The Crypt of Notation: Rote Learning through Video Games For Adult Beginner Keyboard Learners

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ABSTRACT

Playing music and partaking in learning to play an instrument, in this case keyboard, can be a highly rewarding but demanding experience. A key issue of adults that attempt to learn to play an instrument, again, in this case keyboard, is that a vast number of them will give up shortly after beginning their learning. Through both primary and secondary research we established that a core reason for this high number of adults dropping off is a lack of fundamental skills; skills which make the process of learning and playing more efficient, easy and enjoyable. This issue in conjunction with the lack of engaging methods of practicing these skills which require rote learning (copious amounts of repetition) led us to develop a novel solution in the form of a practice video game. We established, through multiple studies, that there was a place for such a solution, but it became apparent that there was a need to empirically measure whether this video game experience could improve or help acquire new skills just as well as a traditional or typical method within real-world contexts. In this paper, we present our novel prototype practice game. We will discuss the various stages and pitfalls of testing, design and development whilst also discussing the methodology of our upcoming longitudinal study. The study aims to measure the concepts of educational value and engagement in a real-world setting using adult beginner keyboard learners over an extended period of time, which is conducted at their own pace and within their own home environments.

CCS CONCEPTS

• **Human Computer Interaction**; • **Interactive and Serious Games**; • **Usability design and Evaluation methods**;

KEYWORDS

rote, learning, games, beginners, keyboard, practice, training, gamification

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1 INTRODUCTION

Learning to play an instrument can be a rewarding and fulfilling undertaking, whilst also being beneficial to mental health and prolonging a healthy brain throughout older ages [1]. However, adults who attempt to learn to play an instrument, in this case keyboard, may struggle to progress past the beginning stages of their learning journeys [2]. We have established, through both primary and secondary research, that a key reason adults struggle to progress is because they lack fundamental skills which make playing and learning easier and more enjoyable. The most recent trend in tackling this issue is via the use of learning-applications [3] which attempt to teach learners how to play an instrument, whilst also utilizing elements of gamification (leader boards, badges etc.) in an effort to enrich the educational experience and motivate learners to progress further. Whilst the learning applications do work to some extent and adult beginners demonstrate a keen interest in the beginning stages of the applications, they eventually taper off and give up. The reason for this is stated above, i.e. they lack the fundamental skills to progress past the beginning stages and, when attempting to learn more complex concepts, they feel frustrated as what they had imagined they could do is not what they can actually conduct in reality. What no new solutions [4] appear to offer is a method of practicing fundamental skills [5] (i.e. skills which require copious amounts of rote learning) in an engaging and appealing way, so the issue will always persist if they choose to learn independently. If they cannot find a way to improve the core skills of playing a physical instrument then they will typically be led to frustration and associate learning with tedium, leading to a quick burn out.

Games are an engaging outlet with which one could spend countless hours playing, improving specific skills and knowledge that are eventually internalized to long term memory. 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 [6]. With this advancement of accessibility within gaming culture and

the much lower barrier of entry to game development, we offer a novel method of solving this complex issue of high drop-off rates observed with adult beginner keyboard learners. We intend to create a video game which is also a method of meaningful practice in order to learn new and valuable knowledge that, additionally, has real-world application. We originally built video games which focused on improving multiple fundamental skills (such as sight-reading, rhythm, hand coordination, and audiation) that typically require rote learning (i.e. much repetition) but, through multiple studies [7, 8], it was established that we needed to focus on a specific skill in order to assess its validity in regard to educational impact and engagement within a real-world scenario. Therefore, we chose the skill of reading music and built a specific Role-Playing Game (RPG) which focused on using the ability of reading music to play and progress. The decision to develop games which focused on notational reading ability (matching positions on a musical staff to physical keys of a keyboard) was chosen as it is a key skill of playing keyboard (and as an extension piano too), in so far that most methods of learning tonal, executive and rhythmic abilities all require some notational knowledge first whilst also being well suited for rote learning and quantitative experimentation.

In this paper, we present our prototype training game, *The Crypt of Notation,* which focuses on improving the ability of reading musical notation. We will discuss the various stages of testing, design and development, whilst also discussing the methodology of our upcoming longitudinal study. The study aims to validate our prototype game regarding the educational value and engagement using beginner learners within their own homes to reflect real world practice and application. This is an element of testing typically overlooked within HCI research, especially regarding musical education research. This research is based on previous multiple studies [7, 8] but specifically our last pilot study, during which we ensured that our prototype game could be just as effective at improving the skill of reading music in comparison to a market standard trainer in a lab-based setting. The end results inferred that the game was just as effective, if not more so. We now wish to ensure that this is reflected into real-world scenarios. We will measure the engagement through mostly telemetric data and Likert-style questions which adopt a mostly quantitative rather than qualitative approach. This we believe to be a novel testing methodology within an area of research which heavily revolves around qualitative data.

2 BACKGROUND

By definition, music and the quality of a musician is subjective but from a scientific viewpoint musicianship can be broken down into specific criteria of assessment. We defined the core skills of musicianship, specifically relating to keyboard, based on West's [9] definition. West breaks down musicianship into 'The Big Five': tonal ability (hearing skills), rhythmic ability, notational ability (reading and writing music), executive functioning (physical attributes, e.g. posture and hand dexterity) and creative application (how one applies these skills in their play, whether it is playing a piece, within a group or improvisation).

Research was also 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 [10] 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) behavior, 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. In consideration to most of these concepts, we implemented narratives and NPCs to provide players a sense of direction, removed health from players if they consistently play the wrong note or rewarded consistent correct notes with additional points and ensured that the end goal was always clear by highlighting specific paths and areas to progress further.

We drew inspirations from many music and RPG-style games which were not focused on the purposes of learning [11-13]. This helped us establish common themes that games use such as simple yet satisfying mechanics, meaningful narratives which draw players in, and a strong core loop [14], which makes players feel that their actions have a purpose and drives them further. Deriving ideas from games that are not serious or educational was crucial to this research as it helped us distinguish our game from what would be perceived as a typical learning game and into something which represented more of a game recognized for primarily entertainment. Finally, we also conducted reviews of existing music games, such as Guitar Hero [15] and attempted to base similar concepts into our prototype game. These types of game, mostly rhythm based, ensure players feel high amounts of satisfaction by making them feel as though they are playing a full piece of music but in reality, are only tapping a few buttons. We wanted to ensure that our players had a similar experience and could feel like rock stars of their own making without the need to play a whole piece, but still learn and practice meaningful concepts that had application to their learning.

3 METHOD

In this section, we describe the development of the prototype training game, delving into the various stages of design, development and testing whilst also briefly describing the training tool which was used for comparison during the previous pilot study.

3.1 The Crypt of Notation

The Crypt of Notation is an RPG/Rogue-like style game in which players are required to master reading musical notation in order to progress and complete the game. The story revolves around a main hero character, *Maalik*, the guardian of purgatory. *Maalik's* evil counterpart, *Yalla*, a pure evil and spiteful entity, has stolen the songs of *Maalik* and corrupted the afterlife of the souls that exist in *Maalik's* crypts. *Maalik* calls upon the player to help him recover the stolen songs and battle the forces of evil that are spreading throughout purgatory. *Yalla* can only be defeated by recovering the songs and restoring the balance to *Maalik's* crypts; it is up the player to fight against evil by playing funky beats and thus ensuring that *Maalik* can restore peace to the corrupted world.

Players control the main character using a MIDI keyboard with a total of 48 keys are required; the lower side of the keyboard is used to

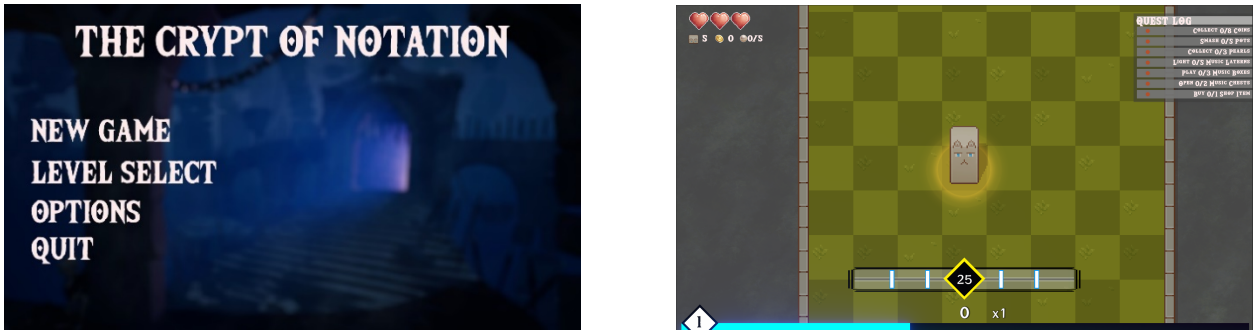

Figure 1: Screenshots of The Crypt of Notation's main menu and hero character, 'Maalik'

Figure 2: Screenshots of the in-game shop and a procedurally generated level

control the character movement and the higher side of the keyboard is used to carry out certain actions, such as switching from play mode (in which players can play notes) to move mode (in which the keyboard is used to move the character and interact with the world, a crucial part of the game). The control scheme encourages players to place their fingers on the keys in certain ways, which reflects typical early-stage hand positions found within teaching (e.g. the five-finger position [16]). For the most part, players must complete each level by playing all the notation found (in which patterns of notes are used to improve finger and hand dexterity, implementing basic finger exercises found in typical learning), though we also wanted to add more to the game to ensure that it was not just a typical trainer with a different guise. So, not only are players required to play the musical notation, but they must solve simple puzzles, navigate through tricky mazes, defeat enemies in unique ways, collect additional items and coins which can be spent in shops in order to improve the character's abilities and style (i.e. powerups and cosmetic items). Whilst most of these additional game design concepts integrate with the learning, e.g. the puzzle elements focus on placing notes in a correct ascending order, we intentionally implemented certain game design concepts to be a distraction from the learning to help ensure that players felt like they were playing a traditional video game, rather than a practice tool. We wanted to branch out further from traditional learning games and offer a concept that felt like a classic video game experience with the learning being almost subliminal, which we hope increases higher practice rates as most learners would typically prefer to play a game than practice elements which require rote learning. The notation that players are required read varies over the course of the game, starting with the basic notes and eventually adding more notes to the gameplay; we consulted learning books [17] and applications [18] to build our own progression of reading notation, focusing on landmark notes and building from this.

As this is a game centered around music, it was imperative that we consider the music and rhythm as a core element of both the design and the mechanics of the game. Using paradigms observed in existing music games, we implemented rhythm in many aspects of the game in order to encourage the player to hit the notes on the beat, which offers a greater feeling of satisfaction and improves their rhythmic ability (another fundamental skill). The game features a visual and audio metronome accompanied by a backing track which has a clear tempo, whilst also flashing other elements to the beat, for example a 'dance floor' flashes over the tiles, the enemies move in time to the beat and most of the animations are timed to the beat of the music. Finally, if players move or interact in any way to the beat, they build up a streak. The higher the streak, the higher score multiplier they receive but they will lose the streak if they miss a beat (building on the gamification concept of 'sunk cost prison' [19]).

Because we are developing an RPG style game, it was important that we add level progression with unlockable skills. Players gain experience points (XP) by completing any positive action (playing notation, completing a puzzle etc.) and on levelling up, they can spend their skill points on specific abilities which help render the

Figure 3: Screenshots of the game's skill tree menu and a sample of a hand-created level

game more enjoyable and eventually easier; abilities include slowing down enemies if they play the correct note of the corresponding enemy notation, gaining extra health and not losing multipliers quite as easily.

In terms of content, we adopted a mix of both hand-crafted and procedurally generated levels; we chose to adopt this style of development due to the size of the team being mostly a sole developer and designer (plus at the same time researcher). There are 51 levels in total, 5 of which are hand crafted by the lead developer and include additional layers of game design such as narrative, secret paths and basic key/door mechanics. The other 46 levels are procedurally generated but still include puzzles and intelligent enemies. The levels were generated using a series of nested for loops (i.e. looping through a series of x and y positions within a given length) and placed a random choice of tile which can be provided within the Unity engine Inspector. Outer walls were created first by using the outer edges of the given size before placing floor tiles within the bounds of the outer walls and then placing objects, notation and enemy tiles at random places on top of the floor tiles. The player, and also enemies, can move one tile at a time in any given position (with most of the enemies moving towards the player position to the beat of the music). Tiles were assigned a specific 'layer' and when an object that can move (either the player or an enemy) it will check if there is such an object in the way and act accordingly; if it is something that breaks then it will break or if it is a solid object then the moving object will remain in its current place. Each level exponentially increases in difficulty in relation to the size of the level, how many notations are required and the difficulty of the puzzles, mazes and enemies. We chose to spawn enemies every fifth level to help players learn the notation before applying it with some agency (as we established from previous studies [8, 9] that players felt overwhelmed trying to read new notation and tackle moving objects). The hand-crafted levels feature enemies of different types and a final 'boss area' in which there is a series of waves of enemies that the player must defeat using notation and also by dodging certain attacks (again, attempting to merge typical learning game tropes with typical video game paradigms). Finally, if players do not want to progress the main story and just want to practice using the game, they can play in the 'arena'. The arena is an endless series of increasingly difficult enemy waves which use randomly selected notation, and the player can test their abilities in order to see how many waves they can defeat before losing a life.

3.1.1 Game Development. The game was developed using Unity engine [20] with mostly C# and some C++. We adopted an iterative cycle of development and testing (an ideal methodology when developing prototypes of a novel nature). Each stage of development would last around 4 to 6 months and we would run small sample studies (ranging typically from 10 to 20 users) over a period of a week, where we would use one to one semi structured interviews, in combination with Likert-style questions, to gain valuable feedback on the development cycle. We would recruit most of our users from the placement company's (ROLI Luminary [22], where the lead researcher works in placement in conjunction with Bournemouth University, specifically undertaking an Engineering Doctorate at the Centre for Digital Entertainment [30] which was part funded by EPSRC [31]) mailing lists, the Bournemouth University game and music undergraduate student cohorts as well as friends and families.

Early prototypes of the game focused on the concept of the 'arena' mode, as this provided an infinite amount of content for players to use within testing. However, though early-stage testing, we came to the conclusion that the game needed more depth and also that there was a need to make use of game design paradigms if it was to be more than a typical learning game. In the second round of development, we replaced all the early design concepts with new artwork which, fortunately, was not a huge undertaking due to the project and code being robust enough to handle design changes of this approach. In the second stage of development, an initial first level was created from scratch by the lead researcher, implementing this with the addition of a basic narrative driven by a 'Wizard' non-playing-character (NPC), which offered the game additional personality and was the first version of the trainer which came close to representing a standard game.

Our most recent version of the game has reached the level that was desired from the beginning of the development; it is a game that does not require any help to play or understand and watching users play test was indeed a joyful experience; in fact, the most common feedback received was 'when can I play this again?' Rather than attempting to design levels by hand, we decided to use procedural generation for the most part. This randomly generated series of levels renders each learner's playthrough unique to them and, making use of the mechanic of playing notation in a variety of ways reiterated our learnings from game development; a satisfying game, it appears, takes a simple yet impactful mechanic, and applies it

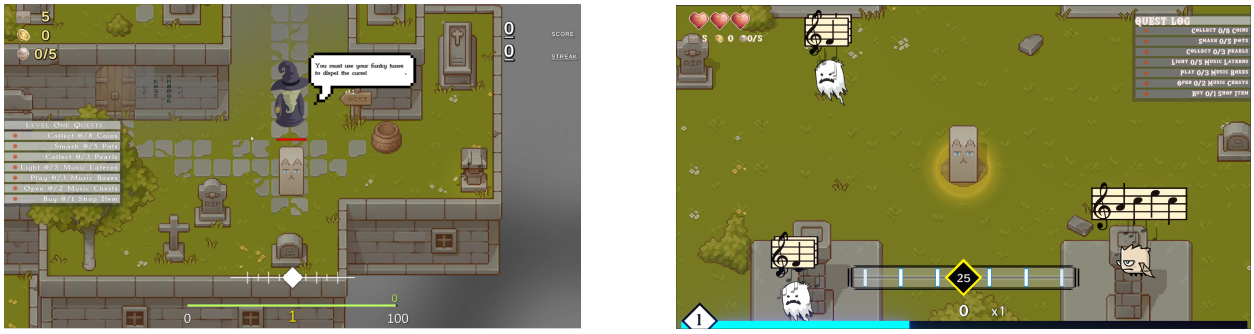

Figure 4: Screenshots of the 'Wizard' NPC from an earlier prototype and the game's 'arena mode'

Figure 5: Early concepts of The Crypt of Notation prototype training game (left is the first prototype developed)

in a plethora of ways to make the player feel as though they are improving and progressing through the game at a steady pace.

3.1.2 Connecting MIDI and Adding Rhythm. As the game is controlled solely by a musical instrument, there were many ways to consider reading input from the instrument. Fortunately, our chosen instrument of keyboard made this process relatively straightforward as we could use a USB or Bluetooth connection to/from a MIDI keyboard. We opted for this method as it was the most robust and least prone to any errors, whereas using a system which listened for pitch through a microphone was inaccurate and would potentially be considered a confounding factor in any testing situation. An existing Unity plugin, 'minis' by Kejiro [21], was used to add support for MIDI input devices. At this point, all that was left to do was connect input actions from the MIDI keyboard to the mechanics of the game, in which we opted to use Unity's event system, where every time a key was pressed on the keyboard an event was triggered which other scripts could listen and respond accordingly.

In order for mechanics and animations to be synchronized to a backing track, we manually had to determine the beats per minute (BPM or tempo) of a given song; this is typically found through a simple Google search, but future considerations will attempt to measure the BPM of a given music file through artificial intelligence. Once the BPM was known, we converted this into seconds and used this variable of 'beats per second' for animation purposes and in order to determine if the user was playing at the same time of the beat (allowing time either side as testing demonstrated it was difficult to play exactly on the beat). Rather than tracking the next beat time based on frame rate, we, instead, opted to track this using Unity's audio settings time as this had greater accuracy and did not wait for any other calls in the background (i.e. when using frame rate, we noticed the time between beats got further apart).

3.1.3 Tracking Game Data. As we needed the tracked data to be accessible during the study, we decided to make use of a remote, secure server in which we could upload text files with the telemetric data written to. Uploading a file to a server within Unity was a simple task of using file transfer protocol (FTP) to a local server for testing purposes but would later be extended to a remote and secure server. The final step was to write data to a text file from Unity; we found that using JSON was the most efficient method to do so.

With the consent of the participant, we can acquire the time of the system that they are playing on when first opening the application and when they close it, determining the total time played. We also have certain flags set on specific actions (using a shop, levelling up etc.) which are also written to file and can provide insight into what the participant did during their play session (which avoids recording screens and creating large files).

3.2 The Training Tool

We adopted to use a third-party practice tool ('sightreading.training') [25]) for comparison in order to avoid bias (as opposed to using something of our own creation). Therefore, we used

one the leading market standard tools for practicing both basic notation recognition and sight-reading (a tool used by many musicians, from beginner to advanced stages of skills). The tool consists of a staff (which participants can choose from treble, alto, bass or grand) and a series of notes which can be chosen by the user are displayed (the notes which are spawned based on the users' choice follow no melodic pattern and are a purely random series). The one action users can carry out is playing the first note seen on the staff (the note they play can be visualized on the staff to help orient themselves if they are unfamiliar with the note they have to play) and three scores are collected: total correct, total incorrect and the current streak (i.e. how many they have got correct in a row). The tool has no elements of gamification or features of game design beside the score. This simple but effective practice tool was ideal as it would make for fair and logical comparisons. In contrast to the game, there is a lack of musicality in that there is no background music nor rhythmic aspects, the user interface is somewhat convoluted and there is a lack of guidance, but most importantly, the key difference is the lack of game design and gamification, whereas the game is designed as a video game first rather than a practice tool.

4 LONGITUDINAL EXPERIMENT

As mentioned previously, in our upcoming study we aim to measure the concepts of educational value and engagement of our developed prototype training game in a real-world setting using a pre/post-test methodology, tracking telemetric data as well in-depth surveys and diaries which make use of Likert-style questions. In this chapter, we discuss the study in detail, outlining the key aims, demographics and methodology.

4.1 Key Questions of the Experiment

- – Does our developed prototype game improve the skill of reading music in a real-world context? (i.e. outside of a lab-based setting)?
  - – Can this improvement of skill be applied to other areas of playing/learning (in this case, can practicing the skill of reading music/playing our developed game help our learners to read a piece of music more fluently and efficiently)?
  - – How well does the knowledge and skill acquired retain over time? (i.e. does setting of practice or nature of practice improve memory of information, especially related to muscle memory)?
  - – Is the developed prototype game more engaging than our control group? (how motivated does each group feel to practice further?)

4.2 Study Outline and Participant Demographics/Recruitment

For this study, we adopted the same procedure as our pilot study during which we use a pre/post form of testing; the notable difference between this study and the pilot is that of time, in that this (new) study will be conducted over a period of two weeks as opposed to our pilot, which was in a lab-based setting for only 15 minutes of practice. We intend to recruit 80 participants in total. This sample size is based on previous findings but also based on an effect size of a 30 percent increase in score from pre to post. Participants will be recruited through the placement company's mailing lists (ROLI Luminary [22] in which a large number of customers are expected to be beginner learners, as this is what the company's latest product, LUMI [23] is designed for. Participants will also be recruited through the University's mailing lists where we will recruit students from both music and game undergraduate courses. Participants must fit into our demographic profile in order to reflect our larger population. The key criteria participants are required to match for eligibility purposes are outlined below:

- – All participants must be over the age of eighteen (with a focus on young adults, although not a requirement and all ages over eighteen years will be considered)
  - – Each participant must be an absolute beginner in keyboard/piano playing (with the assumption that they cannot read music). Or, alternatively, the participant must be an existing beginner keyboard learner/lapser (someone who has previously learnt to play but eventually gave up and wants to start again) who does not have a huge amount of experience reading musical notation
  - – Each participant must have experience playing video games and be familiar with the typical tropes found in most classic RPG style games. Whilst this is not a strict requirement, the participant should ideally be an avid gamer who plays regularly (as the demographic we are aiming for is adults who play video games on a daily or weekly basis)
  - – Participants should ideally already own a MIDI keyboard, but in certain scenarios, one can be sent to them by the research team

4.3 Study Procedure

Once participants have been recruited, they will all follow the same procedure which has been outlined below:

- Participants are required to fill out a survey relating to their background information. Whilst it can be assumed that participants fit into the demographic outlined above, we need to ensure that we are running this experiment on the correct type of user. Therefore, our participants must fill out a background survey initially. This survey covers each participant's age range, gender, notation reading skill level, how they typically practice and their experiences/preferences regarding video game habits (how long they play for each week, what they play etc.)
- Participants receive information on how to complete the pre skill tests in which they are required to undertake two forms of tests in order to gauge their initial ability to read musical notation. Each test the participant undertakes will be online and their scores will be automatically uploaded to a remote server which the researchers will have access to. It will record participant number, name, the time the test was taken and all the data relevant to the test itself (how many mistakes made, time taken etc.). The two tests are as follows:

1.%2 Skill Acquisition Test

The first test is a custom designed flash card test to determine how well a participant can match a given notation to a physical key. The test focuses on a participant's ability to match a notation

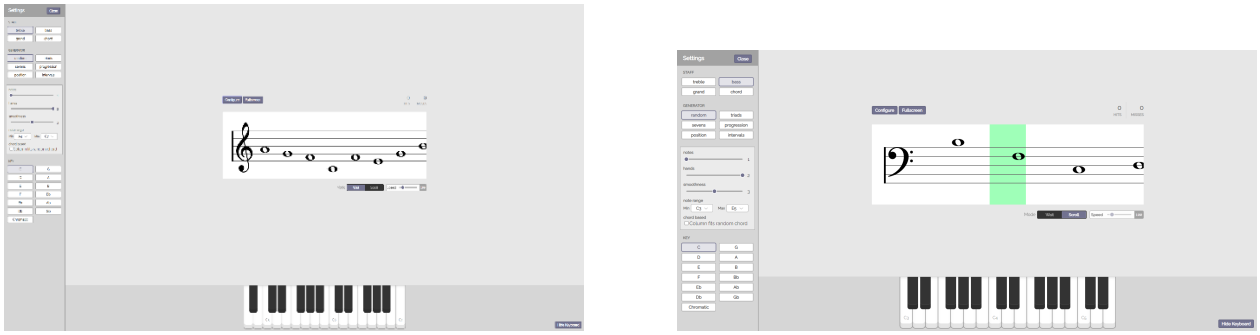

Figure 6: Screenshots of the practice tool used during the study

provided on either treble or bass clef to a physical key rather than trying to verbally say which note it is or press a button a screen/with a mouse. A random notational flash card is shown (using simple single notes within a given range) and participants are allowed as much time as they need to play the corresponding key. The score is based on four factors: accuracy (how many times an incorrect key is pressed before the correct one), time (how long it takes them to actually press the correct key), total time to complete the test itself and, finally, difficulty of questions posed (ranging from notes which are learnt during beginning stages to notes which are less common and appear on unfamiliar ledger lines). The notes shown will be exactly the same for each user, will appear in the same order and will be ranked by difficulty by following similar tests found in early stages of music theory testing (typically following ABRSM and Rock School curriculums [2, 24]).

1●%2 Skill Application Test

We adopted the use of a computer-based approach to measure performance and will base a participant's score on typical measurements of reading music (found in most curriculums): accuracy, tempo stability and rhythm recall. The benefit of this method is that it is measured by a computer and therefore there is no room for human error whilst also being easier to replicate. Participants get 15 seconds to familiarize themselves with a monophonic motif (a basic sight-reading exercise) before then being counted in to play it. A metronome can be used at this stage as well as a basic backing track to help participants keep to time. A total of three exercises will have to be played and the overall score is generated from all three scores (whilst also keeping note of the individual scores for transparency and data analysis).

- Intervention Period

Once participants have completed the pre skill tests successfully, they will be split into two groups: the control group will use a basic notation reading practice tool found on the web, 'sight-reading.training' [25], and the experimental group will play our developed prototype training game. The game group will be guided by an in-game tutorial and the tool group will be offered basic instructions on how the training tool works and what each option does. Each group are required to use either solution for 15 minutes, 5 days a week.; The days do not need to be consecutive, and the time cannot be stacked (it has to be 15 minutes day). The experiment will last 14 days, which totals 150 minutes of practice time if participants only play for the allotted time required. Participants will be informed that they can use the tool outside this time if they wish to do so but that this is not a strict requirement of the study. Participants are also instructed to not practice reading musical notation using other training or practice methods during the 14 days but are permitted to practice other elements of their keyboard learning. Finally, participants will be encouraged, but not explicitly told, to fill out a short questionnaire at the end of each week in order to gain insight into what they have been playing and practicing plus their general views on either practice method.

1●%2 Tracking Telemetric Data of Either Solution

Participants activity will be tracked using telemetry data as well as the optional questionnaire. The telemetric data includes time of logon, duration of log on, and activity during the session. During each session, there will be a timer which the participants can use to keep track of how long they have played each day; they will be informed that they have completed the 15 minutes but will always have access to the solution regardless of how long they have played each day. Telemetric data will show if any participant is not fulfilling the allotted time each day and then, and this is for either solution, they will be informed via push notifications/emails.

- The Post Tests

After the two weeks of practice has finished, participants are required to undertake the same skill tests as before. We will be measuring the difference in scores between the pre-test and post-test with the assumption that both groups will have a significant difference in score, with the hope that the game group improves more so than the tool group, purely because they have practiced more, as the game is more appealing than the tool. These tests follow the exact same format as before and all data will also be recorded and uploaded to the secure, remote server.

- End of Experiment Survey

Following the skill tests, participants are required to fill out a survey about their experiences. They will be asked about how engaging, usable, and educationally valuable they thought their practice solution was. This section of the experiment, in conjunction with the telemetric data, will provide insight into how engaging and usable each solution was; the assumption being that the game will receive a higher rating for engagement as well as more overall positive feedback compared to the practice tool. The questions revolving

around usability are based on a variation of the SUS questionnaire [26], which we have adapted for the purposes of this study, whilst the questions relating to engagement are derived from the PENS questionnaire [27]. We chose to use existing questionnaires as they offer the research more merit and also ensure a level playing field for potential other researchers who may wish to build upon this research.

- Skill Retention Test

The final task participants are asked to undertake is a follow-up test which is conducted one week after the post test. This is optional, as we have already asked a lot of our participants. We want to conduct this test to see how well the skill and knowledge gained through practice was retained; this is to ensure that the difference from pre to post scores was not due to any practice effect, to see how well information retains when using a much more graphical and engaging medium and, finally, to see whether there was an uptake in practice outside the study between both groups, i.e. does setting of practice or nature of practice improve retention of information, especially related to muscle memory?

5 CONCLUSION

With this research and the game described we attempt to lower the high churn rate of adult beginner keyboard learners and seek to prolong their learning journeys through the use of video games. Through this research, we have established that a key reason adult beginner keyboard learners drop off from their learning is due to lack of fundamental skills, which leads to frustration when attempting to learn more advanced concepts and generally play what they imagined would be possible when beginning the learning process. The issue is that those who have not had experience with music and playing an instrument at an early stage in life will struggle to improve these fundamental skills as an adult because it requires copious amounts of rote learning with no tangible method in order to motivate and practice them in an engaging manner. Through our previous pilot study, we can assume that not only was the game just as effective as the practice tool, but the nature of the practice environment also increased other skills and helped build stronger positive associations with practice, which would help increase rates of practice and decrease frustration when learning in other contexts. Improving on the limitations of the pilot study, we now intend to run an experiment within a real-world context which will help demonstrate that a video-game experience will yield higher practice rates, in turn helping to improve fundamental skills, ensuring other areas of learning and playing are more approachable and enjoyable. This will lower the high drop off rates exhibited by adult beginner keyboard learners. Future work includes applying this research to other fundamental skills and running longitudinal studies over much longer amounts of time to establish that training video games will lead to a positive association with learning, thus prolonging the music learning journey of adult beginners.

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