 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 benefiting greatly from these resources and enjoying the first few sessions but, the lack of engagement and fulfilment eventually leads to some learners quitting their learning journey. Existing solutions focus on teaching content through video lessons or attempting to change the method of learning (such as offering easier alternatives to sight-reading); whilst engaging the user initially, learners will hit a peak in which they must look to other methods to improve. We aim to create solutions which help practice fundamentals in an entertaining way which in turn helps render the more traditional methods of learning more approachable and fun, leading to higher rates of motivation and prolonging an individual's learning journey over extended periods of time.

Utilised properly, games can be an engaging outlet in which one could spend countless hours playing, improving specific skills that eventually become second nature. Video games are now much more accepted and played not just by niche groups of specific demographics but by a much wider and mainstream audience. With

this advancement of accessibility within gaming culture and the much lower barrier of entry to game development, we intend to blend video games with music learning. Whilst existing solutions gamify traditional teaching experiences, we intend to create an experience which resembles something more akin to playing a video game, whilst also being a method of meaningful practice or to learn new and valuable knowledge. This blend of video games and learning focuses on fundamental skills which typically require repetition to master; these skills form the 'backbone' of all other areas of learning (such as sight-reading, rhythm, hand coordination, recalling patterns and audiation). We believe practising and learning these skills regularly will help lower the barrier of entry to music plus, make other areas of learning easier, more approachable and most importantly, enjoyable.

Taking advantage of consumer research conducted at ROLI [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 then gave up due to various reasons and wishes to relearn. Using the paradigms of typical video game design and via the setting of simple, yet effective learning objectives defined through the use of an existing framework for learning the piano, a series of games as developed [4] with specific learning objectives.

To determine each game's effectiveness in relation to the aim of this research, we conducted a pilot study with ten participants. The hypothesis for this pilot study is not based on a strict correlation between findings. Instead, it is multi-faceted; does each game achieve its purpose? Is the game effective at imparting knowledge? Is the game a catalyst for fun practice and how much of a balance can we strike between a video game and a learning experience? Through these results we intend to improve upon the current developed prototypes and take on board the experience of the actual study itself in order to help further define specific learning objectives and how to properly assess this.

2 RELATED WORK

2.1 Musicianship and the Fundamentals

A definition the core skills of musicianship and, as an extension, skills that make up learning the piano/keyboard, is provided partly by West [5]. West 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), creative ability (the application of such knowledge to create original sounds) and, finally, executive ability (physical attributes e.g., posture). 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. However, as West states, audiation is crucial; a musician can not only read the music but can feel and hear it [5]. In relation to the work in this paper, it was established that these five areas of musicianship define the essence of playing an instrument, whether it is attempting to play a song, jamming with other musicians or improvising. Within each of these areas, key lessons and skills must

be practiced; reading each part of the stave correctly, playing in time and using correct fingers (to name a few). Typically, one must learn these skills through a multitude of outlets but, normally, it is by playing pieces from sheet music or attempting to play along with another piece of music. Therein lies our problem; beginners (and especially independent learners) must undertake considerable amounts of rote learning (repetitive training) in order to improve these skills and facilitate other areas of playing. However, practicing these elements is typically mundane and can lead to beginners dropping out of learning.

2.2 Gamification and Game Theory

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 [6], we can analyse each learning application featured in this paper to understand how it uses elements of gamification. Chou's framework 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.

Additionally, some research was conducted into theories of game design to help gain insight into typical paradigms that are used in games and incorporate some of these into the developed prototype games. Principles that have been established [7] fit into particular categories with additional facets that can be considered. Categories include: 1) direction, ensuring the player knows exactly what to do without needing to think about it; 2) behaviour, how the player is rewarded or punished based on their actions; 3) progression, how to pace the players progress and allow the player to explore relationships between particular actions; 4) foundation, how do actions affect the player and how are messages communicated to the player.

Another, more recent concept which was considered when developing the games was 'juiciness'. Juiciness refers to the visuals and audio feedback that games provide to players; for example, adding sounds on particular actions such as jumping; a common example of this in shooter games is the muzzle flash when a player fires a weapon. Hicks et al [8] conducted an experiment to determine the effects of juiciness compared to typical gamified experiences; results showed that the participants using the exercise which had both elements of gamification and juiciness scored the highest when compared to those that had just the gamified version.

2.3 Existing Solutions and Use of Gamification

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, educational benefit, skill required, complexity plus, finally, time spent. The actual 'musical learning applications' [9] 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 render them more engaging. Whilst these learning applications do offer rich learning in the form of lessons and interactive exercises, the problem still persists, as learners struggle to get past a certain point because they lack either the skill or knowledge to do so. When they want to practice these elements, the applications can only offer easier lessons which lack any progress for the learner or simple and somewhat mundane exercises. Tools found on the digital marketplaces, such as ear trainers and sight-reading trainers [10], can be used in conjunction with other learning methods but they too largely lack true use of game design and gamification, leading to boredom, lack of consistent practice and, once again, quitting.

There are also methods observed in the literature that attempt to teach people how to play the piano through gamification. One such method of teaching piano basics was developed by Raymeakers et al [11]. Graphical notation is projected on a board in front of a piano that indicates which key(s) need to be pressed and creates a feedback loop to monitor user performances. The authors extended the augmented piano with a shooting game using the same system to help encourage users to continue playing through the use of game-based incentives. The results from the game try-outs suggested beginner piano players become more motivated to practice using the gamified augmented piano system and learn musical pieces without the need of sheet music knowledge. However, the issue here is that learners become reliant on a new system of reading music whilst the rest of the learning journey will, eventually, use sheet music. On top of this, the short time frames in which the studies were conducted do not give insights into how, or indeed if, the system would help motivate learners to practice on a consistent basis nor, whether the skills acquired through the system are applicable to other areas of keyboard/piano playing and learning.

3 METHODOLOGY – GAME DEVELOPMENT, AN ITERATIVE PROCESS

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). Drawing from paradigms found in 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.

We have conducted a pilot study in which interviews were held regarding each game with the goal to improve the user experience and determine how educational a specific gamified experience can be. Specifically, we wanted to find out the following:

1. Why do beginner learners drop off/give up? We have provided reasons for this using secondary data and our own insights, but it was decided that this would be explored and confirmed through the use of primary data
2. Are the games developed focusing on the right areas and which game was the most ideal solution for our challenge i.e., do they have the right scope?
3. Were the games deemed enjoyable, within consideration to usability, time spent playing, difficulty, observed engagement, design and educational value?

4. Regarding enjoyment, educational value and motivation, how can we measure these criteria empirically and furthermore, what lessons can we take from the initial study to improve future ones?

3.1 Hardware Considerations

The collaborating company, which is partly sponsoring the work in this paper, ROLI [12], have recently developed a fully illuminated, RGB keyboard, dubbed LUMI [13]. 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 colour schemes of the keyboard; using theories of cognitivism [14] to reinforce learning through the use of colour.



Figure 1: ‘LUMI keys’ attached via DNA connectors [13]

3.2 An Overview of the Games

The prototype games were developed using Unity (a 2D/3D game engine) [15] with C# scripting. We include an outline of each developed game trialled in the study.

3.2.1 Note Flash. The aim of this game is to help beginners build association between notes and keys on the keyboard as well as acquaint themselves with the basics of notation. The objectives can be extended, such as learning scales, basic rhythms and reading notation. It is intended to be played by beginners initially but extending the purposes of this game also broadens the scope of what type of learner it can cater to.

This is a game in which a visual cue flashes on the screen (either a note shown as a letter or in notation) and players must play the corresponding key. The aim of the game is to get the highest score possible within a set time limit; the faster you press the corresponding key after it is shown, the higher score you are rewarded with.

3.2.2 Note Typer. This game intends to teach learners about hand coordination skills, basic rhythm practice 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.



Figure 2A: Screenshot of *Note Flash*

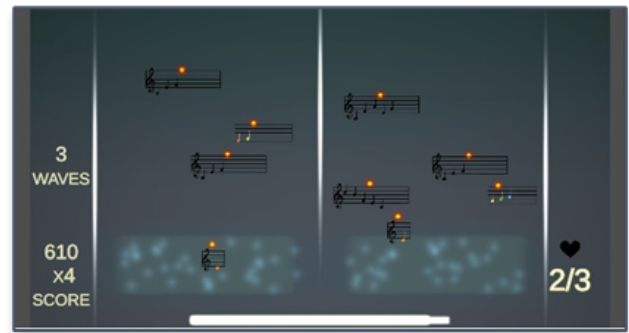


Figure 3B: Newer design for *Note Typer*

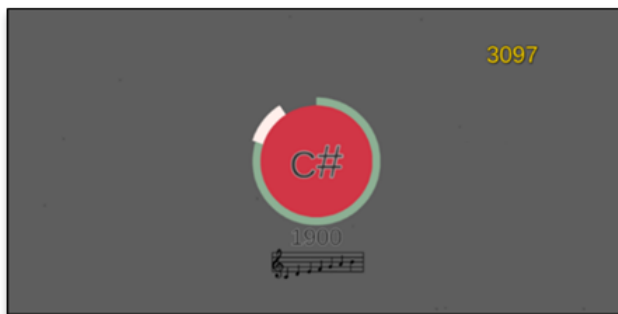


Figure 2B: Newer design for *Note Flash*

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). In order to destroy an enemy, players must play out each phrase. Each ‘phrase’ is designed to help improve fingering skills at the keyboard, using ‘thumb under’ techniques, improving ‘five finger position’ etc.

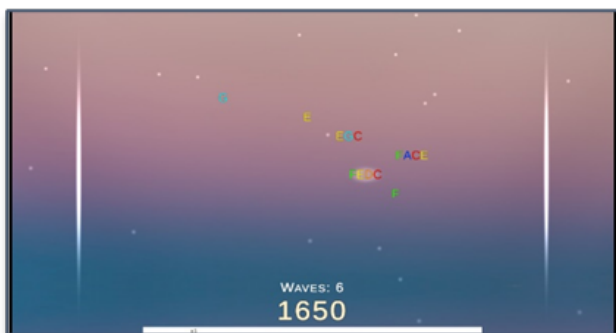


Figure 3A: Screenshot of *Note Typer*

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.

3.2.3 *Note Stack*. Due to the nature of the core mechanic and game design paradigms, the learning objective here 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.

This is a game based around the ideas derived from a similar mobile game, *Stack* [16]. 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 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, otherwise the area of the placed tile that missed the previous one will be ‘chopped’ off and result in a smaller target for the next tile placement, eventually ending in too small of a target and a game over.



Figure 4A: Screenshot of *Note Stack*

3.2.4 *Crossy Notes*. The core of the game revolves around playing repeating scales which change over time as well as practicing with two hands. One core concept is rhythm, which was later implemented; if players move with tempo then they should be able to continuously cross lanes safely.

This prototype is based on an existing popular game, *Crossy Road* [17]. 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



Figure 4B: Newer design for *Note Stack*

a car. The camera constantly moves and if the player falls outside of the camera's view frustum, then this will result in a game over outcome. In our version, players must move forward by playing an ascending scale and can play previous notes to move back.

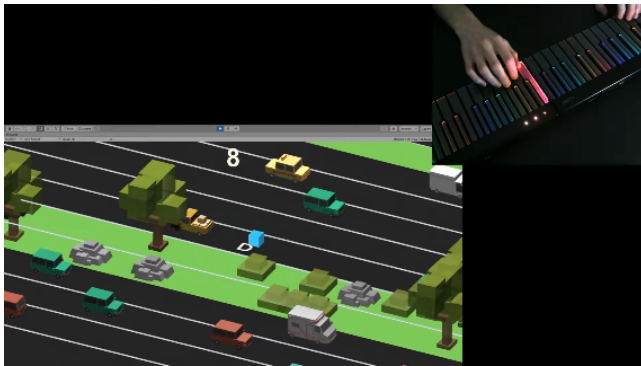


Figure 5A: Screenshot of *Crossy Notes*



This was the first game to make use of more than two octaves; by joining two LUMI keyboards together (which the hardware does allow), the keyboard this way increases to a total of 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 pattern.

3.3 The Pilot Study

We ran ten one-to-one semi-structured interviews with music students of mixed levels and ranging from the ages of 18 to 49 years old; participants were compensated for travel and provided incentive in the form of a gift voucher. During the study, observations were also made, and a final reflection was undertaken by the researcher.

Our participants were ideally learning the keyboard/piano at a beginner stage or are lapsed (those that have studied at an earlier stage in their life but gave up), had little musical experience or background and are currently learning or wanting to learn; compensations were made for the difference in skill levels through the application of each game's difficulty. Not all participants were complete novices, but this range of skilled learners offered deeper insights; more experienced musicians (mostly pianist/keyboardist with some stating guitar was their primary instrument) could see how this would fit into their own practice as well as offered feedback on the actual learning components, which had initially been overlooked.

We first asked introductory questions then asked the participants to sit down in front of a screen (in this case, a MacBook Pro). All participants played each game for a total of five minutes and the researcher took notes and documented observations throughout. Related questions were asked in line with our aim after each game had been played and a final set of questions was asked once all tasks had been carried out; any remaining comments were encouraged to be given by each participant in order to ensure that all opinions had been gathered. Ethical approval was received in line with the University's policy as well as any precautions relating to Covid-19 [18].

4 RESULTS/FINDINGS

4.1 Procedure and Analysis Strategy

Data was collected through multiple methods: recordings of both the participant and the recorded gameplay, observations conducted in real time and answers provided by each participant which were written down in shorthand form and recorded during the interview process. For this study, we collected data from ten participants recruited through ROLI mailing lists and those who had previously participated in user studies conducted at the company. As previously mentioned, our participants were varied in musical skill, from those who had musical degrees to casual musicians; only one participant had never participated in learning an instrument. The analytical approach needed to be flexible to respond to the differences within the data collection methods utilised; thematic analysis provided this flexibility and was deemed the most appropriate method.

4.2 Results: Music Education Insights

In order to ensure that our games were designed for the right reasons and to also ensure that this method of learning would be accepted by music learners and teachers, we analysed the participant responses to questions regarding their music education; pertaining to methods of learning and how much time they are willing to spend practising.

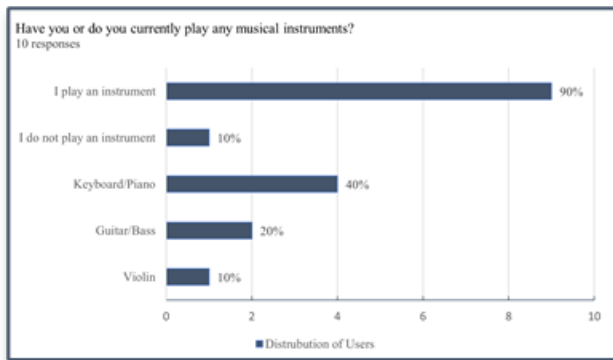


Figure 6A: Chart displaying participants' current use of instruments

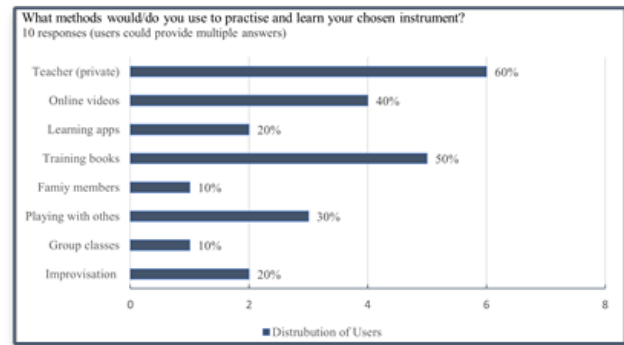


Figure 7B: Charts showing how each participants typically learn

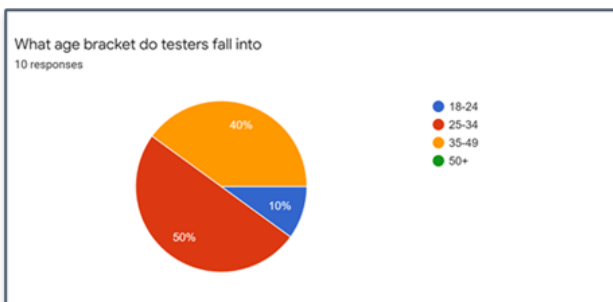


Figure 6B: Charts showing the age ranges of participants

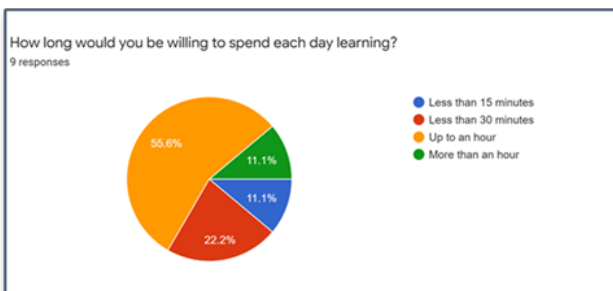


Figure 7A: Chart showing how long each participant is willing to spend learning

Overall, we found that most participants had at least some exposure to music education during the early stages of their lives, typically being made to attend lessons by their parental figures or were involved with music as their family backgrounds were musical. The reason most of our participants eventually dropped out of learning music was that they found no personal connection to it (the fact they were forced led them to associate negative feelings with playing). Tedious practices also led to negative connotations around playing and, finally, most of our participants wanted enjoyment out of playing; they never really saw the application of what

they learnt and found typical ways of practising a bit bland and meaningless. What was established is that each participant had their own method of learning; whilst these methods overlapped (such as having a teacher, using books and applications), each participant had their own personal experience to learning. However, what none of the participants had was a fun/engaging way of practising specific skills or helping to retain new information; our solution is to offer tools to support the learning journey whatever that may be for each individual learner.

4.3 Results: Feedback on Games

To provide insight into how participants perceived each game, and how this can be improved upon, we analysed the participants' responses to each game. We observed each participant whilst playing the game, specifically looking at whether they were using the correct technique, were encountering frustration in specific areas, how engaged they were and how easy the system was to use. In addition to this, we asked specific questions relating to the Scope of Game, Design, Usability and Enjoyment/Engagement; this set of criteria was defined specifically for this research in line with the main aim of the project.

We followed this procedure for each game then asked questions relating to the whole experience. Through analysis we defined sub-themes relating to the primary themes; whilst most sub-themes were shared throughout each game, specific critiques were also observed for each prototype game. Below is a list of each of these themes and sub-themes. This is then followed by an in-depth analysis of the data regarding each theme, for each game. Finally, we provide a general overview for the games.

4.3.1 Scope of Games. Three sub-themes emerged when reading through the transcripts in regard to the scope of the games (referring to the application regarding a specific educational objective). The application itself, improvements that can be made to ensure that it teaches the right content, and how the game could/would be used in conjunction with the participant's typical learning. We later analysed responses provided regarding the games' educational value and how well this was rated (using a Likert scale approach of 1-5 in terms of rating, with 1 being the least educational).

4.3.2 Design. Three sub-themes emerged when analysing the data regarding design (the aesthetic elements). These themes were SFX and VFX (sound and visual effects), how the game 'felt' (regarding overall themes, mechanics etc.) and, finally, music related (this is different from sound effects and pertains only to how music was used in each game). It is important to note that the games are in early stages of development, so efforts made relating to design were mostly focused on the use of colours, specific sounds etc., rather than the *quality* of the design.

4.3.3 Usability. Usability refers to the overall user experience of the application and how easy or difficult it is for a user to understand the concept of the game, navigate menus and whether the game is too hard or too easy. Two sub-themes became apparent when analysing the data: difficulty and complexity (was the game too hard/too easy, was the concept too complex to understand etc.) and frustrations (what gave our participants frustration relating to how the game is played and/or the user experience is handled).

4.3.4 Enjoyment/Engagement. We wanted to understand two concepts regarding the enjoyment of each game: was the game actually fun and can we find trends in both what was observed and within the answers in order to provide criteria to improve upon. The second concept was interactivity (or engagement), referring to how interactive each game was, and this was mostly derived from observation; was the participant too distracted to answer questions and did they want to continue playing outside of the time limit? Through the use of Likert scales (1-5) participants also rated how much fun they had (with a rating of 1 being the least fun) and how likely it is they would want to play again, given the opportunity.

4.4 Results: Prototype Game One - Note Flash

4.4.1 Scope. All participants agreed that the idea of the game would be useful at the beginner stages as well as later stages. For example, the more experienced participants commented that the 'Chords etc. are good as it adds difficulty'. Observing the participants play also showed that they were using the right fingers to play each note and gradually stopped looking at the keys, showing confidence at the instrument. One participant stated, '[the game] forces you to learn note positions without looking at the keys'. What participants wanted was more challenge and this was typically in the form of rhythm or audiation skills. Participants wanted clearer sounds when playing the keys to determine the sound quality of it. It was apparent that participants were worried they would be reliant on colour and the application to something more organic, such as playing a song, could be missing. When asked 'Rate how educational you found the game (i.e., did you learn or take something away from it?)' on a scale of 1-5, 70% gave 4 out of 5 and 30% gave 5 out of 5.

4.4.2 Design. Participants had specific comments regarding design and mechanics. Most commented on the 'floating dust' (the particle effects) being a good thing, '... floating dust is also nice as it adds atmosphere', but a few participants stated that it distracted from the game and wanted to focus on the mechanic rather than how it looked. Regarding sound effects, almost all participants commented on the sounds played when answering a correct question (it was a satisfying bell sound) but they wanted to hear the actual note (a

sound that actually reflected the actual note). Participants also commented on the sound and effects when playing an incorrect note, saying it was too abrupt and caused discomfort, 'the wrong sound is too harsh'. Finally, most participants wanted two main mechanic implementations; to see a few upcoming notes (borrowing mechanics similar to *Tetris*) and to know what the correct answer was if they got it wrong, otherwise they felt they would not improve/progress.

4.4.3 Usability. Most participants agreed that the game was of the right difficulty and enjoyed that it started easier and gradually got more difficult. A few participants stated that the game was too quick to begin with, '... the timer is too tough on the first go and should start slower'. The concept of the timer and the core mechanic were easy to understand but, it could be argued, perhaps a little mundane. Adding additional layers of music such as rhythm should help address this issue. Most participants agreed that it was an easy concept to understand but navigating menus and actually starting the game was slightly confusing; 'UI needs improvement'. Although the idea of agency is a common theme within games, a couple of participants mentioned that the sense of agency when attempting to learn something new can be frustrating and lead to feelings of anxiousness. Finally, the idea of allowing participants to choose their learning objective might not be ideal; participants seemed to want a clear path of progress to follow.

4.4.4 Enjoyment/Engagement. When rating how 'fun' the experience was on a scale of 1-5, 70% gave 4 out of 5 whilst 30% gave 3. One participant noted that the game has 'An addictive attitude', in which they would want to come back and play again because of how easy it was to jump into and felt as though it had challenged their knowledge. What was deemed enjoyable about the experience was the challenge itself. When more experienced participants found the Chord Mode setting, they immediately became more interested and when they gave incorrect answers this did not deter them but in fact encouraged them to try again to beat their previous score and ensure they get the right answers next time.

4.5 Results: Prototype Game Two - Note Typer

4.5.1 Scope. All participants agreed that this game had substantial application and could be used for further complex techniques. They agreed that the game would be great for practicing rhythm and fingering exercises; 'A good learning tool; lots of application'. However, what participants requested was that they wished there was more structure and to sound as though they were actually playing a melody or being forced to play in time more, 'Everything moves at different rates unlike sheet music that doesn't move.' When experienced musicians were introduced to the 'phrase mode' they found this much more challenging and agreed that it could be useful for practicing basic rhythm control, correct fingering and reinforcing sight-reading. When participants played the 'two hand mode' they all struggled to look at both sides of the screen, opting to clear one side before clearing the other, indicating that this game is not an ideal candidate for practicing two hand technique. Participants could see this game being used as exercises to be employed in conjunction with their own learning methods, 'Good to start with/warm up exercises' and when rating the 'educational value',

70% gave 4 out of 5 and the rest gave 5. This indicates that this game could be a very useful tool for learning, after refinement.

4.5.2 Design. Most participants enjoyed the design of the game, commenting, 'Very much like other arcade games' and 'retro'. They all found the error noise a bit 'jarring' and almost all participants said that the notes 'exploding' was 'satisfying' but also detrimental to playing well, 'Explosions cover the notes too much', requesting that they are smaller or slightly more transparent. Most enjoyed the 'panic' when playing and trying to ensure that the notes do not fall below the screen; the idea of building up levels and consecutive right answers led to participants being more cautious and getting less incorrect answers. All participants enjoyed the colours of the notes whilst some did not enjoy the visual effect of the 'particles' claiming it was '... a bit too much'. The most important aspect of this to note was the 'disconnection between sound of notes and the soundtrack'. Participants wanted to feel as though they were playing along with the soundtrack and the idea of playing notes as quick as possible resulted in the sound being 'clunky'. Finally, because this game was infinite (i.e. play until you fail) participants began to get tired of the backing track, 'I got sick of the same tune over and over again'.

4.5.3 Usability. Whilst the concept was easy enough to grasp, participants stated that they wanted a bit more of a challenge. Although 'two hand mode' and 'phrase mode' were implemented, these were deemed a bit too difficult even for experienced participants because it was disconnected from techniques and paradigms found in keyboard/music practice. The concept of notes falling was familiar with most participants, 'Used to falling of notes; akin to YouTube vids etc.', which made the game easy to approach. Frustrations stemmed from the fact that notes would be covered up by the visuals (the explosions) and this hindered how well participants could play and occasionally resulted in unfair game overs. Whilst the navigation of the game was deemed straightforward, as participants could see in real time what the different options meant (i.e., visual representation of options), they felt as though some explanation or acclimatisation was required.

4.5.4 Enjoyment/Engagement. All participants clearly showed states of 'flow' when observed and would struggle to comment when playing, being too distracted to do so. Participants claimed that the single note mode was somewhat dull but found joy in getting multiple notes in a row correct and found playing out phrases the most satisfying and enjoying. The idea of notes 'exploding' when getting the right answer made participants more engaged with the game, '[Note Typer] is much more interactive!' one participant commented when discussing this (in comparison to typical practice). On a scale of 1-5 regarding how enjoyable the participants felt the experience was, 40% gave a 4 out of 5 and 30% gave 3 and 5, respectively.

4.6 Results: Prototype Game Three - Note Stack

4.6.1 Scope. Participants were split on the purposes of this game, some felt as though it could be a great way to practice scales, 'Great way to learn scales as it is all laid out!', whilst others did not associate this with the practice of scales and felt it was more about

muscle memory than the actual concept of learning scales. A number of participants (mostly those that had some experience) claimed that the practicing of scales typically includes playing up and down the scale whereas, in our game, one only plays up the scale (indefinitely). All participants commented on the fact that the audio did not match the visuals and when trying to place 'perfect tiles' on the beat (on the click of the metronome) they struggled as it was not quite right. Participants also felt as though showing the actual scale on the keyboard (i.e. highlighting the keys that belong to the scale) and showing the scale on an on-screen keyboard with correct finger placements would be more beneficial than just seeing it spelled out on screen. All participants agreed that they would prefer to use this more for rhythm practice rather than scale practice and blending these two ideas led to confusion. Finally, when rating the educational value of this game (1-5), 20% of participants gave this 5 and 40 % gave this 3 and 4, respectively.

4.6.2 Design. The main concern from the playthrough, from both observation and remarks from interviews, was that the visual of the shifting tiles did not match the actual rhythm of the metronome or backing track. This led to participants placing tiles incorrectly and having to account for this delay between sound and visual. Besides this, most participants enjoyed the design style, 'the idea of chopping tiles when placing a non-perfect piece is equally satisfying and annoying' and whilst the colours were 'nice', participants wanted the tiles to reflect the note they played (e.g., red tile for the note 'C'). Whilst participants reported enjoying the simple and calming nature of the backing soundtrack, others commented on wanting to have more impact when playing each note; reflecting that the backing track should match what is being practiced.

4.6.3 Usability. Once participants had understood the concept, which almost all did due to the simple mechanic, they found the game quite easy. The overall speed/difficulty of the game did not increase gradually (to try and keep participants playing to a set tempo), but participants struggled to focus on too many concepts at the same time. Observing the playthroughs it was apparent that keeping in time whilst playing out a tonal pattern (the scale) was already challenging for some. In addition to this, participants also needed to look at the screen to place tiles. This led to frustration when trying to look at too many places all at once, as one participant reports, 'Annoying about focusing on the screen whilst trying to play' whilst another notes, '[it was] disconcerting when you get a tile placement wrong'. A positive response stems from how easy the menu was to use; participants could see the result of changing options on the screen in real time.

4.6.4 Enjoyment/Engagement. When rating the game for enjoyment (1-5 scale) 80% of participants gave this 4 out of 5 and 20% gave this 3 out of 5. They reported that it was easy to use and had an 'addictive quality' but eventually the concept 'would get boring' because it is simply repeating the same mechanic. Participants wanted additional features such as going up and down rather than constantly going up and more focus on the performance of a learner, '... more like score attack about how I performed'. Finally, most participants stated that they would prefer previous games as they offer both fun and some educational value right away.

4.7 Results: Prototype Game Four – Crossy Notes

4.7.1 Scope. One of the recurring themes regarding the scope of this game was that it needed to be broader, '[Crossy Notes] lends itself to a broader range of objectives' as well as the game being more about 'fluid movement', which reflects playing keyboard. Although participants could use two hands, most found themselves finding this difficult as, 'Left and right controls make it more of a game but less of a music game because hands are in weird positions'. However, most participants agreed that this would be a fun way to practice concepts such as scales or notes on a staff; a good number of participants commented that the roads/lanes look like a staff so were confused when the game did not play as they figured it would, 'Could be confusing as it looks like a staff'. Participants also wanted the sound of the player 'jump' to be the actual notes they played to help reinforce audiation skills, 'useful to hear the notes properly, game sounds are nice but use piano!'. When rating the educational impact of the game, 20% gave it 2 out 5 and 40% gave it 3 and 4, respectively.

4.7.2 Design. In terms of sound effects, participants reported that they enjoyed the 'arcade' sounds, such as the cars beeping and the jump sound of the character. As this game is based on an existing theme, participants were happy to accept this and welcomed the idea of such themes; most participants commented that this would be ideal for children but would prefer to see something a bit more abstract was it to be aimed at their age range. As this was based on existing games, participants also wanted to see more design regarding the character, 'Better to have a frog than a cube!' Participants also reported that there was too much happening on the screen; the original game is a simple mechanic of one press and this game is more complex than this, so, attempting to marry these two concepts may have led to unnecessary confusion and a lack of educational impact.

4.7.3 Usability. Observing participants, it was apparent that the aim of this game was difficult to grasp. The concept of crossing roads and avoiding hazards was simple but when combining this with having to play a note, participants became confused, especially due to the fact the game looks similar to a musical staff. In addition to this, the speed of the game was too quick to begin with and participants did not want this to speed up over time; 'start slower!' one participant commented. One of the biggest frustrations revolved around when and how participants failed; when getting hit by an oncoming car or playing the wrong note ended the game. Participants struggled to actually acknowledge this and tried to carry on playing. What was clear from this game was that the keyboard was seen as more of a toy, '[the keyboard] is like a game controller, you do not really look at it when playing!'. Comments such as this help to reiterate the direction we must go in next. The lack of options was deemed a positive aspect as participants could jump straight in.

4.7.4 Enjoyment/Engagement. Nearly all participants found this game enjoyable to some extent, 60% of participants scored this 5 out of 5 when rating how fun the experience was and 30% gave it 4 (with 10% rating it 3), indicating that this game was deemed fun though confusing in regard to the actual learning objective.

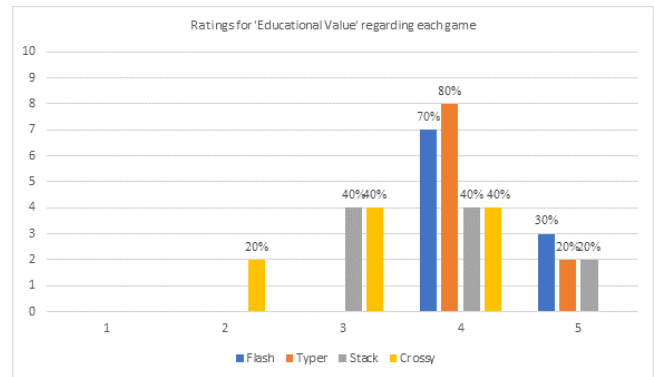


Figure 8A: Ratings for educational value for each game (using a 5-point scale) shown as a percentage of total participants (with a total of 10 participants)

Participants commented that this was 'more of a game' and that 'the music was fun and enjoyable', and 'the most addictive'. Participants also mentioned the idea of using levels rather than an infinite-based mode, i.e., the idea of having something to work towards was more motivating than trying to beat a high score each time. Most participants agreed that they could play this if the concept revolved more around the staff and playing music.

4.8 Games as a Whole

4.8.1 Preferred Games. Each participant was asked of their favourite game and if they could offer insights and reasons as to why they chose a specific game. The two most popular games were Note Flash and Note Typer. Reasons provided relate heavily to how beneficial they are to improving musical skills as well as being 'simple and effective'. Both Note Stack and Crossy Notes received at least a vote for the favourite game question, but most participants stated that this was because they looked most like a game and would only use them if the application was defined, and the mechanics had been refined.

4.8.2 Ratings for Each Game. The charts below show that the games which focused on existing video games were deemed the most entertaining but lacked the educational aspect, and vice versa, for the games which resembled more of a learning exercise.

4.8.3 Overall Feedback. There were some overlapping themes and changes which could be applied to all prototypes and considered when developing additional concepts. This includes:

- Showing an on-screen keyboard to demonstrate scales, notes etc.
- Show the correct answer when a user plays an incorrect one in order to encourage progression
- Each game requires some form of acclimatisation if there is to be no researcher interventions
- Menus and UI need to be simplified in terms of options and how obvious each option change is

Finally, participants were asked to rate how likely it was that they would recommend the game to a budding learner, all participants scored either 4 or 5 out of 5. When asked to rate how likely they

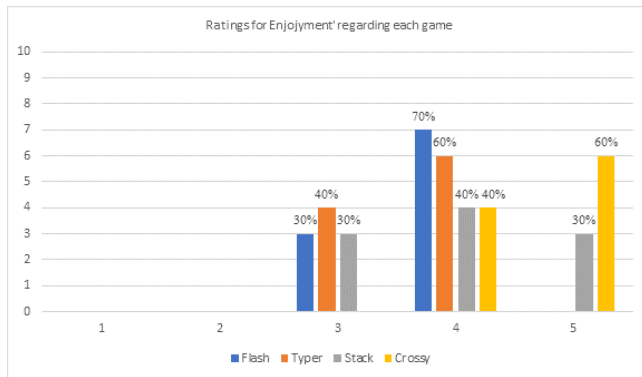


Figure 8B: Ratings for enjoyment levels for each game (using a 5-point scale) shown as a percentage of total participants (with a total of 10 participants)

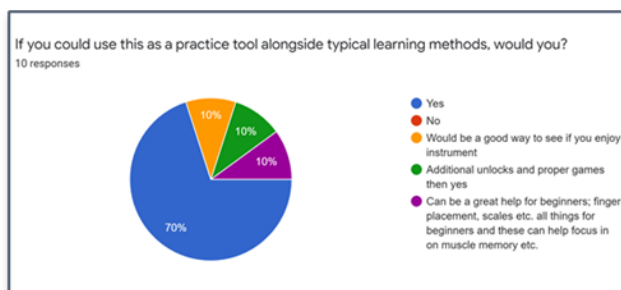


Figure 9A: Chart displaying how likely participants would be to use the games themselves, in conjunction with their own learning methods

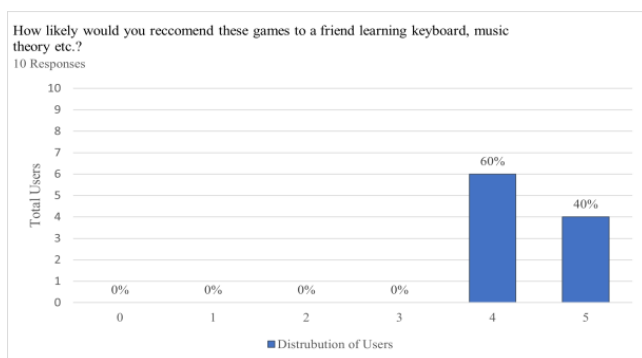


Figure 9B: Chart displaying how likely each participant would be to recommend the games to a friend

would be to use the tools themselves, all participants said that they would be very likely to, with some participants stating that it would be great for purposes outside the typical lessons, 'A good use would be for travel'. Finally, all agreed that focusing on the practice of these specific skills would encourage them to play more and find more enjoyment in doing so.

5 DISCUSSION

5.1 Establishing Research Position and Impact

Through the interview process, we proved that learners (especially during the early stages) struggled to maintain consistent practice and this led to negative connotations around playing. Moreover, we found that the skills we had defined previously such as rhythm control, hand and finger dexterity and audiation were all skills our participants wanted to improve but had no real engaging way to do so.

Future iterations and developments must narrow down a specific area of learning so we can begin to definitively state that the act of playing a game can actually improve a specific skill or area of knowledge. What we found through this study is that all participants were at least familiar with what a musical staff looks like and there were many comments revolving around the idea of adapting our games to look more like one. On top of this, we established that all the games lack a sense of music, so we must keep this in mind for future developments; adding rhythm and basic melodies in which we use primarily the musical staff as a basis of a design and educational goal.

5.2 Choosing the Right Games and Considerations for Future Games

The study showed that the games which were the simplest in design yielded the most positive results in regard to how educationally valuable they can be. Taking this onboard, we decided that it was the best course of action to focus on the two most popular games: Note Flash and Note Typewriter.

We constructed a list of desirables to focus on in regard to improving existing prototypes and building new ones, this was derived from both the study as well as through reflection and play:

- Focus more on the use of music games and game design theory; we focused on casual games, but these do not offer enough detail by themselves. Combining additional features from music games and incorporating more game design theory should help create highly challenging and engaging games
- The challenge (i.e. the learning objective) is what drives engagement; adding elements of rhythm and relating back to music will help create diversity, challenge and depth
- Design work was needed, not just related to visuals but heavily on the sound effects too; they need to be representations of notes and chords in order to help build audiation skills
- Focusing on a specific area of knowledge (sight-reading and rhythm) is key and we can also add exercises/levels/mechanics, such as the pattern of notes spawning, in order to create additional ways of improving muscle memory, audiation, tonal patterns within an existing learning system
- Participants wish to have sense of progression and a game which can be pick up and play, i.e., easy to get in and out of without frustration, this must be taken into account
- Participants want to apply their knowledge and skills to beat the game so we must begin to focus on how these skills are taught outside of digital software. Looking at teacher and

classroom-based exercises, this structured approach adds application, challenge and engagement

- More attention needs to be paid towards the actual use of gamification. Creating a list of features that our game should have adds structure to our development, as well ensuring that it is supported by tried and tested methods found on the market
- Create a list of other applications and games which we will use to inspire our games:
 - Learning applications and training tools
 - Other areas of learning, e.g. typing games/language games/brain training
 - Other genres of games (focusing primarily on music games)

5.3 Improvements for Future Studies

As this was an early and formative pilot study, specific criteria should be improved upon to ensure these mistakes and pitfalls are avoided for the next user study. These changes include:

- What is measured needs to be more specific and replicable (i.e. less qualitative). Of course, the nature of this project still requires large amounts of qualitative data but efforts must be made to ensure that next time the idea of testing 'enjoyment levels and educational value' has specificity regarding mechanics and design choices, (e.g., how to measure 'flow' and 'difficulty curves' more accurately and empirically)
- In regard to measurements, we must measure the actual aim and scope of these games more precisely through developing games with more specific educational objectives and running studies which focus on skill and knowledge tests
- Keep exploring the emergence of new user studies found in both literature and on the market
- Ensure participants meet specific demographics; we are building games for beginners so we must ensure that the majority of participants we test are serious beginner learners but also incorporate expert opinions as this will help validate our games in the fields of both music education (i.e. teachers) but also game development

6 CONCLUSIONS AND FUTURE DIRECTION

In this paper, we presented a series of prototype learning games with the purpose of creating an experience which matches the engagement and enjoyment levels of video game but also has the ability to retain valuable information or practice meaningful skills to aid other areas of playing and learning the keyboard. Through a pilot study, it was established that the developed games were received positively and would be recommended to other learners but would require refinement to do so. It was apparent that the games were focusing on the right areas of learning, but these learning objectives needed to be refined if we are to measure specific facets of each game. In addition to this, the games must incorporate music in a stronger way; using rhythm and simple melodies, whilst also looking to more specific games to perform case studies on and generate criteria and features which can be used. Going forward, we aim to improve the most popular games in this collection by taking on board feedback of the study and by blending mechanics

found within the other games. We will also attempt to develop new ideas based on what we found during the study and personal insights, running further user studies and, eventually, focusing on two or three main concepts in order to add enough content and usability that we can begin to test on a larger scale without the need of a controlled environment, such as large-scale surveys and longitudinal experimental studies.

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