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SCHOOL OF THE ARTS
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FACULTY OF HUMANITIES

A research dissertation submitted in partial fulfilment of the requirements for the degree of Master of Music in Music Technology

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The development of a game-based application for teaching and learning music theory

by

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A research dissertation submitted in partial fulfilment of the requirements for the degree:
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Declaration of originality

UNIVERSITY OF PRETORIA

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RESEARCH PROPOSAL & ETHICS COMMITTEE

DECLARATION

Full name: Tarien van der Linden

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Degree/Qualification: Master of Music in Music Technology

Title of Proposal/Study: The development of a game-based application for teaching and learning music theory

I declare that this study is my own original work. Where secondary material is used, this has been carefully acknowledged and referenced in accordance with university requirements.

I understand what plagiarism is and am aware of university policy and implications in this regard.

30 August 2022

SIGNATURE **DATE**

Ethics statement

The author, whose name appears on the title page of this dissertation, has obtained, for the research described in this work, the applicable research ethics approval.

The author declares that she has observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for researchers and the policy guidelines for responsible research.

Abstract

Several technologies and applications have been developed to increase the music theory teaching and learning experience, however, there has been little research when addressing game-based learning in the music education field. Even though many game-based learning applications have been designed for the medical and business fields, there is a lack of research conducted on how to develop these apps for music education, and how these apps influence the teaching and learning process. This design-based, qualitative study discusses the requirements for developing a game-based learning application that is focused on beginner music theory, and investigates the participants' perceptions of the implementation of the developed game in their learning environments. The study also explores the extent to which the developed game-based app can act as a music theory teaching and learning tool. Through the analysis of an interview with the game developer, it was revealed that the game development process was completed in six simple steps. After implementing the game into the participants' learning environment, the focus group and questionnaire analyses revealed that even though the game needs to be adapted before it can be considered a commercially viable product, it has the ability to positively affect the teaching and learning of beginner music theory lessons. A cross-analysis between the three data collection methods in this study provided various suggestions on how the developed game could be improved, and provided context as to why some students preferred the concept of balancing game-based learning with traditional learning methods. When discussing the implementation of game-based learning into everyday learning activities, there were a few concerns, but the findings showed more excitement and eagerness amongst the participants regarding this implementation. These findings prove the study hypothesis that game-based learning could increase students' attention, engagement and motivation to learn, as long as the implementation of these is balanced with traditional teaching and learning methods.

Keywords

music education

teaching and learning

music theory

gamification

game-based learning

music technology

game development

Notes to the reader

This dissertation is written using British English and the APA 7th edition formatting and referencing style.

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Chapter 1: Introduction

1.1. Background and value of the study

Starting with music at a later age, I was less advanced in the subject than other learners at school. Over time, it became easier to understand the various concepts in music, but some elements of music theory remained difficult. Pursuing a degree in music, however, has taught me new ways of thinking and inspired me to find different ways of teaching and learning music. Finding new ways of teaching music theory motivated me to pursue this research study. I wanted to combine the knowledge I have of music education and music technology in such a way as to make the music teaching and learning process more accessible. Since technology has become part of students' daily lives, I designed an application (or further referred to as the "app") for this research project that incorporates game-based learning into music education.

Most of the post-millennial generation (Generation Z[1]) learners have had continuous access to mobile devices and technology, yet the increased need for technology training amongst teachers remains an important issue in teaching this generation of learners (Bauer et al., 2003). Studies conducted by Bauer et al. (2003) and Lehmann et al. (2007) have shown that in music education settings, learners often reported frustration, lack of motivation and trouble with focusing their attention on traditional practice methods outside of the classroom.

The Philosophy of technology for humanities is concerned with the meaning of technology, and the impact it has on society and culture. When addressing technology, the aim of philosophers in the humanities is to grasp the relationships that can be found between various technological phenomena and aspects of societal structure, the human condition,

[1] Term used to refer to individuals born since 1997.

culture, politics, morality, or metaphysics, rather than to analyse and find an understanding of the phenomenon (Franssen et al., 2018). Technology has become a defining feature of the 21st century, revolutionising how we work, communicate, create, teach, and learn, yet electronically driven technological advancements in music education have not yet reached a peak (Waddel & Williamon, 2019). The expansion of various technologies in the music education field has been studied in great depth. However, published references on developing the skills needed in musical theory, especially when considering the use of apps and electronic devices, are lacking (Waddell & Williamon, 2019).

This study explores how the participants describe the development process and their experiences of playing the developed game-based app. It samples tertiary students who are currently taking first-year applied music theory as part of their sound production degree requirements at a tertiary creative media institution in Johannesburg, South Africa. The developed game-based app will be implemented into the participants' learning environments, with the goal to explore how the experience of learning with game-based apps. Furthermore, this implementation will assist in purely answering the research questions of the study and it is thus important to note that the aim of developing the app was not to create a commercially viable product.

1.2. Research aims

In this study, I aim to explore the steps needed to develop a game-based music theory learning app and how the implementation thereof can benefit the teaching and learning environment in a tertiary education setting. By implementing the app into the music theory classes, I aim to explore the students' opinions and feelings about technology-based and game-based learning. Even though the game-based app has not been developed for commercial use, I aim to provide suggestions on how the game can be adapted to be commercially viable in the future. These suggestions on how to improve the game-based learning app will be grounded in the findings of this research study.

1.3. Research questions

1.3.1. Main research question

How do the participants describe the development process and gameplay experiences of the music theory game-based learning application developed for this study?

1.3.2. Secondary research questions

How does the game developer describe the development process of the music theory game-based learning application?

How do the students perceive the implementation of technologies and game-based applications in their learning?

How do the participants describe their gameplay experiences after the implementation of the music theory game-based learning application?

1.4. Research methodology

This study used a design-based, qualitative approach to explore the participants' experiences of the development and gameplay of the game-based learning app. Leavy (2017) states that through conducting qualitative research, the aim of the data collection is focused on building knowledge and generating new meanings through the exploration of social environments, thus emphasising the importance and value of the participants' experiences. Throughout this study, the development of the game-based learning app was outlined through conducting a semi-structured interview with the game developer. Furthermore, information on the participants' opinions of technology and game-based learning, as well as their experiences of playing the developed game, was collected through a focus group and open-ended questionnaires. The full details of this study, including the data collection techniques and data analysis, are discussed in chapter three.

1.5. Research quality

The quality of the research has been achieved through evaluating the criteria of various quality concepts, as laid out by Flick (2007), Silverman (2006), and Treharne and Riggs (2015). These concepts include credibility, transferability, confirmability, and reflexivity, all of which are discussed in detail in chapter three.

To show the accuracy, truth, and credibility of the findings, there was a prolonged engagement with the participants, and method triangulation (through including multiple data collection methods) was implemented along with conducting member checks (Korstjens & Moser, 2018). The findings provide thick descriptions of the participants' behaviour and the context thereof, in order to provide the study with transferability (Korstjens & Moser, 2018). Finally, the study shows dependability, confirmability and reflexivity. All the research steps have been outlined transparently, the data records were stored after self-reflection and re-evaluation of the developed app, and the data collection analysis has been completed and is presented in chapters four and five.

1.6. Ethical considerations

The data collection process, which included the game developer interview, a focus group, and open-ended questionnaires, commenced only once permission was received from the SAE Institute Managing Executive (Appendix B) and from all participating students through informed consent (Appendix D). Information letters were provided to all parties and consent forms were completed and are stored safely. As outlined in the consent forms, all the participant information was kept strictly confidential. Furthermore, to ensure confidentiality, the game developer was given a pseudonym and all participants were given a number from 1 to 40. No participants were compensated in any way and participation was completely voluntary, with the option to withdraw at any time without consequences. All the collected data and information for this study will be saved on a password-protected platform

in electronic format for a period no less than 15 years, as required by the university of Pretoria.

1.7. Delimitations of the study

This study focused on the development of a game-based music theory app for beginner music theory students studying towards a Bachelor's degree in sound production at a tertiary creative media institution, the SAE Institute. The aim of the developed game was not for it to be a commercially viable product, but rather for it to provide answers to the research questions. Suggestions on how to make the game commercially viable have come from the findings of the study. The study discusses the development of a game-based learning app and investigates whether or not the developed app can benefit the music theory learning experiences of the students.

The study does not provide evidence on whether the app of game-based learning can improve overall music teaching and learning, and it does not show results of the students' learning outcomes with and without the developed app. Thus, if the findings support the hypothesis that the app can benefit the music theory learning experience, they [findings] can provide opportunities for further study concerning how game-based learning and other aspects of gamification could benefit other study areas in music education.

For the study, the participants were only sampled within the tertiary creative media institution and no other primary, secondary, or other tertiary institutions were considered for participation.

1.8. Value of the study

As stated in the background, it is apparent that there is a research gap in technological and game-based music theory learning, thus this study will attempt to narrow the gap by providing more information on music theory game development and the implementation. By exploring the development process and the participants' gameplay experiences of the game-based music theory learning app, this research aims to provide

detailed descriptions of how game-based apps can have an impact on the music theory learning environment. As the game-based app for this study has not been developed to be commercially viable, the study further aims to provide suggestions on how the game can be adjusted for further development and research.

1.9. Chapter outline

Chapter 1 – Introduction:

This chapter provides an introduction to the study, which comprises a background to the study, research aims, the main and secondary research questions, the rationale and value of the study, and the delimitations of the study.

Chapter 2 – Literature review:

This chapter comprises a detailed literature review of music teaching and learning, the effects of societal change in music education, music theory, technologies in music education, and game-based learning.

Chapter 3 – Methodology:

In this chapter, information on the methodologies of the study, including the research approach, research design, sampling strategy, research quality, and ethical considerations, are discussed. This chapter also includes the data collection techniques and the analysis of the collected data.

Chapter 4 – Game development:

The fourth chapter provides the step-by-step process of how the game-based learning app for this study has been developed.

Chapter 6 – Findings:

This chapter includes a discussion of the findings based on analysed data. This chapter is discussed in the order of the themes that were assigned during the data analysis process.

Chapter 7 – Discussion and conclusion:

In the final chapter, the findings are discussed in relation to the research questions, along with recommendations for future research in a brief conclusion.

The final chapter is followed by a reference list based on the information that is cited in the study, and thereafter followed by the appendices that contain all the consent forms and other necessary documentation pertaining to the research study.

Chapter 2: Literature review

This chapter provides a review of existing literature pertaining to how technology and gamification play a role in modern-day musical teaching and learning. These concepts will be discussed in relation to the philosophy of technology, technology in music education, gamification, game-based teaching and learning, and the development of game-based apps for teaching and learning.

2.1. Technology: philosophy and heuristics

This study and its development of a game-based learning app are rooted in the philosophy of technology, heuristics, and the two cultures debate. The philosophy of technology is concerned with thinking and acting through technology, and focuses on three functions. The first of these functions is the analytical function, which is focused on how one would attempt to define concepts to create a conceptual framework (Verkerk et al., 2015). Verkerk et al. (2015) explain the second and third functions of the philosophy as the critical and directional functions. These functions are focused on whether the technologies are harmful or beneficial, as well as an attempt to determine whether they would be a good development (Verkerk et al., 2015). The philosophy of technology, as discussed by Verkerk, et al. (2015), has been developed into four main themes as illustrated in table 1 below.

Table 1

Four main themes of the philosophy of technology:

Theme	Meaning
Technology as artefacts	Characterised as material objects that are made by humans to create a practical solution to a problem.
Technology as knowledge	Focus on the combination of the meanings of art and technique, in which both knowledge

	of certain principles and the ability to achieve certain results are combined.
Technology as processes	The technological software and tools that are used to create products.
Technology as part of the human being	The positive and negative effects that technology has on society and human behaviours.

According to Softjourn (2022), in computer science a heuristic can be defined as a method or technique that has been designed specifically to solve problems faster and more efficiently than classical methods. Different technologies such as software, apps, websites and games can be developed as part of the technological process in the development of a person's learning and problem-solving abilities (Tyler, 1995).

When addressing technology and how it can be incorporated into education, it is important to mention the two cultures debate. The two cultures debate is centralised around the relationship between the humanities and the sciences, in which education and technology are respectively situated (James, 2016). The two cultures debate started when C.P. Snow and F.R. Leavis critiqued one another's ideas about the relationship between these two opposing cultures (James, 2016). Snow argued that science and humanities (or the arts) are two of the greatest areas of human intellect and that the two fields should be combined to benefit society and further expand human knowledge (Krauss, 2009). Even though this may sound like an easy thing to do, the debate is centred around the fact that humanists and scientists from two different cultures who cannot understand one another. Because they cannot understand one another, they do not communicate sufficiently to make the combination of the fields possible (Richmond, n.d.).

2.1.1. Technology in music education

The term technology is derived from a combination of the Greek words *techne* (meaning art or craft) and *logos* (meaning words or speech), and could be defined as the development of systematic techniques to make and do things (Buchanan, 2020). By the early 20th century the term applied to multiple means, processes and ideas, and involved the development of tools and machines, which contrasts with the 17th century definition, which belonged solely to the arts (Buchanan, 2020).

Looking back on new inventions that influenced the music education field, we can see new developments such as paper, the piano, tuning forks, and metronomes – some of which date back to the early 12th century and are still used as essential parts of everyday music teaching and learning (Himonides, 2012b). Himonides (2012b) demonstrated how multiple recording, production, multimedia, and music development technologies have played a role in enabling humans to grow. These developments facilitate people to challenge the world, increase their awareness, foster communication and active social engagement, and engage in prior knowledge and apply it to everyday situations. As technologies have developed ever more, technology has become a vital element of music education curricula in the 21st century (King, 2012).

Parasiz (2018) states that technologies and apps provide rich possibilities in educational settings, since they support teaching and facilitate effective and permanent learning. He discusses how both scientific branches of technology and education are changing at a rapid pace and naturally affect the structure of the education system and the teaching and learning styles that are prevalent. Examples of these changes include how the implementation of music production tools can provide compositional, sound phonics, and critical listening abilities (Parasiz, 2018). Furthermore, Robyler and Edwards (2000) reinforce this by discussing how software progremas un music lessons can help beginners improve their creativity as it provides new methods of learning, and it allows them to make important

contributions in individual and group activites. According to Parasiz (2018), various tools in music education, combined with technological developments, bring a more practical approach to the music curriculum and can provide an expanded view of the core concepts in music. The reason for this is that technology builds on the groundwork provided by the educator and reinforces their knowledge on specific topics, giving them more self-confidence and more productivity in their workflow. Waddell and Williamon (2019) support Parasiz' (2018) findings when they state that technology enhances the development of musical skills and plays a large role in networking and communication.

Students use technology every day, whether it be a smartphone, laptop, or the latest software. Thus, using technology in an educational setting has never looked more appealing (Solfegio, 2017). With technologies developing all around us, teachers are increasing their use thereof when planning and teaching their classes, as they realise that integrating technology with teaching has major advantages (Harrel & Bynum, 2018). One strategy used by teachers in the music education setting includes one-to-one computing models, in which each student receives or uses their laptop to improve their productivity (Harrel & Bynum, 2018). These strategies include online music practicing services, both in and out of the classroom, such as the two tools discussed below: SmartMusic and SoundCloud.

2.1.1.1. SmartMusic.

SmartMusic is a web-based suite of music education tools for effective practice, music teaching, and assessment support. SmartMusic is one of the largest interactive, digital music libraries on which students and teachers can upload and download musical scores, recordings, and more. A few of the functions that music teachers can use in SmartMusic include the printing of music notation, provision of feedback on assessments, grading of assignments, creating custom sight-reading exercises, and providing students with various practice tools to grow their skills (Make music, n.d.).

2.1.1.2. SoundCloud.

SoundCloud is a free mobile app that allows for the uploading and downloading of tracks that can be accessed from anywhere. Teachers can use this app to upload backing tracks, full recordings and more, so that their students can access and listen to them. The sharing of tracks can be private or public and SoundCloud allows the students to like, comment and share their music freely (Solfeg.io, 2017; SoundCloud Global Limited & Co KG).

When looking at the use of technology within the learning environment, the well-known phrase “education follows society” is not unfamiliar amongst music educators (Mark, 2015). As society establishes new needs, goals, and technological developments, music education ought to adjust accordingly (Mark, 2015). Some also argue that the problem of “keeping up with change” arises because of the increasing speed of societal change (Mark, 2015). Reform proposals are plentiful, and this “need for change” within education is not a modern way of thinking. Whilst reviewing the work of John Dewey, Martin (2002) stated that “[e]ducation nourished the appetite for reform, and reform stressed the significance of education” (p. 28).

Society is changing in many ways. Children live and learn “change”, yet music educators have found it difficult to change at the same pace as the setting in which their learners develop (Gates, 2009). Richerme (2015) states that “time not only enables difference, it demands it…” (p. 20). And even though research and school examinations have proven that traditional music education practices are effective, new ways of creating, listening and performing music are challenging music educators. These challenges are also causing a growing sense of unease amongst teachers, as present-day learners might not want to learn what teachers can teach (Jorgensen, 2010; Kladder, 2017).

The South African Department of Basic Education defines subject music (Department of Basic Education, 2011) as “an art form that can be combined with other forms, and is often enhanced by technology…” (p. 8). However, Himonides (2012a) reports that there are still

various challenges related to viewing and using technology as a core aspect of the music teaching and learning process. As contextualised above, in Western secondary schools, such as those described in the study, it is not an option to become estranged from technology, since it has become a part of the human condition. Using it as a tool to create new and effective ways of teaching needs to be embraced and celebrated as a part of the basic, musical, human condition (Himonides, 2012b).

With current affairs in the world, such as the Covid-19 pandemic, it is becoming more and more common to teach online. Thus, technology is already becoming the sole method of teaching. For online teaching, or even for teaching with technology in a classroom setting, Fein (2017) illustrates a few main considerations. These include three devices. The first of these devices is referred to as the *seeing teacher device*. This device refers to the visual method in which the educator teaches, whether it be an interactive whiteboard, a projector, or a computer and a webcam. Second, Fein (2017) discusses the *hearing teacher device,* which refers to the audio playback used in a teaching environment. The audio used can include analogue and digital platforms, such as acoustic instruments, amplifiers, speakers, or our third device which is *digital instruments* like MIDI keyboards.

Further visual and audio methods for teaching music include the encouragement of creatively experimenting with keyboards, sound recording apps, multi-track music production apps, and music notation software, all of which are discussed by Watson (2011) and illustrated in table 2 below.

Table 2

Creativity with technology:

Creativity with…	**Description**
Keyboards	Electronic keyboards create easily produced, attractive sounds with the press of a key. It allows students to access and work with hundreds of built-in sounds, including the sounds of instruments (e.g. violin, trumpet, etc.), sound effects, and digital synthesisers.
Sound recording apps	Allow students to capture, organise, edit, and alter music and sounds for creative projects.
Multi-track music production apps	Using various sound production apps and DAWs, such as GarageBand or Pro Tools, allows students to record and edit multiple instruments at one time. They can also record MIDI devices and create loops that can be layered to compose new electronic tracks.
Music notation software	Notation software is often the first and most used area of music education technology. Students can make use of this software and these apps to compose music on a score, or a lead sheet directly on a computer, which can then be played back and printed.

Watson (2011) states that “some great music technology, both hardware and software, can break students free from their inhibitions to achieve spontaneous, ‘in the moment’ creativity and to document these improvisations for further use” (Watson, 2011, p. 63).

He discusses how the comfort of commonly used interfaces in modern times (like drum pads, etc.), along with the attractiveness of sampled or synthesised sounds, can benefit the teaching of musical concepts (Watson, 2011). The reason for this is that the use of these interfaces with sounds are inviting and can encourage experimentation with expression. And when we think about how technologies and the internet has become so

easily accessible over the past few years, the next step in teaching should be technology or even game orientated (Watson, 2011).

2.2. Games

A game can broadly be defined as “a system in which players engage in an abstract challenge, defined by rules, interactivity, and feedback, that results in a quantifiable outcome often eliciting an emotional reaction” (Kapp, 2014, p.70). Games are often different in their gameplay strategy and visual appeal. Thus, choosing a game for the teaching and learning process can become a challenge for educators (Zirawaga, et al, 2017)). Games contain various elements and perspectives and can be easily categorised by content area – for example, board games, war games, puzzles, science fiction, first-person shooter and more. For this research study, however, we will look at the types of game activities, since these are the focus points for game developers and designers (Kapp, 2014).

As a game developer and an educator struggling to choose a game for their lesson plans, it is important to focus on the activities that will occur during gameplay and the goal that one wants to achieve through playing the game. Once the focus is shifted in this way, the activities can be adapted to suit various types of games, which can lead to increased engagement from students with different learning styles (Zirawaga, et al, 2017).

2.2.1. Types of games

Some of the most common game activities include matching, collecting/capturing, allocating resources, strategising, building, puzzle solving, and exploring, all of which will be discussed below (Kapp, 2014).

2.2.1.1. Matching games.

In matching games, the player is provided with a variety of items that they need to match with one another, whether it be within the game space or not. An example of matching items

within the game space includes card matching games, where the player is provided with a variety of cards and the aim is to match the same cards, encouraging the player's memory and recall abilities (Kapp, 2014). On the other hand, matching outside of the game space provides the player with a problem where the solution is not visible within the game. For example, in Hangman the player is given several letters for a word, and has to recall letters and words from their memory to solve the puzzle before the game ends (Kapp, 2014). When looking at the memory recall in matching games, it is feasible to say that trivia games also fall under the category of matching games, because they require the player to recall knowledge and match it to a question (Kapp, 2014).

2.2.1.2. Collecting / capturing games.

In collecting and capturing games, the goal of the gameplay is to collect the required number of objects throughout the gameplay journey (Kapp, 2014). These can be digital games like Pac-man or analogue games like the card game Go-Fish (Kapp, 2014). In the classic Pac-Man game, the player has to navigate their character through a maze while collecting several dots and avoiding other characters who could kill the character (which leads to the player losing the game) (Kapp, 2014). The same concept is applied when playing the Go-Fish card game, for the aim is that players should "capture" or "collect" cards from other players to win the game (Kapp, 2014).

2.2.1.3. Allocating resources games.

In resource allocation games, the gameplay success is catered around balance (Kapp, 2014). The player becomes responsible for a variety of resources that need to be collected and allocated to the appropriate places and objects, placing a focus on the interrelationship among variables (Kapp, 2014). An example of a resource allocation game is SimCity, where the player, as mayor of a city, should attempt to generate revenue by balancing variables to help grow their city (Kapp, 2014).

2.2.1.4. Strategy games.

Strategy games are similar to resource allocation games. However, in a strategy game one is competing with another player for resources (Kapp, 2014). A good example of a strategy game is chess, where the goal is the use of strategy against a competitor to move one's own pieces and attempt to win over the opponent's pieces (Kapp, 2014).

2.2.1.5. Building games.

In building games, players get a variety of materials and are prompted to create an object using the provided materials (Kapp, 2014). Examples include the analogue game Jenga, and the digital game Minecraft (Kapp, 2014). In both these games, players should use materials to build objects with a focus on protection against other forces, or do something as simple as removing blocks and rebuilding them to keep the tower upright on their turn (Kapp, 2014).

2.2.1.6. Puzzle solving games.

Puzzle-solving games aim to solve a problem by completing puzzles or by searching for clues. Games like Clue are good examples of puzzle-solving games, where one has to solve a murder mystery by collecting information and making guesses based on murder weapons, characters, and various locations in a house (Kapp, 2014).

2.2.1.7. Exploring games.

Exploration games focus on the character's journey to find an item of value (Kapp, 2014). Players interact with objects in an environment to locate these items, which can guide them (through clues, riddles, puzzles, and more) to the solution of a problem and a prize like coins, lives, or even winning the game (Kapp, 2014).

2.2.1.8. Helping games.

Helping games are about helping a player or non-player character to accomplish a task or escape a situation of imminent doom (Kapp, 2014). By rescuing or helping a character in the game, the player achieves new levels and collects prizes to further their gameplay (Kapp, 2014).

2.2.1.9. Role-playing games.

By assuming the role of another person or avatar (e.g., becoming a doctor or a president of a country), the player has to complete missions like completing a successful surgery on a patient (Kapp, 2014). Role-playing games are all about *how* you play the game and the steps that are taken to reach success (Kapp, 2014). These games usually reach a high level of complexity and are not always recommended for learning environments. However, when any of these game types and their elements are applied to existing learning activities, gamification can be applied and engagement in learning activities can increase (Kapp, 2014).

2.3. Gamification

Burke (2014) defines gamification as the convergence of game mechanics and experience design to assist with human engagement and motivation on a digital platform. This definition can easily be explained as the application of game-design elements and principles to other contexts (like music theory knowledge), to increase engagement and participation (Growth Engineering, 2021).

Many educators have attempted to find new ways of motivating and engaging their students throughout the teaching and learning process (Kim et al., 2018). There are many approaches to motivate learners, of which a commonly overlooked – yet extremely effective one – is gamification (Kim et al., 2018). Kapp (2104) supports this view by discussing how gamification is closely related to the concept of games, and can be conceived as using

various elements of games as motivation for teaching and learning (Kapp, 2014). The motivational and teaching and learning influence of games and gamification is discussed further in the following sub-divisions. But it is important to first note how the field of gamification has grown and what types of gamification exist.

2.3.1. Growth of gamification

The term “gamification” was coined by Nick Pelling in 2002 (Growth Engineering, 2021). Since then the gamification trend has been growing at a phenomenal pace, with gaming elements making their way into various settings, such as corporate training and educational institutions (Kapp, 2012).

Kapp (2012) states that since 1999, the average video gamer age has increased by 9% and grows yearly. Furthermore, Kapp (2014) shows that in the United States, computer and video game sales generate an annual income of over $10.5 billion, with 67% of American households playing games. Internationally, countries like the United Kingdom, France, and Japan are spending $270 million, $220 million, and $2.2 billion a year respectively on multiplayer online role-playing games. This clearly illustrates the proliferation of video and computer games, and it is predicted that over the next few decades gamified services will become as important as social media platforms like Facebook, Twitter, and Amazon (Kapp, 2012).

2.3.2. Types of gamification

When discussing gamification, it is important to evaluate the two types of gamifications: structural and content gamification. Even though these types differ, they are not mutually exclusive and can be combined to become more impactful on the teaching and learning experience (Kapp, 2014). However, to understand these types of gamification, the following sub-sections discuss each separately.

2.3.2.1. Structural Gamification.

This type of gamification concerns adding gaming elements to the structure of the content, while keeping the content unaltered (Designing Digitally, 2019). The learners thus make use of this type of gamification to help propel the learning with no need for the educator to adjust the content in any way (Kapp, 2014). Through structural gamification, the learner is pushed through the learning process, by receiving rewards for each task completion, which drives them to “do just one more task” to excel in the game (Designing Digitally, 2019).

Thus, according to Kapp (2014) and Designing Digitally (2019), the goal of structural gamification is to motivate learners to work through the content while having fun and receiving positive reinforcement through gameplay rewards.

Some forms of structural gamification that can be used to motivate learners include progression-based, badge-based, casual, and competition-based games (Designing Digitally, 2019). In progression-based games, there is a set goal that needs to be achieved by the player. In a learning context, the learner needs to achieve small steps in the learning process that guide them towards the goal that must be achieved. This can be done through progress bars or lives. Thus, every time an answer is correct, the progression bar percentage increases, and when an answer is incorrect, the progression bar remains the same, or the player loses lives.

In badge-based games, the learners win badges depending on their level of competence. The badges are displayed on their player profiles, thereby motivating the learner to work harder to receive their next badge and climb the leader board.

Casual games attempt to trap the learner’s attention by having them play a game before completing a task. Thus, the learner is engaged in a game (that relates to the content) and then prompted to answer questions about the learning content.

Finally, competition games are used to encourage positive competition-based learning. Learners are asked to complete tasks while competing against their classmates to achieve the goal in the shortest time, making the learning process almost unnoticeable to students.

2.3.2.2. Content Gamification.

Content gamification focuses on changing the content in such a manner that it becomes more game-like (Kapp, 2014; Designing Digitally, 2019). This can include the addition of story-telling, challenges and feedback loops to increase learner engagement. An example of such content gamification would involve a game in which the player needs to locate the proper equipment to extinguish a fire. Players will then, after gameplay, be asked to discuss the fire extinguishing procedures they used and demonstrate how this relates to real life and content.

2.3.3. Core drives in gamification

In his book *Actionable Gamification: Beyond points, badges, and leaderboards,* Chou (2019) illustrates his Octalysis framework for gamification design, which focuses on the analyses and strategies around the systems that make games engaging. He developed this framework after analysing multiple games and finding that almost every successful game appeal to specific core drives that motivate one to do certain activities and make decisions. The Octalysis framework is illustrated in an octagon shape and contains eight core drives. After just one year, Chou's framework has been translated into over 14 languages and is seen to represent not only the core drives in gaming, but also the core drives that motivate the desired everyday actions of human beings. Thus, if none of the eight core drives are present in daily activities, there is no motivation for a person to participate in them (Chou, 2019). Each of the eight core drives (2019) are displayed in table 3 below.

Table 3

Description of the core drives in Chou's Octalysis Framework:

Core drive		Discussion
1	Epic meaning and calling	When a person does something because they believe it is for the greater good and that it is their 'destiny' to do something. Gaming example: 'Beginner's luck' – when a player believes they can receive a gift every time they achieve something in the game because they are lucky.
2	Development and accomplishment	This innate human drive to make progress, learn, and achieve is situated in this core drive. In gaming, this is where a 'challenge' and a reward come into play without a reward, the challenge does not have meaning and the player does not feel like they can achieve it. Gaming example: Leaderboards, points, and badges.
3	Empowerment of creativity and feedback	When a player is engaged in the creative process of the game, this core drive is triggered for them to repeatedly try and figure out new things and ways of achieving. Through feedback on their creativity, the player learns to adjust and adapt to receive better feedback. Gaming example: Building Lego or cities (e.g. Sims).
4	Ownership and possession	Another core drive in humans is to feel like they are in control. The moment people feel like they have ownership of something, they feel confident and work to improve and increase their ownings. Gaming example: Customising an avatar.
5	Social influence and relatedness	This drive incorporates all socially related needs, such as social acceptance, feedback, companionship, mentorship, and competition. Gaming example: Interaction with other gamers, leaderboards, etc.
6	Scarcity and impatience	The need to have something unavailable is the foundation of this drive.

		Gaming example: When new products, features, or levels are made available, and the player needs to achieve certain tasks to unlock them.
7	Unpredictability and curiosity	Curiosity, and the need to be constantly involved in one's environments and events, keep players intrigued in gameplay, as they always wonder what will happen next. Gaming example: Tension build-ups before a fight or shootout.
8	Loss and avoidance	Humans need to stop anything negative from happening. We avoid possible losses and change our behaviour to fulfil this need for satisfaction. Gaming example: "Special offer for a limited time only."

Note. Chou's Octalysis Framework. From *Actionable Gamification: Beyond points, badges and leaderboards,* by Y. Chou, 2019., Packt Publishing Ltd.

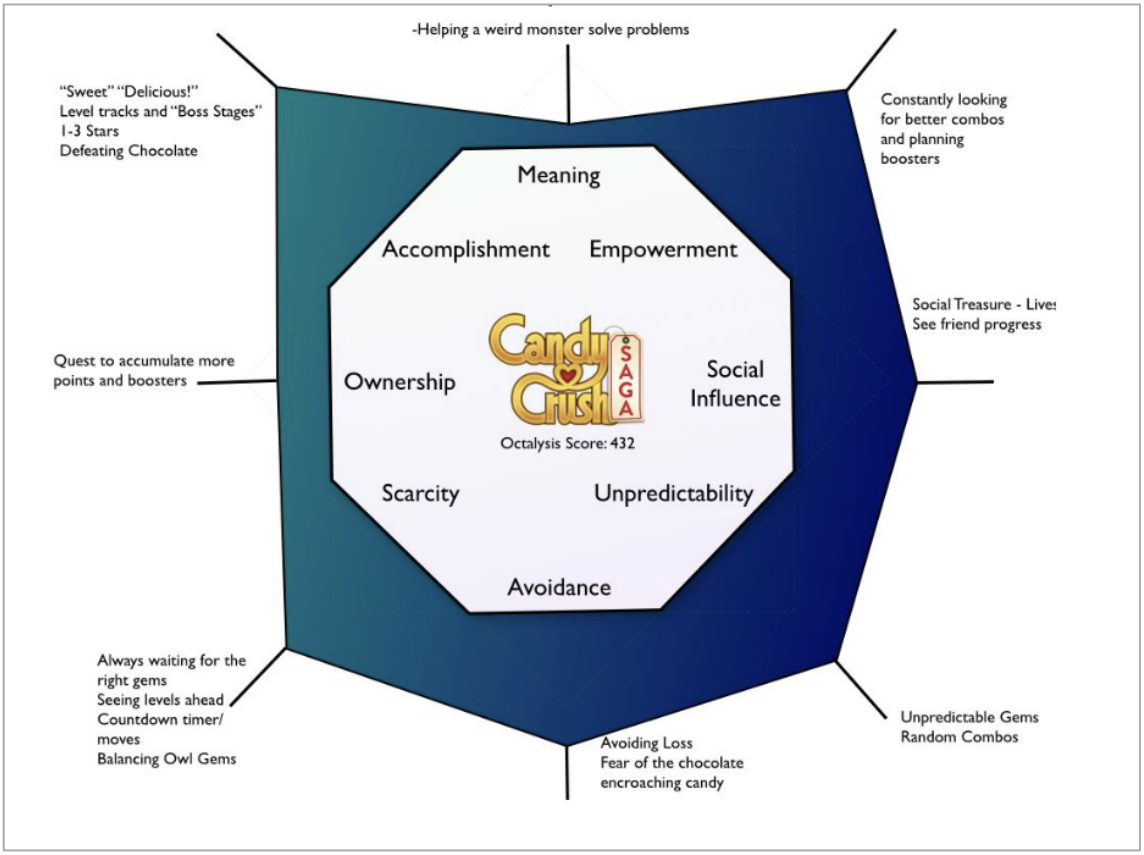
The Octalysis framework is further split into the left brain (extrinsic tendencies) and right brain (intrinsic tendencies) drives, which demonstrate the natures within the drives. These intrinsic and extrinsic tendencies make the user feel powerful and can create urgency, obsession and addiction, and some focus on short-term effects and some on the long-term effects. The right-brain core drives are all the drives that focus on creativity, self-expression and social dynamics, and the left brain is focused on the logical, analytical drives of the framework (Chou, 2019). It is important to note that the belief that students are 'left-brain' and 'right-brain' orientated is midguided and can potentially have dangerous consequences and from this belief, a teacher constructs certain expectations that affect the student outcomes (Coch, 2021).

Furthermore, Chou (2019) expands on this framework by referring to 'black hat' – and 'white hat' gamification. The white hat gamification represents the top half of the octagon

and represents the positive core drives, whereas the black hat at the bottom of the octagon represents the negative core drives. This does not mean that the black hat gamification is bad, but it shows the motivators of the game designs and these can be turned into motivators for acquiring healthy and productive results in games. Figure 1 below illustrates the 8 core drives of the popular game, Candy Crush.

Figure 1

Candy Crush Octalysis Framework:



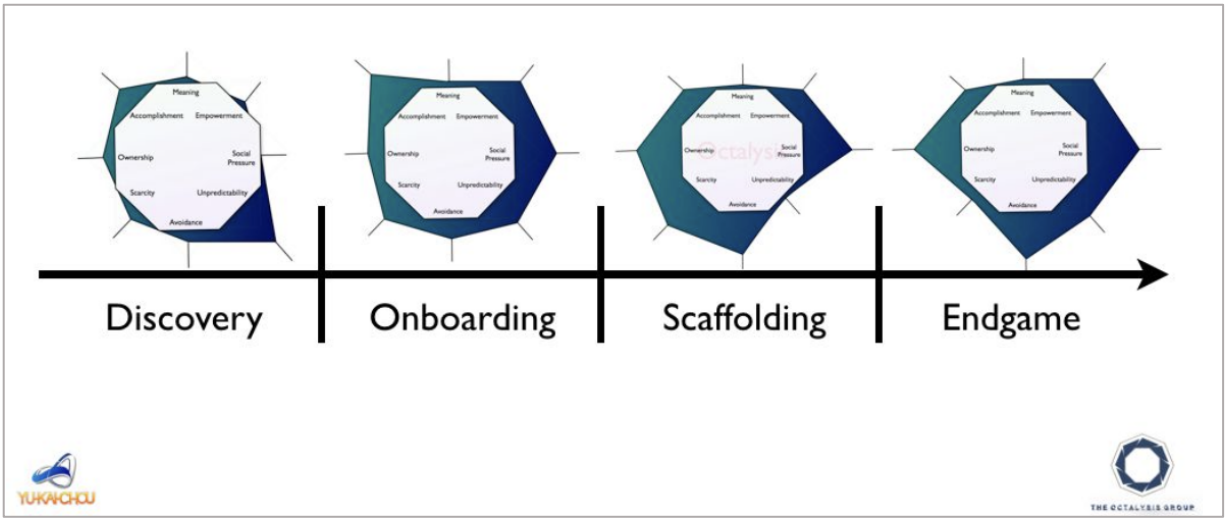
Note. Candy Crush Octalysis Framework. From *Actionable Gamification: Beyond points, badges and leaderboards,* by Y. Chou, 2019., Packt Publishing Ltd.

The Octalysis framework, as discussed above, is merely the first level and it can be applied further up to more advanced levels in which Chou (2019) describes the player's journey and the player types while exploring their motivation during each phase. For this study, however, a brief outline is provided of this advanced level framework for an overview.

In level two of the Octalysis framework (as illustrated in figure 2), it is possible to evaluate how the different core drives become more focused and prominent during the four experience phases: Discovery; Onboarding; Scaffolding; and Endgame (Chou, 2019).

Figure 2

Level 2 Octalysis Design for all 4 phases:



Note. Level 2 Octalysis Design for all 4 phases. From *Actionable Gamification: Beyond points, badges and leaderboards,* by Y. Chou, 2019., Packt Publishing Ltd.

Chou (2019) briefly discusses each of the four phases by referring to the core drive that the motivation derives from, as well as the motivation present. His discussion is illustrated in table 4 below.

Table 4

Level 2 Octalysis phases: Motivation and core drives:

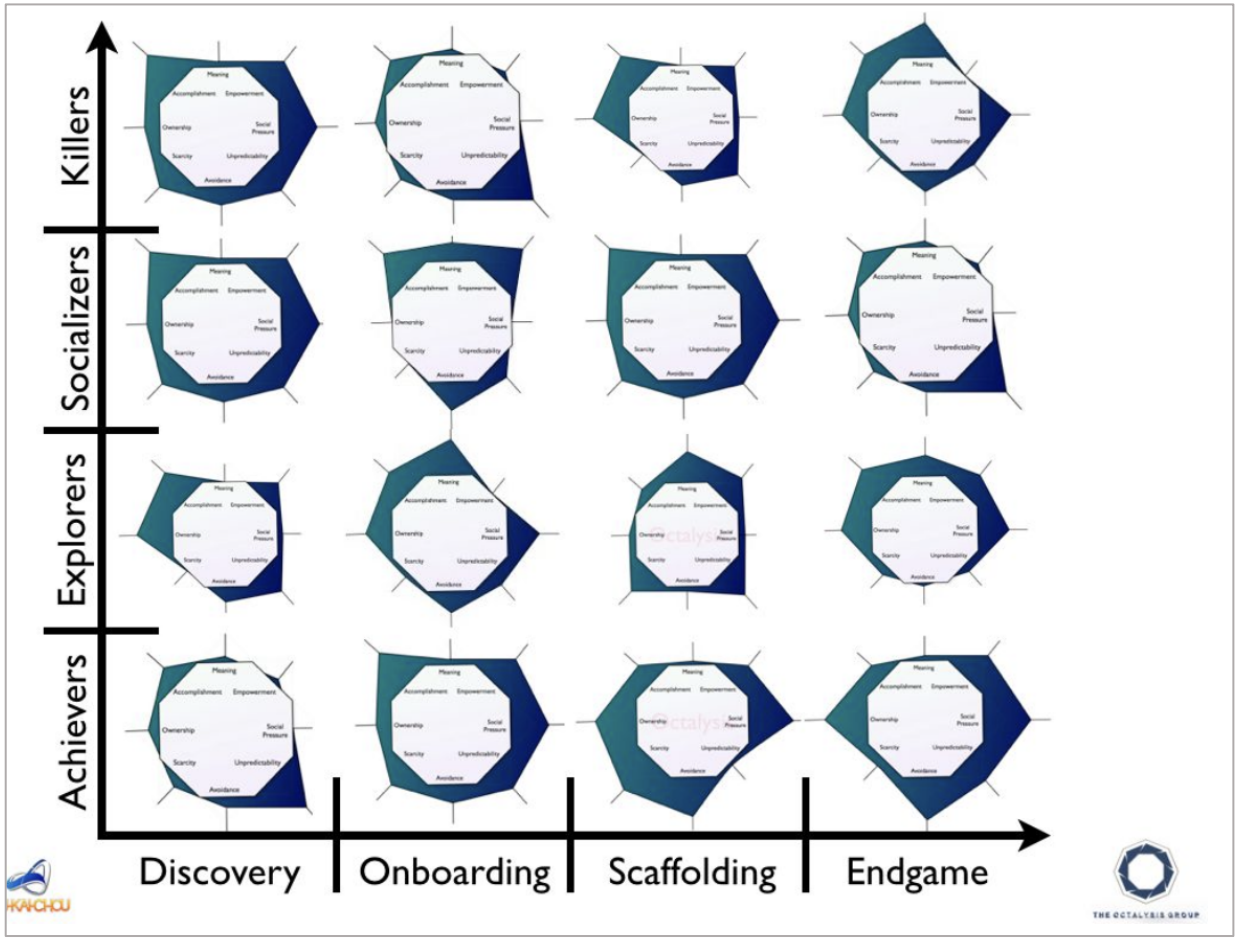
Phase	Core drive	Motivation
Discovery	Core drive 7: Unpredictability and curiosity	Finding out about the game through marketing and word of mouth.
Onboarding	Core drive 2: Development and accomplishment	Early stage gameplay in which the player feels competent and smart.
Scaffolding	Core drive 5: Social influence and relatedness Core drive 6: Scarcity and impatience	Social dynamic and interaction. Need to reach a goal that they cannot reach yet.
Endgame	Core drive 8: Loss and avoidance	Continued engagement with a game to avoid losing their achievements or gamer status.

When designing a gamification experience, incorporating the four experience phases in this framework along with the following level three player types (illustrated in figure 3 below) increases the enjoyment of gameplay (Chou, 2019). The player types are based on one of the most recognised gaming models, as developed by Bartle (1999), and show the four feelings the players go through during gameplay, which are labelled *achievers, explorers, socialisers,* and *killers.* The level three model helps to identify where the weaknesses are within the game and thus help improve the motivational elements at various points of gameplay (Chou, 2019). Through evaluating the framework, one can see that – based on the type of player (achievers, explorers, socialisers, and killers) – they experience various motivational elements throughout the four phases of discovery, onboarding, scaffolding, and endgame (Chou, 2019). Chou (2019) provides an example in figure 4 by stating the following:

Looks like the Achievers start the experience in Discovery well, Onboarding is fine, but in Scaffolding, they lose motivation and drop out. The Explorers will test the product because of Core Drive 7: Unpredictability & Curiosity, but during Onboarding, they feel confused and would leave. Socialisers wouldn't even test the experience because there is no Core Drive 5: Social Influence & Relatedness advertised in the product. Finally, the Killers seem to be the ones, in this case, to stay through Discovery, Onboarding, Scaffolding, and Endgame – possibly showing off to the new players (p.74).

Figure 3

Level 3 Octalysis Framework:



Note. Level III Octalysis: Player type and Motivation during each Experience Phase. From *Actionable Gamification: Beyond points, badges and leaderboards,* by Y. Chou, 2019., Packt Publishing Ltd.

Level four and five of the Octalysis framework is explained in Chou's other sources and expands on the gamification using this framework, however this study will not expand on these levels because they are too advanced.

2.4. Game-based teaching and learning

Game-based learning is focused on taking elements of a learning task and redesigning the game in a more interesting and meaningful way, by incorporating these tasks into a virtual environment in which learners increase their skills and knowledge through play (Plass et al., 2019).

Game-based learning is defined by Salen and Zimmerman (2004) as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (p. 5). Mayer (2014) states, however, that even though there is no general agreement on the definition of game-based learning, it can be said that the characteristics of games mentioned in these definitions are all similar, if not the same. These characteristics include the fact that games:

- are rule-based and follow these clearly defined rules;
- are responsive and enable player actions;
- provide system feedback and responses;
- are usually challenging and contain an element of chance;
- have a cumulative progression through reflection on previous actions; and
- invite and motivate player engagement (Mayer, 2014).

A game can only achieve success in a learning environment if these characteristics are incorporated into the design process, along with the use of game-design elements such as

game mechanics, incentives, aesthetics (visual and auditory), and a story or narrative (Plass et al., 2015).

The ultimate goal for game-based learning is that the facilitation of learning should create tension in the design process, to balance the need to cover the learning content and the desire to encourage gameplay (Plass et al., 2010). When referring to Piaget's theory of cognitive development and learning, he describes play as an integral part in cognitive development as play becomes more abstract, symbolic and social as children mature (Piaget, 1962). DeLoache (1987) explains this by referring to how a child can pretend as if an eraser is a car, thus holding multiple representations of a single object. This type of play is a skill required for the development of symbolic thinking, which is significant in the development of various learning skills including the acquisition of theory of mind, and emergent literacy and numeracy. Game-based learning is deeply grounded in existing theories and research and addresses multiple empirical foundations such as motivation, player engagement, adaptivity, and graceful failure, of which some are discussed in the coming sections (Plass, et al, 2015). Plass et al. (2019) state that games designed for learning purposes could be aimed at preparing for future learning, learning new knowledge or skills, or – as in the case of this study – practising and reinforcing existing knowledge through engagement with games.

2.4.1. Theoretical foundations of game-based learning

There are four main theoretical foundations in game-based learning that are similar to the types of engagement above, such as the sociocultural, emotional, motivational, and cognitive foundations, of which the cognitive foundation is briefly discussed below.

2.4.1.1. Cognitive foundations.

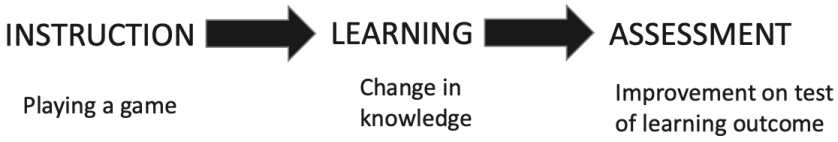
When playing a game changes a player's academic knowledge, game-based learning has been achieved and the cognitive foundation of this learning is grounded in the cognitive

theory of game-based learning (Mayer, 2019). This theory states that gameplay may foster generative processing, in which cognitive processing occurs to make sense of the information received by the player and how it motivates them. Mayer (2019) states that to design effective educational games, a balance is required between instructional features that minimise extraneous processing and manage essential processing, and game features that promote generative processing.

Mayer (2019) expands on the cognitive approach used in game design by looking at the three components embedded in this approach: instruction, learning, and assessment (see figure 4).

Figure 4

Three components in the cognitive approach to game-based learning:



Three components in the cognitive approach to game-based learning. From *Handbook of Game-Based Learning* (p.85), by J. L. Plass et al., 2019, MIT Press.

Mayer (2019) explains that learning is a change in a learner's knowledge because of their experiences, and thus game-based learning can be defined as a change in someone's (the learner's) knowledge because of game-play experience. When breaking down the three components in the cognitive approach as discussed by Mayer (2019), each component can be defined as illustrated in table 5 below.

Table 5

Three components of the cognitive approach explained:

Component	Definition
Instruction	The intentional manipulation of an environment to cause learning. Instructions in games can include anything from providing no guidance to providing detailed tutorials and feedback, as long as educational games have clear learning objectives that describe the knowledge that would be learned through gameplay.
Learning	A change in someone's knowledge due to experience.
Assessment	Determining what the learner knows through assessing their knowledge. This can be achieved through various assessments embedded within a game (e.g., stealth assessments) or external assessments (e.g., retention tests to test memory).

Furthermore, Mayer (2019) continues by stating that the five types of knowledge associated with the cognitive approach are facts, concepts, procedures, strategies and beliefs, which all should be included in game design to ensure effective game-based learning.

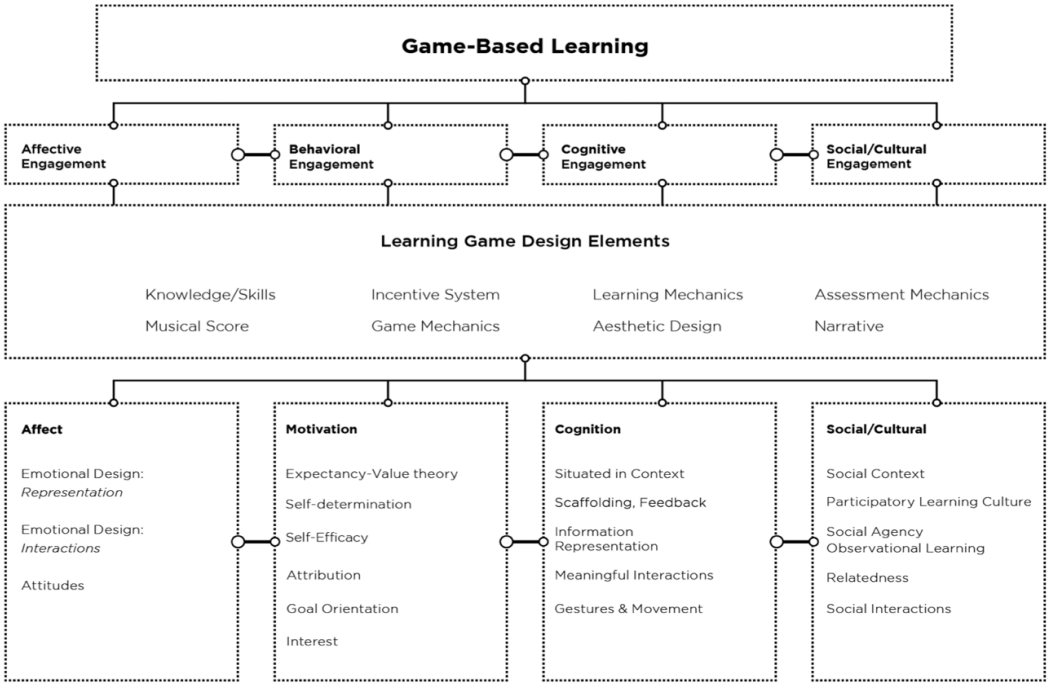
2.4.2. The value and types of engagement in game-based learning

Schwartz and Plass (2019) explain that the designing of games for learning should be based on various theoretical perspectives – which is discussed in 2.3.4.2 – such as those considering cognitive, motivational, affective and sociocultural views. Plass et al. (2015) address these foundations in their *Integrated Design Framework for Playful Learning*, as illustrated in figure 5. This illustration incorporates these theoretical perspectives and links them to the design elements for game-based learning, and the types of engagement that can be generated from the engagement.

When evaluating this design framework, it can be seen that there are three components that result in playful or game-based learning (Schwartz & Plass, 2019). The lowest part of this framework illustrates the four areas from which the theoretical foundations are drawn, namely affect, motivation, cognition, and social/cultural. The second part shows the game design elements used to apply these theories, and the top part shows the affective, behavioural, cognitive, and sociocultural levels at which players can engage in learning through a game (Schwartz & Plass, 2019).

Figure 5

Integrated design framework for playful learning:



Note. Integrated design framework for playful learning. From *Handbook of Game-Based Learning* (p.13), by J. L. Plass et al., 2019, MIT Press.

Schwartz and Plass (2019) continue to briefly discuss the types of engagement when learning with games as follows:

2.4.2.1. Behavioural engagement.

Behavioural engagement includes physical interaction with the game, such as swiping the screen, button pressing, movement in virtual reality, gestures, and full body movement using sensors like Xbox Kinect.[2] The best possible way to foster behavioural engagement is through game mechanics and input devices. Salen and Zimmerman (2004) state that game mechanics describe the "essential play activity players perform again and again" (p. 316) and when games are successfully designed for learning, it means that the activity is based on a mechanic that supports the learning objectives. The input devices can be any device used to play the game, such as the keyboard, mouse, console controller, sensors, and more (Schwartz & Plass, 2019).

2.4.2.2. Cognitive engagement.

Cognitive engagement involves the information processing of the gameplay, with the goal of creating meaning and constructing mental models, which in game design is closely linked to the intended learning outcomes. In order for players to achieve the set goals, they will need to experiment with the available resources and character actions. Through this experimentation the player actively thinks, processes information, plans their approaches and makes decisions that could increase their gameplay strategy.

This form of engagement is described in process theories such as the cognitive theory of multimedia learning and in capacity theories such as the cognitive load theory, which is further addressed in Chapter four of the book by Plass et al. (2019). These theories discuss the cognitive processes involved in learning (selecting, organising, and integrating) and the

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[2] The Xbox Kinect sensor tracks full-body movement and individual voices, creating controller-free fun and social entertainment.

essential processing involved in representing a learner's working memory (generative processing, and extraneous processing).

Cognitive engagement is usually fostered through all the other types of engagement, as well as through incentive structures such as extrinsic rewards (e.g., points, badges, trophies, and more) and intrinsic rewards that are tied to a specific game mechanic (e.g., power-ups, character upgrades, etc.).

2.4.2.3. Affective engagement.

Affective engagement occurs when emotional responses are triggered through gameplay Schwartz & Plass, 2019). When the player interacts with other characters or elements of the game, and they feel an emotional response as a result of this interaction, the game designer has achieved affective engagement Schwartz & Plass, 2019). By fostering an emotional engagement with the game, players play longer, show more empathy and positive attitudes, and an increased cognitive engagement Schwartz & Plass, 2019). Some of the design features that feature in affective engagement include the aesthetic design, narrative, musical score and sound design, game characters, incentive system, and emotional design elements Schwartz & Plass, 2019). These emotional design elements occur when game design elements such as feedback, rewards, narrative, and social interaction are deliberately used to induce emotions in the player (Schwartz & Plass, 2019).

2.4.2.4. Sociocultural engagement.

Finally, through sociocultural engagement, the focus is placed on social interaction and the emergent culture within the game. This type of sociocultural engagement can increase cognitive engagement and improve the learning experience. The sociocultural engagement comes into play when games provide social support to the player through group activities, missions, mini-games, and the story or narrative in the game. When designing a game, sociocultural engagement can be fostered through the establishment of chat groups,

multiplayer functions, character options, incentives, and role-playing (Schwartz & Plass, 2019).

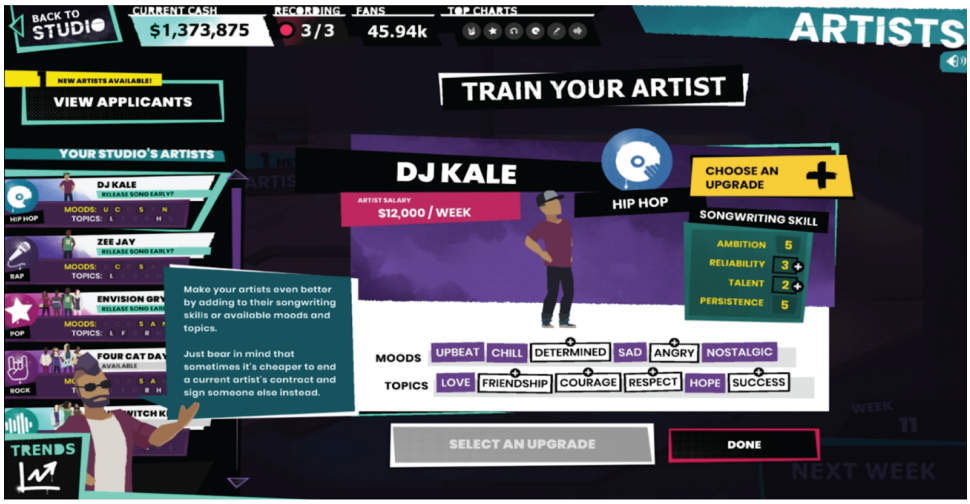
These types of engagements can be further explained by looking at the theoretical foundations of game-based learning as discussed in the next sub-section (Schwartz & Plass, 2019).

2.4.3. Game-based apps in higher education

Games specifically designed for education are effective learning tools in multiple educational fields, including medicine, business, and music (Javornik, 2020). Javornik (2020) states that Filament games teamed up with researchers at Columbia University to create an award-winning game-based learning project called *Beats Empire* (see figure 6). She continues by explaining how the project is a computer-based game where the player's main role is to manage a record label through analysing market data that pertains to the musical preferences of the people in New York. The player uses the insights gained to book gigs, sign artists, record music, and complete marketing requests, actions through which the player gains knowledge and an understanding of computational thinking and the recording industry (Javornik, 2020).

Figure 6

Beats Empire:



Note. Beats Empire. From *Educational games in Higher Education*, by J. Javornik, 2020. Filament games (https://www.filamentgames.com/blog/educational-games-in-higher-education/).

Furthermore, Jensen (2022) discusses multiple educational games in various fields of higher education and how these games can benefit learning through lesson reinforcement, practice, skill development, and memory training. After conducting a research study in which he had higher education students complete a variety of educational games as part of their learning, Multiple authors found that the student reflections on participating brought the following conclusions (Barr, 2019; Carpenter, et al, 2021; Taub et al, 2020):

- Students experienced the gameplay as being a tool for effective communication and increased their socialisation among their peers;
- Students stated that they collaborated more in the gaming environment than they would have in a standard educational environment;
- Students felt more adaptable and could change their thinking in more creative ways because of the environment changes;

- Students expressed how they felt they were more resourceful and reliable after learning through gameplay;
- The students said their experience made them more independent because they brought an increased sense of investigation and critical thinking to their everyday lives;
- Students felt they had become more ethically and socially aware after playing the various games that come from different backgrounds; and
- Students demonstrated an increased level of reflection when asked about their experiences.

Barr (2019) also concludes that after evaluating the role that game-based learning plays in the higher education environment, the benefits that game-based learning can provide to students are remarkable. After seeing what games can do to the learning environment, it seems obvious to keep it in that environment (Zirawaga, 2017).

2.5. The development of a music theory game-based learning app

Stein (2022) defines music theory as the building blocks of how music works and the study of how these building blocks (key, time, rhythm, melody, etc.) are used to create music. For this study, only the elements relating to notes, such as pitch recognition and sight reading for keyboard and musical staff are discussed in this study.

2.5.1. Current apps for learning music theory

After searching for music theory-based software and games, some online based apps were discovered, which will be discussed in the following sub-sections based on the musical element or skill focus of the apps. In conclusion to this section, a discussion of the effectivity of games in comparison to software is provided.

2.5.1.1. Educational music theory software.

Educational software can be defined as a set of programmes developed to facilitate knowledge and learning by students (Smirnova & Clark, 2019). Furthermore, educational software allows for convenient learning at any time and in place, as long as the student has a stable internet connection (Yefremenko, 2021). Some examples of educational software available for music theory learning are listed below and a description of each can be found in Appendix O.

- Musictheory.net and Tenuto.[3]
- Musicards.[4]
- Theta Music Trainer.[5]
- EarMaster.[6]
- Solfeg.io.[7]
- PerfectEar – Ear Trainer.[8]

2.5.1.2. Educational music theory games.

Educational games are described as games that are solely developed for the purpose of reaching certain learning outcomes through game-based learning (King, 2021). Some examples of educational games are briefly discussed below.

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[3] https://www.musictheory.net/products/tenuto

[4] http://musicards.net/

[5] https://trainer.thetamusic.com/

[6] https://www.earmaster.com/

[7] https://solfeg.io/

[8] https://www.perfectear.app/

Tone Gym.[9]

Tone Gym is an online, ear training platform that promises to develop musical intuition and improve core skills, such as rhythmic ability and sense, the recognition of chords and chord progressions, the recognition intervals, and more (Tone Gym, n.d.). It provides teachers and students with an online learning and training environment that can be set up to show leaderboards and rewards to encourage positive competition and gamer engagement.

Eek! Shark!.[10]

Eek! Shark! Is a music theory-based arcade game designed for online play on any device. The game was created to improve students' note name recognition and is focused on the repetition of concepts. The aim of the game is to move the mouse over the screen to have the character, Oliver, catch the correct coins that are falling from the sky. Each coin has a note name on it. Thus, it is important to catch the note names that correspond to the given pitch. Once players have caught 15 notes or coins within the designated time, they progress to the next level, and once they have won five levels, they win the game (Music Theory Arcade, 2007-2022).

Music Press Distress.[11]

Music Press Distress is a multiplatform online game designed to teach note values from beginner to advanced levels. The game has multiple levels and instruments, including

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[9] https://www.tonegym.co/

[10] https://makingmusicfun.net/flash/eekshark.php

[11] https://www.makingmusicfun.net/flash/mpd.php

piano, guitar, band, and orchestra, and covers note values up to complex dotted rhythms. To play the game, the player reads the message in the pop-up box to prompt them on how many beats they need to catch. They then move their character, Oliver, under the flying notes and the character catches the notes and places them back into the music press that threw out the notes. The goal of the game is to earn as many points as possible within the allotted time and without losing any lives (Music Theory Arcade, 2007-2022).

Rhythmic Village.[12]

Rhythmic Village is a game-based app available on the Google Play store and is designed with rhythm training in mind. This game introduces concepts associated with percussion instruments and provides the player with rhythmic and score reading challenges. The game also allows for real instrument play if the device's microphone is activated.

When evaluating the advantages and disadvantages of both software and game-based education, it is feasible to state that game-based learning can be seen as the superior learning tool, since it requires a more interactive and competitive environment that motivates students to participate more (Schwartz & Plass, 2019).

Educational software is known to benefit the educator more than the student, as it is focused on tracking student progress, reducing teacher workload, and making content organisation simpler (Yefremenko, 2021). Yefremenko (2021) states that educational software could enhance student performance and engagement. However, maintaining student attention is not as simple with the use of this educational tool. On the other hand, educational games have been proven to improve student attention and engagement, because they are interactive while also requiring problem solving skills and hand eye

[12] https://play.google.com/store/apps/details?id=com.classplash.rhythmicvillage&hl=en_ZA&gl=US

coordination (Gamelearning, 2018). Educational games also assist in expanding the students' memory capacity, with repetition and memorisation being some of the core concepts in these game designs, something which is discussed further in the following section (Gamelearning, 2018).

2.5.2. Game design processes

Game design refers to the process in which a game designer creatively designs educational or entertaining games (Stefyn, 2019). These games are created using a game engine, and contain stories, characters, levels, goals, rules, challenges and other game elements to encourage player interaction with objects and other players (Stefyn, 2019).

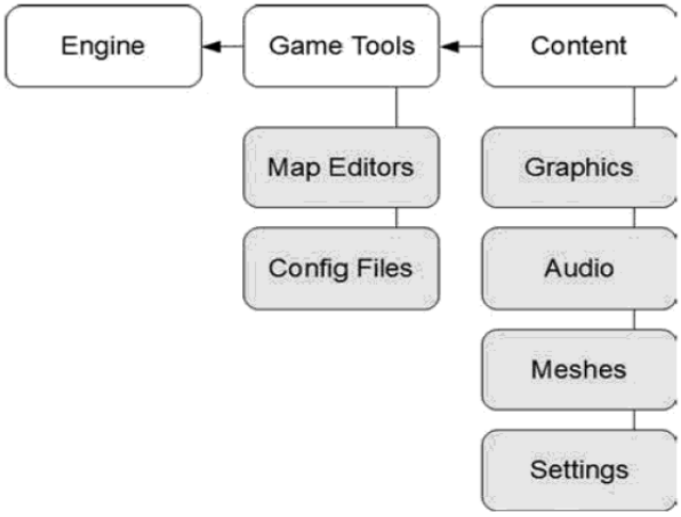
2.5.2.1. Game engines.

A game engine is known as the software framework that contains various settings and configurations used to develop and optimise games across multiple programming languages[13] (Thorn, 2011). The game engine is generally viewed as the core in which all game components can be found. However, the game components do not belong to the engine, but rather to different parts of the game, such as the content, and the development tools (Thorn, 2011). To simplify, Thorn (2011) visually illustrates the game engine and its relationship to other parts of game development. In figure 10 below, it can be seen that the game content includes the graphics, audio, meshes, and settings, which flow into the game tools and finally into the engine.

[13] A set of rules that convert graphical programme elements to machine code outputs.

Figure 7

The game engine and its relationship to other parts of game development:



Note. The game engine and its relationship to other parts of game development. From *Game Engine Design and Implementation* (p.7), by A. Thorn, 2011. Jones & Bartlett Publishers.

Typically, a game engine complies with the four principles as outlined by Thorn (2011), of modularity, simplicity, recyclability, and abstractness. These principles are often beneficial to the developer, since it proves to be more cost effective in multiple ways. For example, the game engines:

- are more versatile, as they can be used for multiple games in various genres;
- have increased bug identification and correction abilities, making them more reliable than before; and
- are easily commercially viable, as when a creator designs and licenses an engine, it can be used by multiple developers for the purpose of creating their games (Thorne, 2011).

Thorn (2011) further suggests a few game engines for designing educational games, including Torque 2D and 3D, Unity, Crystal Space, Blender, ClanLib, Novashell, Multimedia Fusion, and Leadwerks, all of which are discussed briefly in table 6 below.

Table 6

Game engines used for educational game development:

Game engine	Brief description
Torque 2D and 3D[14]	Torque 2D and Torque 3D are two separate, commercial game engines designed for the development of 2D and 3D games. Neither engine is genre specific and they are available on several platforms. Games developed using Torque: Wildlife Tycoon, ThinkTanks, and Marble Blast.
Crystal Space[15]	Crystal Source is an open-source game engine available across all platforms, and is designed for 3D game development. Games developed using Crystal Space: The Icelands, and RPG PlaneShift
Blender[16]	Blender is another open source, cross-platform game engine designed for 3D game development and is associated with the Blender 3D rendering software.
ClanLib[17]	This open-source game engine is available on all platforms and can be used for 2D game development.

[14] https://torque3d.org/torque2d/

[15] https://sourceforge.net/projects/crystal/

[16] https://www.blender.org/

[17] https://www.clanlib.org/

Novashell[18]	Developed by Robinson technologies, this opens source game engine is integrated with a level editor in which game art and defined game maps can be imported.
Multimedia Fusion[19]	This commercial, proprietary game is designed for 2D game design on Windows.
Leadwerks[20]	Leadwerks is another proprietary, commercial game engine, which is designed for 3D game development on Windows, using multiple programming languages such as C++, C# and BlitzMax.
Unity[21]	Unity is a game engine and authoring tool in which 2D and 3D game design can take place.

For this study, the game developer used the Unity game-engine. Unity is a two-dimensional (2D) and three-dimensional (3D) game engine[22] and authoring tool[23] which enables users to design and build their own games (Creighton, 2013). According to Creighton (2013), Unity consists of three distinct things that are combined to create the software. The first is the authoring tool, in which the game and the storyline are designed. The second element of Unity is the game engine, which is the driving force of the software, making it run depending on the platform it is exported to. These platforms could be a

[18] https://www.rtsoft.com/novashell/

[19] https://www.clickteam.com

[20] https://leadwerks.com

[21] https://unity.com/

[22] A software development environment with settings and configurations that optimise and simplify the development of video games across a variety of programming languages.

[23] Used to create games from scratch, integrate content and game mechanics easily, and can assist in a multitude of ways in the production chain of a game.

Windows, Linux or Mac computer, which is the third element in the Unity software (Creighton, 2013).

With Unity's large community and user base, it is quicker and easier to find answers to game-design-related questions, The development of the software also keeps developing, making Unity a popular choice when evaluating which game engine to use (Creighton, 2013). Creighton (2013) states that Unity is the first choice for game development software, because of its reputation in the industry and its market success. He also continues to discuss the success of the Unity software by commenting on the user interface (discussed in section 2.1.2.2), multi-platform capabilities and the customisability of the interface, thanks to the Unity Asset Store.

After the game developer decides on the most appropriate game engine, the next step is the consideration of the development process.

2.5.2.2. Developing games.

According to Ferro (2016), when developing games, the developer usually follows nine steps. The first is to generate ideas and come up with the story and decide how it should be told. The second step is defining the ideas, to add more body to the game, which can be accomplished by asking questions such as:

- How will the players learn to play the game?
- How many people can play the game?
- How will the game progress?
- What are the main elements of the game?
- How will you market and sell your game?

After the game ideas have been defined, they need to be brought together (step three) by looking at how they work or do not work together. Thus, the ideas need to be kept or taken out to create a piece of 'art' that will succeed (Ferro, 2016). In this stage of game

development, the designer will come up with storyboards,[24] character design sheets[25] and game user interfaces (GUI's).[26]

The fourth step, according to Ferro (2016), is the prototyping phase in which the game is developed and 'made real'. This can start with simple paper sketches or even 3D modelling, and include environment and level designs. Step five is all about iteration, which Ferro (2016) explains as being an iron on a creased shirt. In step five, the game is adjusted to make the gameplay flow better before going into play testing, which is step six of game design.

Play testing is possibly the most important part of game design (Ferro, 2016). Play testing can be done multiple times and there is no limit to how many times a game can be tested. Through conducting these tests the game designer can see where there are bugs or points in the game where the players lose interest, and they can then adjust the game to maximise the player engagement and motivation to play (Ferro, 2016). After play testing the game, the game designer will evaluate the game (step seven). When they are happy with the final game, they will build the game to get it ready for distribution (step eight) and finally publish it (Ferro, 2016).

2.5.2.3. Developing games: for who, what and why?.

According to Bartle (as cited in Ferro, 2016, p. 45) game players can be categorised into four player types. These player types attempt to synthesise the various traits and behaviours that players exhibit during gameplay, and are labelled achievers, socialisers, explorers, and

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[24] An overview of the game story and the gameplay evolution.

[25] Outlines characteristics of the characters and their roles in the game.

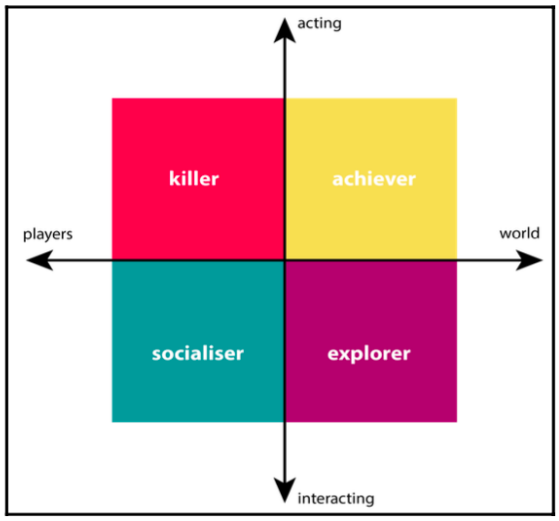
[26] Provides information to the player during gameplay (e.g., progress bars, points, lives, etc.).

killers (Bartle, 1999, as cited in Ferro, 2016). Ferro (2016) expands on these player types by explaining each (as listed below) and illustrating them in a diagram (as seen in figure 11 below).

- "*Achievers* act ON the world" (Ferro, 2019, p 45). These players play with their primary goal set on winning and feeling accomplished.
- "*Socialisers* interact WITH other players" (Ferro, 2019, p 45). Socialisers find their motivation and encouragement through interacting with the gaming environment and other players.
- *"Explorers* interact WITH the world" (Ferro, 2019, p 46), and enjoy games that involve discovering new environments and objects that help build their knowledge.
- *"Killers* act ON players" (Ferro, 2019, p 46) and want to dominate the game and other players by killing, attacking or making a player's life difficult within the game.

Figure 8

Bartle's four player types:



Note. Bartle's four player types. From *Gamification with Unity 5.x,* by L. S. Ferro, 2019., Packt.

Bartle (as cited in Ferro, 2019, p. 46) further expanded on his model by adding another dimension that established another eight player types, as seen in figure 12. These additional eight types are opportunists, planners, hackers, scientists, friends, networkers, grievers, and politicians, and the updated diagram in figure 12 shows that these players are either implicit or explicit in a specific domain from the original four player types (Ferro, 2019).

The typology of these player types has proven to be a good framework for designing games, since it is grounded in considering the players as a whole, thus broadening the designers' considerations and ideas for the game (Ferro, 2019).

Other than the player types, designers need to focus on their audience or target market by researching the users based on their demographics, ages, interests and needs, their loyalty to the game (based on whether it is for learning or entertainment), and the devices they use (Ferro, 2019). When evaluating their loyalty or dedication the designer should ask questions like are they a:

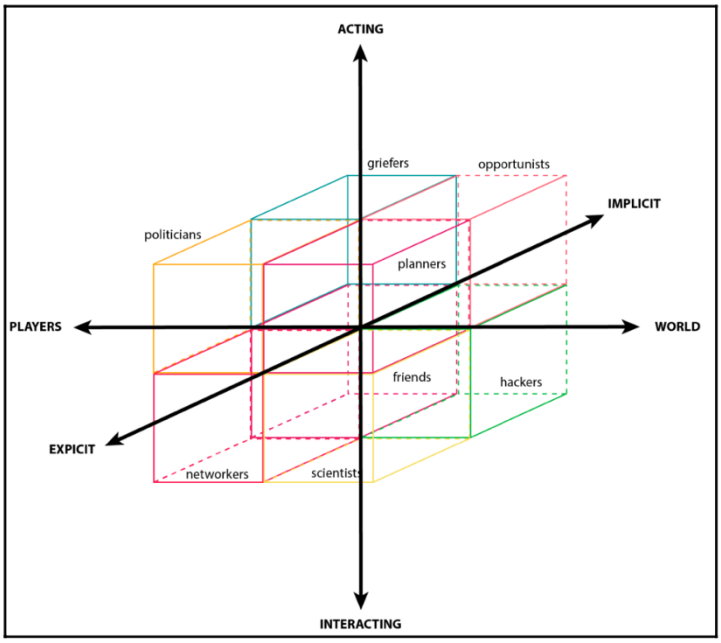
- Newbie who is trying games for the first time?;
- Casual gamer who plays games less frequently than other gamers?;
- Core gamer who engages in different games and plays games frequently?;
- Hardcore gamer who engages in all gaming elements for learning, studying, practicing, entertainment, and so on?; or
- Professional gamer who plays games for a living rather than just for winning points?

When a designer starts developing a game, it is important to consider the context for the experience, since it can influence the design and development of the game (Ferro, 2019). Designers need to ask what type of game they are developing and whether the game is for education, business, personal use, or just a game with minimum personal objectives (Ferro, 2019). These decisions are also focused on what one wants the users to achieve. Therefore, it is important to establish and aim for the game, the objectives that need to be performed by

the players, the outcomes one wants from the game, and the rules the users need to play by (Ferro, 2019).

Figure 9

Bartle's updated player types:



Note. Bartle's updated player types. From *Gamification with Unity 5.x,* by L. S. Ferro, 2019., Packt.

2.5.2.4. Player engagement and motivation.

The most important thing in a game's success is player engagement and motivation, because players should ideally keep going back to play a game (Ferro, 2019). Through extrinsic and intrinsic motivation, which is described below, the players will feel driven to take part and keep playing the game (Ferro, 2019).

Extrinsic motivation.

Extrinsic motivation is focused on external elements that motivate users to play and can be compared to giving a child a piece of candy when they are being good (Cherry, 2022). In the gaming environment, these extrinsic motivators can appear as rewards, points, and feedback when particular actions are performed (Ferro, 2019).

Intrinsic motivation.

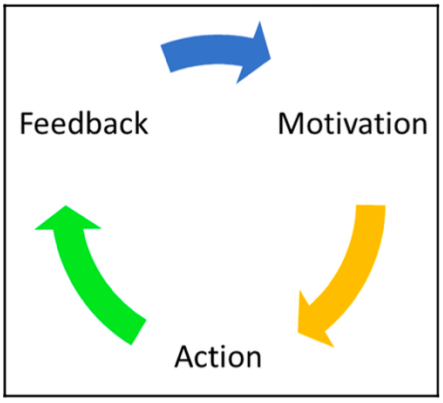
Intrinsic motivation is focused on how the player feels and experiences the gameplay It drives them to *want* to play the game more (Cherry 2022). This can include encouraging messages and long-term extrinsic rewards like ‘50 points for completing 10 tasks’ to make the player feel valued for playing the game (Ferro, 2019).

The frequency and intervals at which rewards are scheduled are crucial to ensure that players don’t get too few or too many rewards and thus have a negative experience. In this context, Ferro (2019) proposes that game designers consider an engagement loop model. The engagement loop model (as illustrated in figure 13 below) targets the micro-level of user experience (e.g., user actions) and indicates a loop that motivates them to perform actions (Ferro, 2019).

The model is broken down into the three levels of motivation (what brings the user to play the game), action (what the player does during the experience) and feedback (how the player is doing). It flows in such a way that once a user has completed one level of the model, it flows into the next. For example, an action provides feedback, and feedback leads to motivation through rewards (Ferro, 2019).

Figure 10

Engagement loop model:



Note. Engagement loop model. From *Gamification with Unity 5.x,* by L. S. Ferro, 2019., Packt.

2.5.2.5. Elements in game design.

Kapp (2012) questions what makes games exciting, motivational and irresistible, and suggests that the answer lies in the game elements or game mechanics. He emphasises how games are designed to be an operating model[27] of reality and should represent elements of reality, and in some cases imaginary, hypothetical, or fictional content. Through the creation of this abstracted reality, the player manages a conceptual space and understands the game and its complexity through exploration and engagement with the environment and obstacles (Kapp, 2012). By applying problems that need to be solved in a game, the player experiences the cause and effect more clearly, opening up their mind to

[27] An academic term referring to the verbal, graphic, mathematical or physical models, applied to various contexts in order to represent reality.

real-life problems, such as tax-paying, crime, employability, quality of life (Kapp, 2012). He claims that games also focus on relationships with other players, removing players from the extraneous factors of reality that could make the gameplay uninteresting, like doctor's visits, shopping. Kapp (2012) concludes by stating that games are also designed to reduce the time taken to grasp concepts and ideas, making it easy for players to "learn" and experience driving a race car, or operating on a patient, without the required real-life training, making the gameplay experience more enjoyable.

Even though the motivational aspects and enjoyability of gameplay are arguably the most significant factors in game design, Kapp (2012) acknowledges that it is important to address the various elements that are considered in game design (discussed in the following sub-sections).

Goals

One of the first elements of gameplay is the goal of the game. By introducing an objective to the player, the game designer gives the player a focus, a purpose and measurable outcomes to stimulate their motivation to play (Deliyannis, 2020). The player is then encouraged to explore their surroundings and complete various activities to achieve this goal and progress or succeed in the game. This statement is supported by Salen and Zimmerman (2004) when they write that "goals are fundamental to games… at the outcome of a game, the goals are either reached or not, and this quantifiable outcome is part of our definition of games" (p.80). The goals in a game are usually figuratively and literally clear, and the player will undoubtedly know whether or not they have reached the set goal (Kapp, 2012). This awareness is because the game is designed to restart from a specific point when the goal is not achieved, or to let the game progress forward when the goal is achieved. An example of this is when the goal is to defeat the dragon: The player will either

defeat the dragon and move forward or die trying to defeat the dragon and restart the fight (Kapp, 2012).

Kapp further (2012) explains how visual incentives are used to show a player's progress towards the goal and also to motivate a player to play longer and to be aware of how close or far they are from reaching the set goal. He continues by discussing the structure and techniques of setting goals, and how giving players freedom and autonomy in achieving these goals can help give them a choice in how they want to achieve these goals – which adds to the sustained meaning and motivation of gameplay. When designing instructional games, Kapp (2012) adds that one needs to set *terminal goals* and support those goals with a series of enabling objectives, which are the steps required from the player to move forward and achieve the goal. The reasoning for this is that "… a game's goal is the death of play" (Salen & Zimmerman, 2004, p.259), meaning that the ultimate gameplay goal is to finish the game. For this reason, Kapp (2012) emphasises the need to incorporate several smaller goals or objectives that build the prerequisite skills for reaching the ultimate end goal and encourage sustained gameplay.

Rules.

To achieve the set goals, a game needs a set of defined rules, such as the maximum number of players, how to get points or rewards, and what the player can and cannot do in the game (Kapp, 2012; Deliyannis, 2020). It is important to note that without rules games can't exist, since games are specifically designed to have boundaries that limit the actions of their players and for these players to manage the game and outcomes within these constraints (Kapp, 2012). The different rules, as defined by Salen and Zimmerman (2004), are the following:

- *Operational rules* describe the gameplay and provide the player with a basic understanding of how to play the game – for example, in order to open a door, the player would need to locate a key to unlock it.
- *Constitutive or foundational rules* describe the game functionality, such as the mathematical formulas that calculate the outcomes, which are usually only understood by and provided to the game designer.
- *Implicit or behavioural rules* are the rules that govern the social construct between two or more players. Thus, these rules dictate the game etiquette and how players should interact with others. These rules are usually not written, but not following them can have gameplay consequences like point penalties or losing players.
- *Instructional rules* are usually solely for instructional games and show the players (i.e., the learners) what they need to know and remember after gameplay is complete.

Conflict, competition, or cooperation.

All games contain either conflict, competition or cooperation between other players or bots[28] (Kapp, 2012). When faced with a conflict situation in gameplay, players will usually need to win a set challenge in which they will have to defeat an opponent to win, and avoid loss or damage while hindering the progress of the opponent's gameplay (Kapp, 2012). Competition or cooperation, on the other hand, entail being more efficient and being 'better' at the game than the opponent, or working together with other players to reach a mutually desirable outcome (Kapp, 2012).,

[28] Bots are computer-based players programmed by the game designer.

Time.

Kapp (2012) states that time is an essential element in gameplay and can have multiple dimensions to motivate play activity. He expands on his statement by discussing how time can accelerate gameplay, by providing players with a timeframe in which they need to complete an activity or objective, forcing them to focus, jump into action and move quickly to achieve the goals. By applying time limits to a game, the game designer mimics certain real-world work conditions in which a task needs to be completed to achieve optimal satisfaction levels (Kapp, 2012). These timeframes can also be designed as resources or rewards that the player can collect and use to extend the time needed to complete other objectives and levels (Kapp, 2012).

Rewards.

Every game relies on various reward structures, and implementing badges, points and rewards can increase the enjoyability and motivation of gameplay (Deliyannis, 2020). In instructional games, a motivational reward structure could involve the implementation of leaderboards that motivate learners to ‘outperform’ their peers and reach a new high score through winning points for each achieved goal (Kapp, 2012).

Feedback.

Feedback is a common feature in games, and players rely on the frequency and intensity of feedback to help them progress toward the goal (Kapp, 2012). Game feedback is constant and is provided in real-time, in the form of how much life and energy the player has, the location they are in, how much time or resources they have, their inventory, to name a few (Kapp, 2012). Kapp (2012) explains the importance of feedback and the provision of information to the player, as feedback and information evoke emotion and guide players to the correct behaviour, ideas, actions, and outcomes. Hunicke (2009) discusses the characteristics of game feedback as being:

- *Tactile* – the player can almost feel the feedback happening on screen, thus creating a natural, unforced experience;
- *Inviting* – the player needs to achieve in the game and to receive positive feedback in the form of rewards or power;
- *Repeatable* – the feedback can be received every time the goals or objectives are achieved;
- *Coherent* – the feedback should stay within the game's context;
- *Continuous* – the player needs to await feedback, but the feedback should come naturally as a result of interacting with the game;
- *Emergent* – the feedback should emerge contextually in the environment and not in a distracting manner;
- *Balanced* – the player should know the feedback they are receiving and not feel overwhelmed by it; and
- *Fresh* – the feedback can be surprising (to increase interest), but should be incorporated into the continuous feedback of the game.

Levels.

All games have different levels that the player needs to unlock through gameplay to reach the end of the game (Kapp, 2012). Kapp (2012) states that there are different levels that can be selected or applied as the player progresses in the game. The first of these is the game levels, which consists of level and mission-based structures that are designed to keep the game manageable and to give players a step-by-step progression through the completion of tasks. The second is the playing levels, which Kapp (2012) refers to as the levels of difficulty a player can choose from when starting the game, which is essential to make the game more enjoyable. Finally, the third is the player levels, which refers to the

players' experience. The player levels are usually reward-based, to help motivate players gain more experience with game play (Kapp, 2012).

Storytelling, hero's journey and curve of interest.

Storytelling is an essential part of games, especially if used for learning (Kapp, 2012). When a game has a story or narrative, it adds reality, relevance, and meaning to the player, making the gameplay more engaging and interesting to play (Kapp, 2012). When developing a game, the developer should apply the basic elements of storytelling, such as characters, a plot, tension, and a resolution, to create an effective story that unfolds and builds enough tension to keep players interested to play each level (Deliyannis, 2020).

Furthermore, Kapp (2012) explains how the story should depict the hero's journey. This journey usually depicts the hero or heroine, who lives an ordinary life and is called upon to take action in a mission that could save the person they love, their town or the world. The hero or heroine usually refuses the invitation until a wise figure appears who encourages them to take action, after which they agree and start their mission. The mission then appears to have multiple setbacks and difficult tasks with death-defying stunts and fights, but the hero or heroine keeps fighting until they succeed and return home (Kapp, 2012).

A curve of interest also adds interest to a game, and refers to the flow and sequence of events, which includes the timing of these events (Deliyannis, 2020). This curve of interest starts with a "hook" that grips the player and then progresses naturally to build up tension until released through gameplay.

Aesthetics.

Visual aesthetics play a vital role in games and ignoring this can reduce the overall experience of the gameplay and the learning process (Kapp, 2012). The aesthetics grip players and immerse them into the gaming world. Thus, small cues and details need to contain meaning to make the visual aesthetic as relevant and realistic to the storyline as

possible. Dickey (2015) further expands on this need in games by discussing Dewey's description of aesthetics, which states that aesthetics should be memorable, have a seamless flow of events, be bound to emotions and constructed in unity with emotional feedback, and that they should also build up to a climax of events that lead to a tension releasing conclusion.

Replays and do-overs.

The final and one of the most important elements of a game is the ability of a player to replay or redo a level or task (Kapp, 2012). This ability permits players to fail and provides them with a sense of freedom in knowing that they can place their characters' lives in danger if the need arises to win the game (Kapp, 2012).

When the above game development processes and elements are considered, the player will remain interested and motivated to play, meaning that the developed game would be viewed as successful and enjoyable (Kapp, 2012).

In conclusion, it can be feasible to say that there is a space for technological development within the music education field. Through the implementation of game-based applications, the music theory teaching and learning process can show an increase in student engagement and knowledge. The following chapter will outline the methodologies of this study and provide a guideline on how a developed game-based learning application has impacted the music theory learning environment at a tertiary education institution.

Chapter 3: Methodology

3.1. Research approach

The research approach can be described as "… plans and procedures for research that span the step from broad assumptions to detailed methods of data collection, analysis and interpretation" (Creswell, 2018, p.40). According to Leavy (2017), there are three major approaches to research: qualitative, quantitative, and mixed methods. After evaluating these three approaches to research, a qualitative research approach has been chosen for this study, however there are two quantitative questions embedded in the questionnaire.

Qualitative research aims to build knowledge and generate meaning through the exploration of a social environment (Leavy, 2017). This approach values the importance of the participants' experiences and creating meaning and focuses on exploring, describing, and explaining information (Leavy, 2017). The qualitative research approach is grounded in philosophical assumptions that are studied through theoretical frameworks, such as grounded theory research and phenomenological studies (Creswell & Poth, 2018).

When researching situations that pertain to lived experiences, the qualitative research approach is recommended, because the participants' feelings and opinions form the basis for collecting knowledge (Creswell & Poth, 2018).

By conducting this study's research using the qualitative approach, the development of a game-based app will be outlined. This research project investigated tertiary student responses to using a game-based learning app and these are dealt with in terms of qualitative data collection and analysis (Creswell, 2014).

3.2. Research design

Creswell (2014) explains a research design as a type of inquiry within the research approach that provides a direction for research procedures. This study is based on an educational, or design-based research strategy, which Luo (2011) defines as "a systematic

but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually sensitive design principles and theories" (p. 10).

Educational design-based research aims to understand contexts and to design effective systems that can create meaningful changes for the participants (Armstrong, et al., 2018). This research design is centred around developing knowledge in education and is grounded in the pragmatic philosophical paradigm, which considers practical consequences as vital components in meaning and truth (McKenney & Reeves, 2012).

Anderson and Shattuck (2012) explain that a design-based research study primarily uses mixed methods research tools. However, in this study predominantly qualitative data was collected, which focused on the participants' feedback and opinions of the developed game.

This design-based research strategy is adaptive, flexible, interactive, collaborative, theoretically orientated, and process-focused. It strives to have a positive impact on practice through the intervention of educational products, processes, policies, or technological programmes (McKenney & Reeves, 2012; Kang & Ritzhaupt, 2021).

Through close collaboration with a game developer (see the memorandum of agreement in Appendix E), the development of a game has been undertaken and responsively grounded. The game has been shaped to narrow the gap of game-based learning applications in the music education field (McKenney & Reeves, 2012) and was tested by me, the developer, and various music and gaming lecturers at the tertiary creative media institution, SAE Institute.

3.3. Sampling strategy

This qualitative study follows a judgmental or purposive sampling strategy. When using this sampling strategy, it is not uncommon to have no preconceived sample size, as

this strategy is focused on gathering the best information for the study based on the judgement of the researcher and who they think would be the best participants (Kumar, 2014).

Blackstone (2012) furthermore states that purposive sampling can be used to focus on participants who possess very narrow and specific criteria that are beneficial in answering research questions. For this study, a set of criteria was established, and according to which fifty students at the SAE Institute were chosen as the target group for the data collection. These criteria were outlined as:

- students over the age of 18;
- students who are studying a Bachelor's degree in sound production at the tertiary creative media institution, SAE Institute in Johannesburg;
- students who have applied music theory[29] as a core module.

Furthermore, an interview was held with the game developer in order to determine the steps taken in the development process of the game-based learning app. The game developer for this study was chosen through convenience sampling, as the developer was conveniently accessible because he was a Higher Certificate game design student at the SAE Institute where the study took place.

Once all consent was acquired from the developer and participants, a total of forty out of the targeted fifty Bachelor's degree students were sampled. Thus, 80% of the targeted

[29] At the SAE Institute, applied music theory covers foundational music theory concepts and the practical application thereof. Thus, students learn about basic time signatures, note recognition, and compositional skills, and apply these in theoretical and practical assessments to show their understanding of the basic concepts needed for sound engineering.

population was sampled for the focus group and questionnaires for the data collection of this study.

3.4. Data collection techniques

Once all ethical considerations had been met, the game development and testing phase began. And once the game was finalised, an interview was held with the game developer to outline the development process. Thereafter, the game-based app was implemented into the first ten minutes of two, weekly applied music theory classes at the SAE Institute. When the two weeks of gameplay was complete, the participants were asked to complete an open-ended questionnaire in which they commented on their experiences with both technology-based learning (such, as learning with laptops, software, and Digital Audio Workstations (DAW's) and game-based learning. All datasets and files can be accessed through a Google Drive link in Appendix N.

3.4.1. Data collection tools and processes

After the game-based app was tested and finalised, it was loaded onto the computers to give the participants access for the data collection phase of this study. As I was fulfilling the role of the researcher and the lecturer of this module, the extraneous variables, such as the environment and the frequency and timing of gameplay, were controlled to provide accurate data.

To incorporate these gameplay sessions, careful lesson planning was considered to ensure all learning outcomes were met without disrupting the weekly classes. The gameplay was thus scheduled to become part of the lesson plans for the fourth and fifth weeks of class.

Week four of the applied music theory class was scheduled to be two hours long and was focused on basic note recognition.[30] The learning objectives for this class was for students to read and write basic musical signs and notation, and to read a basic musical score, which would be achieved through direct instruction from the lecturer, using PowerPoint slides and various time-based learning activities. The gameplay element of the study was implemented into the final ten minutes of the class, in order to reinforce their learning and to assess their understanding of the content.

Week five of the class schedule was focused on revision of week four, as well as basic scale and key recognition. The learning objectives for this week were similar to week four, with the addition of perceiving a sense of tonality and a key centre. The two-hour class started with revision of note recognition and then continued on to ten minutes of gameplay, after which the questionnaire was completed. The lesson schedule for these two classes can be seen in the table below.

Table 7

Lesson schedule for week four and five of applied music theory classes

Time	**Content**
	Week four
5 minutes	Introduction to basic note recognition
30 minutes	Note names - The Western tonal system

[30] Students were taught the foundations of recognising pitches on the staff (treble and bass clefs) and the keyboard.

	- Identifying notes on a treble and bass clef using rhymes (FACE, All Cows Eat Grass, Every Good Boy Deserves Fudge, and Good Boys Deserve Fudge Always).
10 minutes	Learning activity 1 – Identifying pitches on the treble and bass clefs.
15 minutes	Sharps and flats.
30 minutes	Playing notes on the keyboard. Transcribing notes onto a DAW (e.g. Ableton) piano roll.
10 minutes	Learning activity 2 – Placing provided score of 5 notes on a piano roll.
15 minutes	Gameplay brief (5 minutes). Gameplay of developed game-based learning app.
Week five	
15 minutes	Note recognition revision.
10 minutes	Note recognition revision activity – gameplay of developed game-based learning app.
30 minutes	Completion of research study questionnaire.
Further content delivery on scales and key signatures.	

Before the gameplay started, the participants were briefed on how to play the game and was provided with more information about the research study through handing out the information letters and consent forms.

After the gameplay period the participants were asked to complete the printed questionnaire that was designed for the data collection process, as seen in the above lesson schedules.

3.4.1.1. The Interview with the Developer.

As part of the data collection process, it was decided to conduct a verbal interview with the game developer in order to understand and evaluate the approach adopted in the game-development process (Cohen et al., 2018).

By implementing the interview guide approach, as outlined by Cohen et al. (2018), the topics and questions, as well as the discussion sequence, were outlined in order to create a

more conversational environment. This interview was focused on the development process of the game, and was held in person and recorded using the voice memo function on a MacBook Air. After the interview, the recorded voice memo was transcribed verbatim and sent to the interviewee for perusal. The interviewee was also given a transcript confirmation form that was signed to affirm that all the views and comments were accurately documented in the transcription (see Appendix F).

3.4.1.2. The Focus Group.

Focus groups are based on group interviews in which topics are discussed by the researcher and the group to gather information based on the interaction with the group (Cohen et al., 2018). According to Blaxter, Hughes and Tight (2010), conducting focus group interviews could challenge a researcher's views and provide them with various opinions on their research topic in an open and honest environment in which they are not judged. This approach is beneficial to qualitative research studies, as some participants could encourage others to discuss their thoughts and feelings on the provided topics, which can then lead to unanticipated findings as the discussion unfolds (Blaxter et al., 2010).

For this study, the focus group discussion was guided by the researcher in order to steer and keep the focus for the discussion (Cohen et al., 2018). This focus group discussion was focused on the participants' views of using game-based apps for entertainment purposes, and as part of their learning experiences. The focus group was recorded using the voice memo app on a MacBook, and the recordings were transcribed for analysis.

3.4.1.3. The Questionnaire.

Questionnaires are similar to interviews, as during both methods of data collection, a list of questions are answered based on the interpretations of the participants. However, questionnaires are less time consuming, because participants can simply write down their responses (Kumar, 2014). During the data collection, the printed questionnaires were

handed out to the participants in a controlled environment, with the researcher present to clarify any possible questions that the participants might have. These questionnaires consisted of open-ended questions, which gave the participants the opportunity to elucidate on their unique learning experiences (Merriam & Tisdell, 2016).

The questionnaire layout structured in four sections to make it more understandable and to increase the readability. By asking open-ended questions it was possible to collect in-depth perspectives from the participants, and the participants could answer freely without feeling limited to a selection of answers. The questionnaire was divided into four sections in which the questions focused on the participants' experiences with technology when studying music theory. These sections were labelled as follows:

- *Section One: Personal information,* which was treated with complete confidentiality by the researcher. The participants were also given the option of not disclosing their personal information if they chose to be anonymous. The personal information provided was gathered only to assist the researcher in locating the source of the information if the need for further questioning arose.
- *Section Two: Use of technology when learning music theory,* which contained five open-ended questions relating to the types of technologies used in the participants' learning, their frequency of using technology in learning, and their experiences and opinions about using technology in their learning and homework activities.
- *Section three: Experience of playing the game,* which consisted of four open-ended questions. These questions investigated the participants' views on their perceived understanding of music theory, how they thought the developed game could change their music theory learning (for better or worse), how the game could be adapted, and which of the game elements they viewed as meaningful to music theory learning.
- *Section four: level of difficulty of the game,* which consisted of two open-ended questions and two closed-ended questions. This section asked about the participants

experience on the game's level of difficulty, the elements they would recommend for adaptation to increase or decrease the level of difficulty, and finally whether or not they would play the game again or recommend it to their peers. The full questionnaire can be accessed in Appendix H.

After the week four and five classes and gameplay were complete, the printed questionnaire was distributed among the participants. The participants were then given thirty minutes to complete the questionnaire, with the researcher present to answer any questions. Once all the questionnaires were complete, they were collected by the researcher and each one was given a number from one to forty for data analysis purposes.

3.5. Data analysis and interpretation

In qualitative data analysis the intent is to make sense of data provided during the data collection process, through dividing the data into various segments for categorisation and reassembly (Creswell, 2018).

To prepare for data analysis, the recorded interview with the game developer and the focus group recording were both transcribed verbatim, using Microsoft Word. Each transcribed response was given a letter from A-Y, regardless of who the response came from, and the interviewer questions were labelled as "IN". Furthermore, each questionnaire was assigned a number from 1 to 40 to maintain confidentiality, and the inductive coding process began. The analysis process is discussed in the sub-sections that follow.

3.5.1. Interview with the game developer data analysis

After the game developer's interview had been transcribed, the printed transcript was reviewed through highlighting the keywords that related to the game development process. Once the main keywords of the interview responses were highlighted, the transcript was reviewed a second time to evaluate the accuracy and appropriateness of each keyword. Each keyword was then written into the margins of the transcript and assigned a number that

indicated the order in which the development of the game occurred, as revealed in the interview. Table 8 below indicates the keywords assigned to each step of the development order, as well as the final wording used as part of the development order.

Table 8

Interview and development process keywords

Keywords	Development order
Information needed - Game audio (MuseScore) - Theoretical information	Step 1: Resources
Confusing Dance tile blocks Club setting	Step 2: Brainstorming
Sketches - Club - Lighting	Step 3: Sketches and modelling
Time left Intervals Finish	Step 4: Timeline
3D modelling – Blender Coding – C# - Visual Studio Game engine – Unity Assets Elements - Intuitive - Simple - Easy to understand - Story - Mechanics - Enjoyment - Rewards - Points Challenges	Step 5: Development

Prototype - Unity - Mac and Windows export Feedback - Mechanics - Tiles to keys - Note names	Step 6: Play testing, feedback, adjustments, and finalisation

3.5.2. Focus group data analysis

Once the focus group transcript was complete, the file was imported into the qualitative data analysis software Atlas.ti. Once imported, the transcript was re-read and the coding process started by using Atlas.ti's sentiment analysis function, in which each sentence was rated as either a *positive, neutral,* or *negative* code. After the completion of the sentiment codes, the transcription was reviewed and descriptive codes were further applied to each sentence. These descriptive codes summarise the content of the text in short descriptions that encapsulate the content of the raw data. Table 9 illustrated the descriptive codes assigned to each of the sentiment codes.

The focus group responses were further analysed in vivo,[31] to ensure that the meaning and intention of the participation responses were communicated accurately in the analysis. This coding process was focused specifically on the responses relating to the elements that make games more enjoyable, and the concepts in music theory that the participants were struggling with, as the overlap between these two responses constitutes the foundation of the developed game-based app.

[31] A form of qualitative data analysis that emphasises the spoken words of participants by choosing codes based on their responses.

3.5.3. Questionnaire's data analysis

By following a few coding steps, as illustrated by Creswell (2018), a thematic analysis was implemented for the questionnaire analysis of this study. Thematic analysis is a method for analysing raw data to find and interpret common patterns or 'themes' in participant responses. This method is seen as one of the best approaches for studies pertaining to teaching and learning, as it is not tethered to particular epistemological or theoretical perspectives (Clarke & Braun, 2017).

Furthermore, this study follows Braun and Clarke's (2006) six phase guide to qualitative, thematic analysis as illustrated in a step-by-step manner below.

3.5.3.1. Phase 1: Becoming familiar with the data.

The first step in the data analysis involved assigning each questionnaire a number from 1 to 40, to keep a record of the responses. The first steps included reading and re-reading all responses from the participants, to become familiar with the entire body of data before going further with the analysis. During the reading phase of the analysis the keywords that stood out in the participants' responses were highlighted.

3.5.3.2. Phase 2: Generate initial codes.

The goal of the second step was to organise the raw data in a systematic and meaningful way. For this study, the questionnaire responses were analysed through the use of open coding. As the raw data was being read through, codes were thus developed based on emerging themes, and not before the data collection process. This option provided more flexibility during the coding process and allowed for the identification of common patterns that appear in the responses, which might not have been expected before the data collection process.

The coding element of the analysis began through reading the most in-depth questionnaire, highlighting prominent keywords and writing the themes in the margins. After reading through this questionnaire, the process was repeated until all the questionnaires had been read and assigned their initial codes.

After completing the coding by hand, all the edited responses were transcribed into a spreadsheet and imported into the qualitative data analysis software Atlas.ti for the third phase of the analysis.

3.5.3.3. Phase 3: Search for themes.

After completing the initial coding and importing of the transcribed data into the qualitative analysis software, the data was investigated for emergent themes. The primary codes that were assigned to each response were categorised into different groups, which became the themes for the analysis. Phase 4: Reviewing themes.

During this phase, the identified themes were reviewed and modified to make sure they make sense. To do this, all the codes that applied to the themes were analysed and grouped into a folder labelled with the theme names in Atlas.ti. The data associated with each theme was then evaluated further to check whether the data supported these themes and whether they fit the context of the data set. The themes were evaluated by asking questions as illustrated by Maguire & Delahunt (2017):

- Do the themes make sense?
- Are there subthemes that need additional attention?
- Does the data support the themes?
- Are all themes separate and not overlapping?
- Are there any other themes that appear?

Furthermore, questions such as “do the themes relate to the study’s research questions?” and “do the themes address all the aspects associated with the research study?”, were asked to evaluate the quality of the themes in relation to the research study.

After evaluating the themes, it was determined that the specificity of content codes was at risk of becoming vague. Therefore, the main theme labelled “Developed game-based learning app” was renamed “Feedback on the developed game-based learning app”.

Furthermore, as there is insufficient information on the participants’ music theory understanding for it to be considered a main theme in the research, a decision was made to remove the theme labelled “Music theory understanding”. The codes originally assigned under this theme, however, were still used for further analysis of the data as these provide possible links to other descriptive codes.

3.5.3.4. Phase 5: Define themes.

During phase five the themes were refined and defined to find the ‘essence’ of what each theme is about (Braun & Clarke, 2006). Each theme was then broken down into the separate paragraphs below, which discuss the significance or ‘essence’ of each theme.

Theme 1: Technologies and games used in music theory learning.

Theme one is focused on the various technologies that the participants use when they study music theory, and it addresses how frequently the participants use these technologies. It further investigates the participants’ views on using technology and game-based apps for everyday learning and homework activities. This theme can thus be sub-divided into the following categories:

- Technology used when studying;
- Feelings about using technology in music theory learning;
- Feelings about using technology in homework activities; and
- Feelings about using games in music theory learning.

Theme 2: Feedback on the developed game-based learning app.

The coding process revealed various themes that relate to the participants' views on the developed game-based app, which include:

- Feelings about the implementation and playing of the game;
- Elements of the game that can improve music theory learning; and
- Suggestions on how the game can be improved.

Based on these emerging sub-themes, a decision was made to focus the second main themes on the participants' feedback on various elements of the game.

3.5.3.5. Phase 6: Writing the report.

Once the thematic analysis had been completed, a report was written in which the findings were contextualised. This report, which can be found in chapter four, includes quotes from the embedded passages, diagrams, tables, and answers to the research questions based on how the analysed data is interpreted.

3.5.4. Conclusion

For the final stages of the analysis process, the codes for the interview, focus group and questionnaires were reviewed and linked to all the relevant codes gathered from other documents. These links were created using Atlas.ti's 'Network' function, in which codes can be dragged and merged with other codes, and assigned to different documents to create code relationships across all your analyses. These relationships are discussed in depth in the findings section in chapter four.

3.6. Ethical considerations

Ethics can be defined as being "in accordance with principles of conduct that are considered correct, especially those of a given profession or group" (Kumar, 2011, p. 241).

For this study, a full research proposal was submitted by the researcher to the Department of Music Proposals Committee and the University of Pretoria's Faculty of Humanities Ethics Committee. Once reviewed by these two committees, the research study was approved from an ethical point of view and data collection could be initiated with the necessary permissions and consent.

Before data collection could begin in earnest, permission had to be obtained from the Managing Executive of the tertiary creative media institution and the participants. All parties were provided with an information letter that discussed all information pertaining to the research study, including the topic, purpose of the study, expectations of the participant, and all possible risks and benefits of participation. The letter also indicated that participation was voluntary, and that all participants were free to cease participation at any given time, and without consequences, should they feel the need.

The Managing Executive and participants received consent forms, which acted as an acknowledgement that they had read the information provided, and that they agreed to take part in the study. After all of the consent forms had been signed, the data collection and analysis processes began. For the interview section of the data collection, the interviewee also received a consent form and a full transcript of the interview, along with a transcript confirmation form to confirm that the transcribed material was an accurate reflection of what had been said in the interview.

The questionnaire responses were collected and numbered, after which all the names of the participants were blocked out to ensure that confidentiality was maintained.

The collected data, analyses, and other necessary information were uploaded onto a secure, password-protected platform and the full study has been submitted onto the UPSpace system. A scanned copy of the signed UPSpace permission form was sent to upspace@up.ac.za. The final research datasets have been uploaded onto the University Research Data Repository (Figshare). All private information will be stored in an electronic

format in the University of Pretoria's School of the Arts for a period of 15 years, after which it will be destroyed, and only the final dissertation will be made available to the public on the UP Library platform for further research.

3.7. Research quality

To ensure a good quality research study, it is important to attend to multiple concepts of quality criteria, as laid out by experts in qualitative researchers (Flick, 2007; Silverman, 2006; Treharne and Riggs, 2015). These concepts include credibility, transferability, confirmability, and reflexivity, all of which are discussed below.

3.7.1. Credibility

Credibility is the measure of truth and accuracy in the findings of a study (Korstjens & Moser, 2018). Through implementing methods and a research design that is suitable for this study, credibility is already achieved. Korstjens & Moser (2018) further suggest that various strategies should be used to ensure credibility. This study addressed three of these strategies, namely prolonged engagement, method triangulation and member checks. Through prolonged engagement, I invested sufficient time with the participants to build trust and have them become familiar with the content of the research study (Korstjens & Moser, 2018). The study also made use of multiple data collection methods, such as interviews, focus groups, and questionnaires, thereby establishing method triangulation in the study. Finally, the study can be deemed credible, as the data was fed back to the interview participant in the form of transcript reviews to ensure that the information was articulated correctly.

3.7.2. Transferability

The concept of transferability refers to the reader's ability to connect their experiences to the research, or the degree to which the results of the study can be transferred into various

contexts (Korstjens & Moser, 2018). By providing thick descriptions in which the contexts of the participants' behaviour and experiences are discussed, as has been done in this study, the findings become more meaningful to the reader, enhancing the study's transferability into other contexts (Korstjens & Moser, 2018).

3.7.3. Dependability and confirmability

The dependability and confirmability of research relies on its stability and the degree to which the findings of a study can be confirmed by further research studies (Korstjens & Moser, 2018). Through transparently describing the research steps taken from the start (chapter three) to the findings (chapter 4), and keeping records of all the data acquired throughout the study, the dependability and confirmability is enhanced (Korstjens & Moser, 2018).

3.7.4. Reflexivity

The reflexivity of the research refers to the process of a researcher's self-reflection when considering the research findings (Korstjens & Moser, 2018). Before the game development process started, I had very high expectations for the outcome of this game, however as the development progressed and the playtesting started, I experienced much self-reflection. Originally, I had expected a commercially viable game-based learning app to be delivered, and I hypothesised that the developed game would be enjoyable and exciting to play. Once the playtesting phase was complete, I reflected back to the questions asked in the data collection and had to change some questions, as my own personal bias had become evident in the original questions.

One example of an adapted question is the adaptation of question seven in the questionnaire, which originally asked "How do you think this game can benefit music theory learning?". After reflecting on the questions, it became clear that I assumed the game would

benefit music theory learning, thus showing my personal bias to what outcome I wanted for the study. The question was accordingly adapted to “How do you think this game can change music theory learning?”. This self-reflection and re-evaluation of the data collection questions show evidence of reflexivity in this research study.

Once the data collection and analysis were completed, the study was presented transparently to further ensure quality research. This has been done by providing the reader with adequate information regarding the decisions and the processes of the game development and study procedures, to ensure that each step is fully understood (Flick, 2007).

Chapter 4: Game-based learning app development and interview findings

In this section the development process of the game-based learning app is discussed by following the development order presented in the interview analysis section, with links to the literature on game development.

4.1. Game development process and interview findings

During the interview with the developer, we discussed the development process of the game-based learning app and established five steps as part of the development process. This discussion will be illustrated using five steps. Each step outlines the development with referrals to the game development files and screenshots, and includes supporting and contrasting links to the literature and the relevant research findings.

4.1.1. Step 1: Resources

The literature by Ferro (2016) states that there are nine steps in game design, of which the first and second step is the generation and definition of ideas. In the interview conducted, we established that the first step of this game development process was the compilation of resources, which in essence covers the first two steps as mentioned by Ferro (2016). During the interview we also discussed possible ideas for the game, where the decision was made to focus on beginner note recognition, and the developer requested some notes on the music theory content for the game. The reason for this decision was because it would appeal to music theory beginners from any age groups, as this topic was part of foundational music theory. Even though there was no prior research conducted on the needs of the participants, the focus group findings revealed that approximately 41% of the participants did in fact struggle with note recognition and felt like they needed new methods of learning this concept.

After compiling extensive notes and providing the developer with videos, book sources and website links (all of which are accessible in the link in Appendix J), the developer started with the next phase of the development process and the compilation of the required audio files began.

The open-source score writing software, MuseScore,[32] was used to create the required audio samples. This software made the score writing and transcription simple and easy, as it provides live playback abilities as the pitches are inserted. To create the samples, a new project with a simple treble clef score was opened on the software. On this score, each pitch was inserted individually as whole notes, thus each pitch playback was the length of four seconds when measured at a tempo of 60 beats per minute (bpm). Once each pitch was inserted, the sound sample was exported as .wav and .mp3 files and uploaded to a Google drive folder for the developer to access, after which the process was repeated for every required, individual pitch. After sharing these notes with the developer, the brainstorming phase of the development process could begin.

4.1.2. Step 2: Brainstorming

Ferro's (2016) next step in game design includes the "bringing together" of ideas in which the developer works on the character, storyboards, and user interface. For this discussion, the second, third and fourth steps of the development process are discussed as a whole to illustrate its link to Ferro's (2016) third step.

During the interview the developer explained the process that he followed to come up with the idea for the game. This interview revealed that, after the developer looked at other

[32] https://musescore.com/

music theory learning apps such as EarMaster[33], PerfectEar[34], and Tenuto[35] (all of which are briefly discussed in chapter two), he decided to create a club scene in which the player would step on various dance tile blocks to make music. After the initial research and brainstorming, the developer worked on some sketches (see figure 14 below) of the game environment and lighting to prepare for the modelling and timeline development stages. This phase can further be linked back to Kapp's (2012) discussion of the importance of aesthetics in game design, and how overlooking this can reduce the overall gameplay experience. Kapp (2012) continues by stating that a game's aesthetics make its players immerse themselves in the gaming world and that the environment and character should be as realistic as possible. Furthermore, according to Dewey (2015), a game's aesthetics should be memorable and have a seamless flow of events, to ensure there is an emotional response from the player.

The participation findings have provided evidence of the importance of game aesthetics, as discussed by Kapp (2012) and Dewey (2015), as after playing the final game, the participants stated that the game "lacks realism" and is "boring and uninteresting". Even though the goal of the developed game was not for it to be a commercially viable product, the participants had a few recommendations on how to improve the game for possible further development – for example, the addition of more characters and visual cues like lighting, to create a more realistic game environment.

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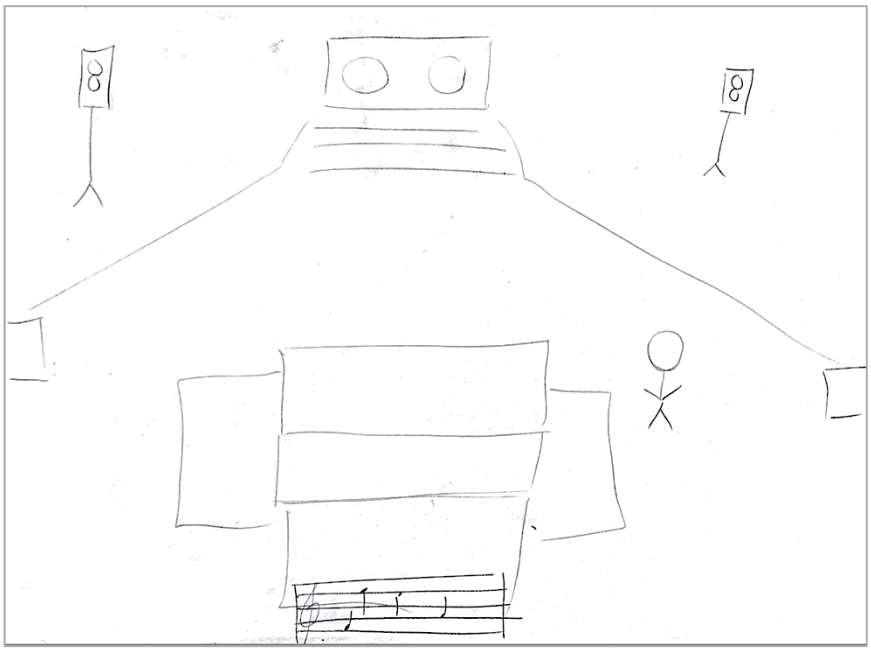
[33] https://www.earmaster.com/

[34] https://www.perfectear.app/

[35] https://www.musictheory.net/products/tenuto

Figure 11

Rough sketch of game environment



4.1.3. Step 3: Sketches and modelling

In the interview, when the developer was asked to discuss the whole game design process, the response was “Well, at first, I just did a few sketches of what I thought the club would look like what it would have maybe some lighting as well on a piece of paper”. After finishing the rough sketch (as seen in figure 14) the developer started with the digital 3D modelling using the open-source software Blender[36]. The developer stated that:

> The modelling was the thing that took me, I wouldn't say the most time but it was the most… (pause) I had to really think it through because there were a lot of iterations of

[36] Free software that aids in 2D and 3D rendering, modelling, sculpting, animation, rigging, VFX and more – https://www.blender.org/

what I wanted it to look like and where certain things had to be. And the tiles at first, they were like simple square blocks, ...

Figures 15 and 16 below illustrate screenshots of the design process in Blender.

After finalising the basic design in Unity, the developer continued building the virtual environment by adding camera views and lighting (as seen in figure 17). Appendix M explains how to download the above-mentioned software and how to open the game development files.

Figure 12

Character development in Blender

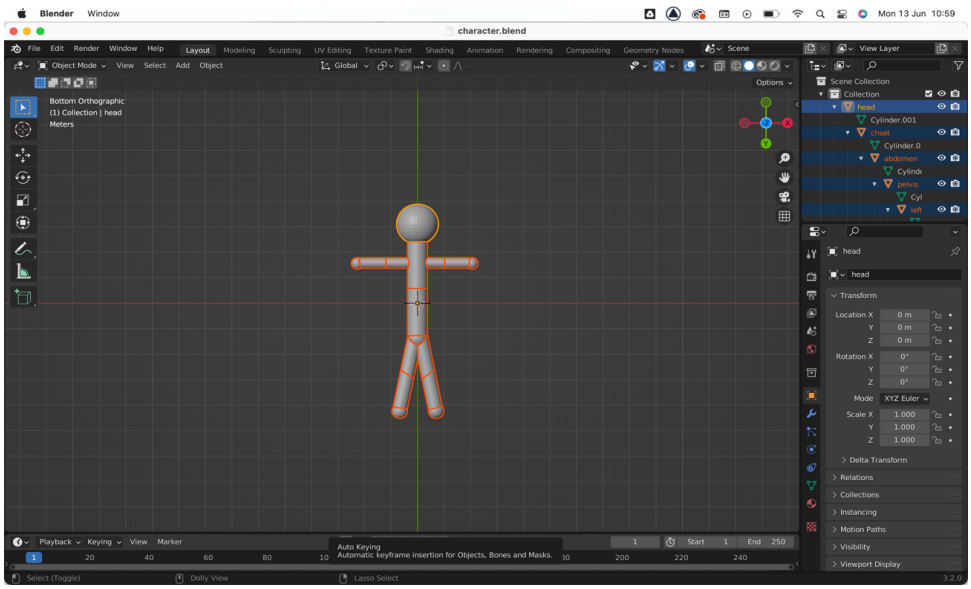


Figure 13

Environment development in Blender

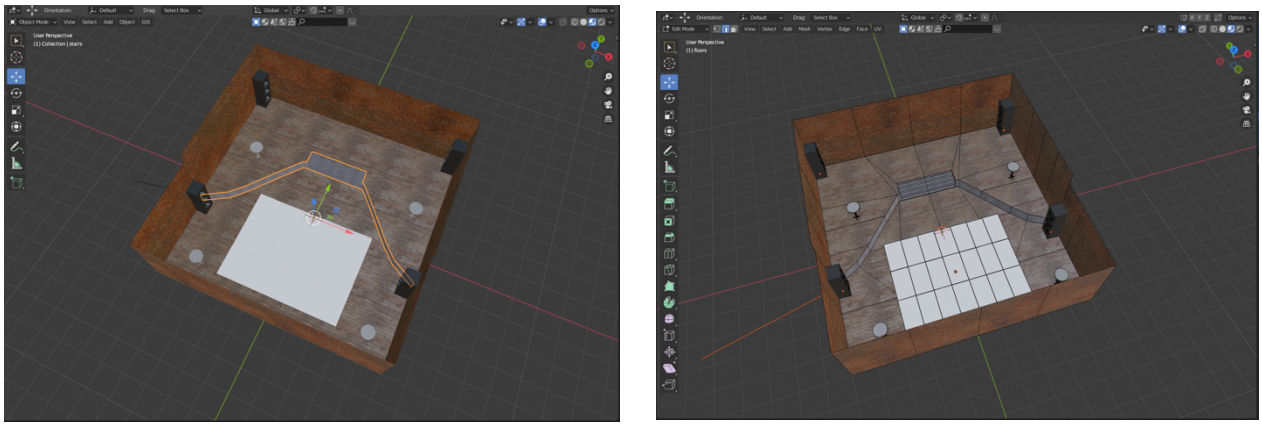
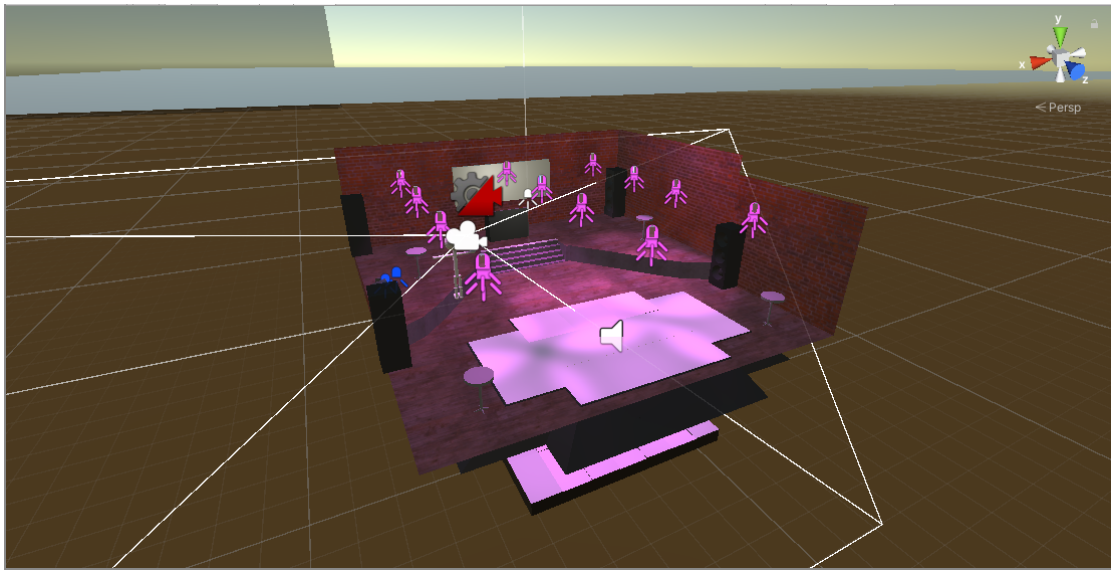


Figure 14

Lighting and camera design in Unity



4.1.4. Step 4: Timeline development

Step four in the development process focused on the timeline development, to establish when the game would be complete for the research to continue. Throughout the first three

phases of the development process, the timeline was established by setting dates for when each component of the game should be complete. These dates can be seen in table 11 below. The research findings revealed that the proposed and actual timeline dates did not always correspond. The reason for this was that the developer is a student at the creative media institution and had to extend these deadlines because of other school responsibilities. Sometimes the play testing also revealed some errors that needed fixing, delaying the proposed deadlines slightly.

Table 9

Proposed and actual deadlines for game development

Task Due	Proposed deadlines	Actual deadlines
Resources shared	08 November 2022	
First communication on planning	05 January 2022	
Proposed completed game deadline	18 February 2022	19 May 2022
First sketches and modelling complete	12 January 2022	12 January 2022
Developer's request for audio clips	24 January 2022	
Play testing and feedback	15 February 2022	15 February 2022 18 March 2022 04 April 2022 21 April 2022 09 May 2022
Fixes and final upload	18 February 2022	19 May 2022

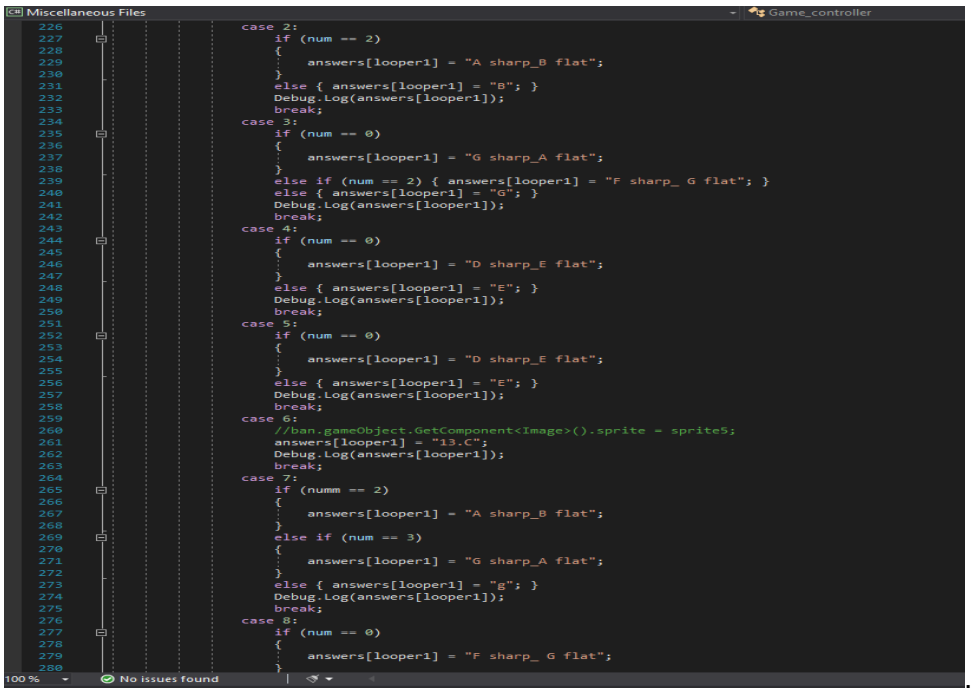
4.1.5. Step 5: Development

Ferro's (2016) fourth step is all about prototyping and development, just as step five is in this study. During this phase the developer started designing the first iteration of the game in

the game-engine, Unity. The game was developed in Unity and coded in Visual Studio, using the C# coding language. All these development files and how to open them can be found in Appendix M. Figure 18 shows a screenshot of the coding done during this phase of the development process. Once the first iteration of the game was complete, the development phase moved on to step six, in which play testing and adaptations occurred.

Figure 15

Excerpt of the game coding in Visual Studio



During the interview, the developer was asked about what the five key elements to a good game are, based on his experience and studies. He replied that a good game has to achieve the following ideals:

- be intuitive – thus the game should be simple enough and the player should not need to be told what to do or how to do it;
- be easy to understand and not contain any elements that could be too complicated for the player;

- have a story to keep the player interested in the game and to keep them motivated to play;
- have well-developed mechanics – thus the objects that the player can interact with should work as they were intended to; and
- be enjoyable to play, and educational games should consider reward elements as part of the motivational elements of play.

These responses from the game developer resonate with Mayer's (2014) statement on the important characteristics that make a game, which are discussed in section 2.4.

To build the game, the developer made use of a few platforms; for example, for the rough sketches the developer made use of a simple pen and paper, after which these sketches were translated into 3D models using Blender.

Once the developer was satisfied with the modelling of the character and scene, the 3D models were imported into the game-engine, Unity,[37] and the computer programming (or coding) process began. The developer made use of the C# programming language in Visual Studio, as it works hand-in-hand with the game-engine, after which the first prototype of the game was completed for play testing.

4.1.6. Step 6: Play testing, feedback, adjustments, and finalisation

Step six of the game development process involved five phases of play testing, feedback and adjustments before the final game was complete for the research. The developer did a first play test in Unity before exporting the final game to a Windows and Mac build to then be tested by the researcher and gaming colleagues at the tertiary creative media institution.

[37] Refer to the literature review.

The first iteration of the game was uploaded to Google Drive for play testing on 15 February 2022. After we received information on how the game is played, myself and two gaming lecturers of the tertiary creative media institution then tested the game.

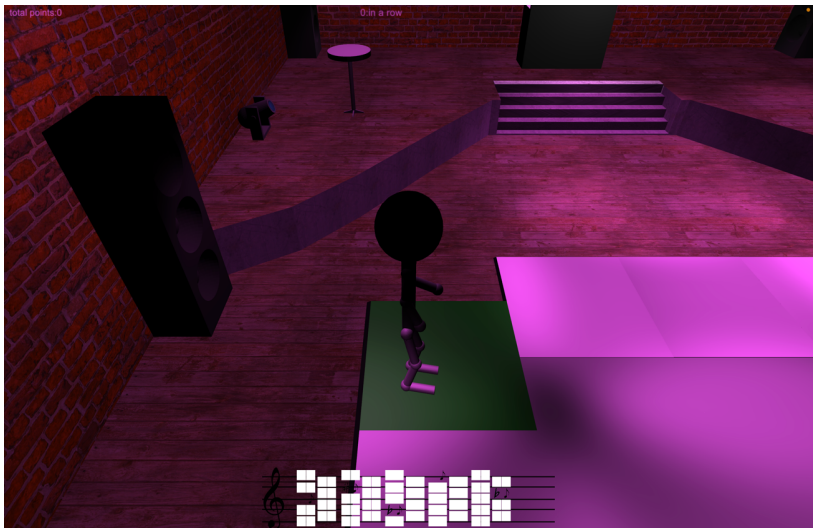
Upon opening the game, it looked uncomplicated enough to play. The game had a musical staff with a treble clef and a variety of pitches, as well as a white floor panel that responded to the pitches on the staff. The player had to move the character over the floor tiles and identify (aurally) the correct pitches as shown on the staff, after which they would move to the DJ booth, and then the player had to press the spacebar to see whether their answer was correct or incorrect.

The play testing revealed some mechanical issues such as the point system not working when the player moves to the DJ booth. The game's floor tiles were also not effective, because the player had to move to different spots on the white floor panel, without knowing what to do or where to step, and press the shift key to select a space and hear the note. Once the space was selected the player would need to aurally identify the correct pitch of the notes on the treble clef to get a point. This means that the player would have needed perfect pitch to accurately identify the notes on the staff.

After play testing the first iteration, the developer was provided with feedback on 22 February 2022, and it was requested that the next iteration be completed by 18 March 2022. The feedback on the first iteration game was predominantly focused on the game mechanics, as the note recognition was purely focused on aural pitch identification, which is too advanced for beginner-level music theory students. Furthermore, the dance tile blocks were to be changed to piano keys, as this was more appropriate to the class content in which the game would be tested. Figure 19 shows a screenshot of the first iteration game.

Figure 16

Screenshot of first iteration game



Iteration two.

On 18 March 2022, the developer sent the second iteration of the game for play testing, and the feedback from the first iteration was addressed. This iteration showed that the game scene and character remained the same as before, but that the dance tile blocks were changed to a basic keyboard layout as requested. The point system still did not work effectively when the spacebar was triggered at the DJ booth. The developer was therefore asked to fix this mechanical issue by 4 April 2022.

Iteration three.

The third prototype was completed for play testing by 21 April, which was approximately two weeks later than the proposed deadline. There were now visual errors on the game screen: e.g., there were floating “insert text here” words over the piano keys. Furthermore, the point system was still not active. Instead, the spacebar just switched the notes on the staff without giving the player points to show whether they were correct or incorrect. This error was requested to be fixed as soon as possible and the developer was

asked to make the notes on the staff more visible by adding a white background to it. Figure 20 shows a screenshot of the third iteration game.

Figure 17

Screenshot of third iteration game

Iteration four.

On 9 May 2022 the developer uploaded the fourth iteration for play testing. This version still had the errors as mentioned in iteration three, however the white background had been applied to the staff as requested, making the notes on the staff more visible. The developer was asked by the gaming lecturer to send through all of the game development files for a review of the coding, and for possible guidance on fixing the problems.

Iteration five.

The final iteration of the game was uploaded on 19 May 2022, and the previously mentioned mechanical issues were resolved. However, there were still some slight errors in the points system. When walking to the DJ booth and pressing the spacebar, the points system would work on some occasions and would not work on others. After some extensive testing it was seen that the possible reason for this was the placement of the notes on the staff, as in some cases the note placement is off centre, which caused some confusion to the participants when they played the game.

The post-development interview with the game developer revealed that the developer had some challenges with the mechanics of the point system and that he was concerned about completing it up to standard on time. Unfortunately, due to time constraints and the need to start the data collection process, a decision was made to keep this iteration as the final game that would be used for the study.

Once the data collection process began, the participants found that the point system worked. However, the note placement (as mentioned above) impacted their answers, since notes might be too close to a line on the staff. Thus, if they answered C-flat to the first note in Figure 21, the answer might be incorrect, and it might be a D flat instead. This proved that the note alignment and size caused confusion and could make it difficult to use the game for learning if the problem is not addressed before distribution. Figure 21 shows a screenshot of the final iteration that was used for the study's data collection process. The links between the participation and interview data are discussed in more depth in the findings chapter that follows.

Figure 18

Screenshot of final game iteration

Chapter 5: Findings

This section provides information on the participation findings as outlined in the analysis section of the research study. As the interview findings were outlined and discussed in chapter four, this chapter provides information on the findings of the analysed focus group and questionnaires. Chapter six then provides all the links to the various findings and literature for a more in-depth discussion on the collected data.

5.1. Focus group findings

The following sub-sections illustrate the findings gathered from the focus group analysis. After transcribing and analysing the focus group data, three main themes – 'sentiment', 'game elements', and 'struggling with' – were assigned to the responses. These themes act as the sub-headings that outline the findings of this section. All the assigned codes for the focus group analysis can be found in the table below.

Table 10

All codes assigned to the focus group transcriptions

Sentiment	**Positive** 27 would prefer game-based learning 16 think educational games are beneficial for learning reinforce learning practicing after class
	Neutral 32 like playing video games 30 like playing educational video games
	Negative purpose counterproductive 18 struggle with note recognition now

	learning in class instant gratification 16 struggled with note recognition before attending the tertiary creative media institution
Game elements	language memory mechanics practice problem solving interesting background music interaction quick thinking story strategy user-friendly redo/respawn META – Most Efficient Tactical Approach
Struggling with	Circle of fifths Aural training Note recognition

5.1.1. Theme 1: Sentiment

During the focus group, there were questions that led to various sentiments in the responses, which were described as positive, neutral or negative in the analysis. Even though this is a qualitative study, the first two questions asked during the focus group were of a quantitative nature, and were asked purely to spark discussions among the group. The data pertaining to the positive, neutral and negative sentiments are presented below in table 12.

Table 11

Prevalence of sentiment themes in focus group participant responses

Prevalance of themes (Participant responses) - Focus group																									
Sentiment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Positive																										
Neutral																										
Negative																										

Key:		
		Response purely discussion points that carry no sentiment
		Indication of wehther the response is postive, neutral or negative

5.1.1.1. Positive and neutral sentiments.

The first two questions asked focused on how many participants enjoyed playing video games, and how many enjoyed playing educational video games. With forty four participants present in the focus group, thirty two showed that they enjoyed playing video games, and thirty enjoyed educational video games. When the participants were asked to expand on their enjoyment and how they felt about the implementation of video games in their learning environment, the responses were generally positive. Participant responses B and E stated that:

> I feel like the repetition of educational games can reinforce the learning. [B]

> Ma'am, that [the video game implementation in educational environments] actually sounds nice because it will make me enjoy this class [music theory] specifically a lot more. [E]

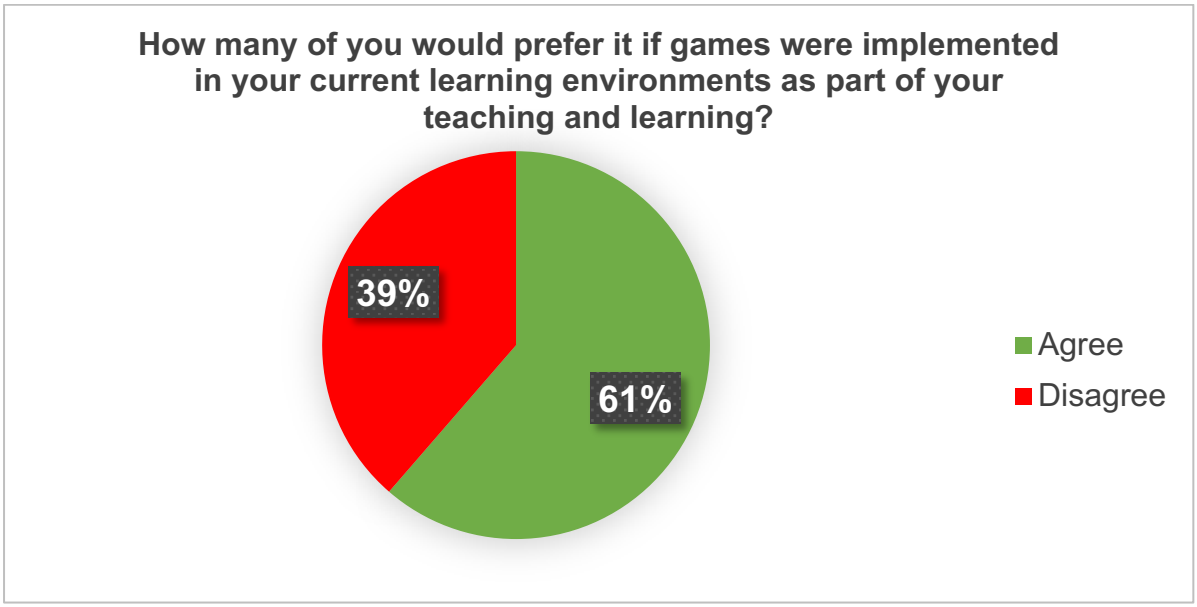
Furthermore, when the participants were asked to raise their hands if they would prefer games to be incorporated into their current learning environments – as part of their teaching and learning tools – twenty-seven agreed (as illustrated in figure 22 below).

> Ma'am I feel like learning with a game will help a lot more when I need to remember content for tests. [T]

Overall, sixteen participants raised their hands when they were asked who thought the implementation of games into a learning environment would be beneficial to their learning. This result is less than 50% of the participants who participated in the focus group, which led to the negative sentiments of the findings.

Figure 19

Statistics on participants who would prefer game-based learning



5.1.1.2. Negative sentiments.

During the focus group there where a few negative sentiments that arose in the participant responses, of which responses A, D, and G capture the essence of these negative sentiments.

> Ma'am I feel like it [implementing games into the learning environment] kind of defeats the purpose of the video game, because the reason video games are so successful is because it is instant gratification for the work you put in. So, your instant

> gratification in educational games is that you have access to the next topics of study which could seem counterproductive to the point of what gaming is about. [A]
>
> Woah, video games as part of learning, overall…it would ruin video games for me, because now we're in school and I like the tradition of video games where it's mindless and I can control whenever I want to do it. I feel like of you put that into an environment where I can't control anything anymore then the fun of it will, like, disappear. [D]
>
> And another thing about video games, Ma'am is that if you play games like FIFA or whatever. It gets competitive, and if it gets competitive it gets less about education and more about winning. [G]

Furthermore, the participants discussed the competitive environments of games, and it became clear that even though some responses indicated that competition was a good motivator for them, all participants agreed that the competitiveness of games would hinder their learning, unless implemented in group activities.

In conclusion, the focus group discussion revealed some arguments about implementing game-based apps into learning, since numerous students stated that game-based learning could reinforce their learning, if implemented as after-class activities rather than in-class. Even though these participants agreed that game-based learning can be beneficial, more enjoyable, and that it would improve their learning in multiple ways, they also agreed that this implementation should be balanced. They reiterated the importance of the game content being focused on the learning outcomes, and of making sure that there is a good balance between game-based learning (preferably as after-class activities) and traditional learning. There was also a point on competitiveness that was brought up, and some students showed

concern about competing against their classmates, as they would not feel comfortable with an environment in which they are constantly fighting to “be on top”.

5.1.2. Theme 2: Game elements

During the focus group the participants were asked what they thought the most important elements of any game should be, to establish whether their responses were similar to that of the developer. These responses are discussed in chapter six. The data pertaining to the participant responses on the game elements are presented below in table 13.

Table 12

Focus group responses about the important elements of a game

Focus group responses about the important elements of a game								
	Game elements in literature							
Response number	Mechanics	Story	Goals	Progress	Strategy	Interface	Aesthetics	Replays
1 to 13								
14								
15								
16								
17								
18								
19								
20								
21 to 26								
Key:			No response on game elements					
			Game elements mentioned					

The analysis of this question revealed that the most important game elements, according to participant responses M-S, are the game mechanics, interaction, background music, activities, strategy, storyline, and the respawning.

It's the mechanics to me that make it [a game] fun Ma'am, like in a fighting game the combo's must be interesting and not just like, you hit and hit by using the same button. There needs to be options [on how to play the game]. [M]

And then I think interaction with the game is also [an] important [element] because it [the game] should be user-friendly and easy to play. [N]

Also, it [the game] needs interesting background music Ma'am. [O]

And [the game needs] problem solving and quick thinking! You have to "want to" play the game and have problems that come up that you want to solve to progress. [P]

META is also important [in a game] Ma'am. The Most Efficient Tactical Approach. Like, the game should be diverse in the way you play it so you don't have to follow a specific approach to win, there needs to be options to play [the game] and [how to] get to the goal. [Q]

Also, the story [of the game] and strategy [you can approach]. I feel like you need to be interested in the storyline and [you should] be able to outsmart the opponents in the game. [R]

You get to redo everything [in the game] if you fail or die. [S]

Finally, to conclude, the focus group revealed that as a player of any game, the most important elements that makes a game fun is the interest. Thereafter, additional elements include an interest in the background music, the content of the game, and the storyline.

Because if any of these elements create a lack of interest, the player would get bored and stop playing. Another important element that they mentioned is the game mechanics and how there needs to be options on how to play the game. If a game does not have any fighting combinations or a most efficient tactical approach (game strategy), for example, then the player might lose motivation to play the game. Finally, the participants mentioned some factors that are similar to those mentioned by Mayer (2014). These factors include the fact that the user-interface should be easy to understand, provide one with the option to redo a level, and that any game should make players think and solve problems. An interesting thing to note is that these responses have multiple links to the developer interview. These are discussed in chapter six.

5.1.3. Theme 3: Struggling with…

The final questions asked during the focus group were related to the participants' understanding of the different music theory concepts, including musical note recognition before and after the implementation of the game.

When the participants were asked to mention some music theory concepts they struggled with, the three most common answers included aural training, the circle of fifths, and note recognition (which reinforces the need for a game-based learning app in this field). The participants discussed that they struggled with these concepts in music theory because many of the terminologies are in different languages and because the adjustment from not knowing any music theory to learning these concepts was a difficult one to make.

> …learning all the names of things [music theory terms] that are in different languages [was very difficult]. [W]

> Ma'am we are still adjusting [to music theory]. Like, before I studied for the [music theory] test Ma'am. Joh, I would have failed [the subject]. It was not easy to remember all the notes and their places [note recognition]. [Y]

The focus group findings finally showed that out of the forty-four focus group participants, sixteen struggled with music note recognition prior to studying this concept. However, they were eager to learn more about this concept through the implementation of the developed game-based learning app.

5.2. Questionnaire findings

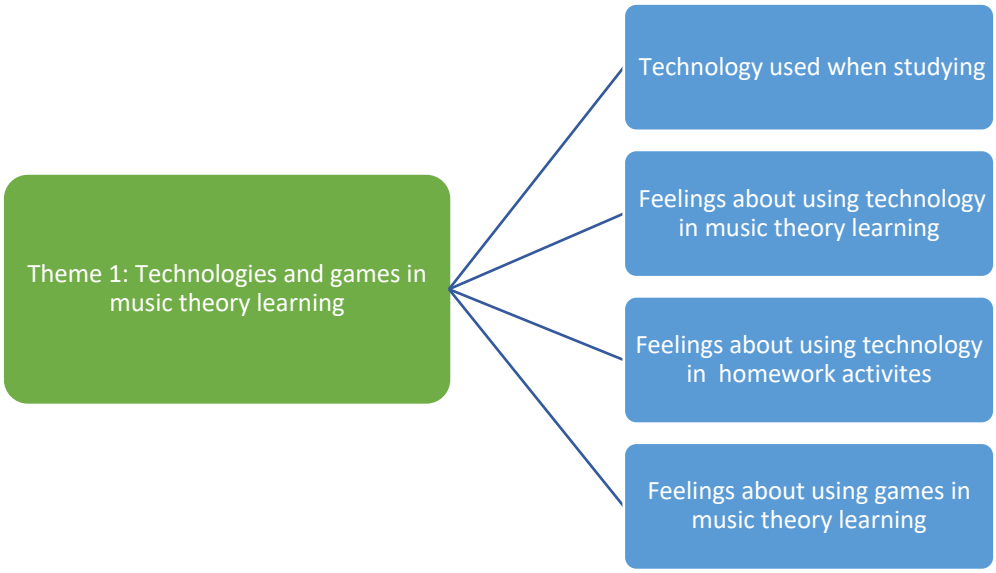
This section provides the findings derived from the analysis of the collected questionnaires. Each sub-section below is labelled according to the themes assigned in the analysis process and contains information that is broken down into further sub-themes, to help provide a clear outline of the findings. A full spreadsheet containing all the summarised questionnaire responses can be found in Appendix I.

5.2.1. Theme 1: Technologies and games in music theory learning

The questionnaire consisted of multiple sections that touched on technologies in music theory learning environments. These sections included the feelings of using technologies, and games in music theory learning environments, which are outlined in figure 23 and the sub-sections below.

Figure 20

Theme 1 sub-sections



5.2.1.1. Technologies used when studying.

After analysing the data from the questionnaires, various similarities and differences were found among the responses, based on how the participants feel about using technology when they are studying music theory. The analysis revealed that most students use technologies such as electronic devices, computer software, mobile apps, and online platforms (table 14 illustrates the participant responses) in their learning for at least three or more days a week.

Table 13

Technologies used by participants when studying music theory

Technologies used by the participants																																												
	Participant numbers																																												
Technologies	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Cellphone		■			■	■		■				■	■		■	■	■					■	■			■		■	■	■	■		■	■		■	■		■	
Computer								■	■							■														■						■		■		
Laptop	■	■	■	■	■					■	■	■	■	■	■	■	■	■	■	■	■		■			■	■	■	■				■	■				■	■	■
Metronomes		■																																								
Piano/ Keyboard			■			■					■							■																								
Tablet													■								■																				
YouTube				■					■										■					■			■									■			■		
Other online																																										
Ableton							■												■																							
FL Studio							■																																			
ProTools																			■																							
Other software																																					■					
PerfectEar				■	■	■			■													■	■							■	■			■	■						
Other apps										■														■	■						■	■		■								

5.2.1.2. Feelings about using technology in music theory learning.

During the questionnaires, the participants showed a high interest using technology in their everyday learning of music theory, indicating that it helped them to learn more effectively. A summary of their responses can be found in Appendix I.

> It [technology in music theory learning] assists in the learning process. [6]

> It [technology in music theory learning] helps me have a better understanding and it also helps me to be able to recognise the note whenever it is being played. [18]

> I feel like without using technology it would be much harder for me to study music theory. [19]

> I feel like technology makes it much easier to learn/study music theory. [28]

The participants also commented on the how the study and research content is more accessible when using technology than it is with paper resources. There was also a general agreement that technology would make learning more interactive and enjoyable and that it could help the learners focus and remember school content more easily.

On the other hand, it is important to note that not all participants agreed that studying music theory with technology was the best way of studying. Two of the participants (participants 12 and 35) stated that they preferred traditional learning and studying methods above using technologies, because of the disruptive nature that technology can have.

> Personally, I see it [technology] as a distraction [to learning] as you may not study and decide to do something else on your electronic device. [12]

> It [technology] can be quite disruptive [to learning]. [35]

These participants commented on the distractions of social media and its disruption of their ability to focus, stating that the use of technology is only helpful if it is not used as a primary method of learning. Thus, among a few others, these participants concluded that they prefer learning with books and paper. But if technology is applied to learning in moderation to the content of their studies, it could benefit their learning.

> I think it [technology] could be helpful [in learning] but should not be the main form of learning. [22]

> I think it [technology] is very useful [in the learning environment] but should not overlap the fact that skill is better. [25]

5.2.1.3. Feelings about using technology in homework activities.

When the participants were asked how they feel about receiving homework that needs to be completed by technology, the findings that emerged were interesting. Even though there were quite a few responses about not enjoying the use of technology in studying, the dominant response to technological homework was positive. Participants indicated excitement about getting technology-based homework, and commented on how it made their homework more enjoyable and interesting. They also commented on how these homework assignments made them more eager to work, by improving their understanding and encouraging them to be more creative while learning more efficiently.

The participants stated that technology-based homework increased their productivity and that it is “convenient and time-worthy” and that it “challenges their creativity and helps them figure things out on their own”. The only negative feedback that came up on this topic was from participants 2, 12, 22, and 35, when they stated that technology-based homework should not be forced and that it should be done in balance with traditional homework.

> I think that it [technology-based homework] shouldn’t be forced and it shouldn’t be like we have to do it, but the lecturer could still give the learners homework. [2]

> It [technology-based homework] would be nice, but it would be even better if there is some theory work to do. [12]

> It [technology-based homework] would be fun as an extra activity every once in a while. I would not enjoy it [technology-based homework] if all our homework was that way. [22]

> I would not mind. If it [technology-based homework] is related to my academics then it is okay. [35]

Finally, participants 13 and 20 showed concern about the accessibility to equipment and software when completing technology-based homework, and that it could be difficult to complete these assessments at home when there is loadshedding in their home environments.

> Sometimes it [technology-based homework] won't be possible to fulfil or meet the teacher's requirements as a nation we are prone to load shedding, so no electricity means that the [technology-based] homework will pile up constantly. [13]

> …there may be people who do not have access to these types of technology [required in homework activities] at home. [20]

5.2.1.4. Feelings about using games in music theory learning.

When the participants were asked how they feel about having game-based learning apps implemented in their learning, the response was primarily positive (the summarised responses can be seen in table 15 below). A full summary of the responses can be seen in Appendix I.

Table 14

Summarised responses to question 4

Response editing	
Summarised response to questions	
Participant number	Question 4: How do you feel about having game-based applications implemented in your teaching and learning
1	needed
2	love the idea
3	games are fun and addictive
4	interesting - depending on how it is implemented and the content of the game
5	repetition of gameplay will make it easier to remember
6	if done right, learning can be more fun
7	I associate games with leisure and relaxation and prefer not using it to learn
8	will make lessons more interactive and fun
9	good way to make lessons fun and exciting
10	would enjoy it
11	if balanced with traditional learning, yes
12	it would be fun
13	it would give me more time than traditional assignments
14	could be counterproductive because gaming and learning work with different reward systems
15	wouldn't mind
16	does not sound appealing
17	open to it if it makes learning easier
18	will help make learning more enjoyable and push students to keep trying when they get answers wrong
19	could help students who struggle with music theory
20	good for class environments - will compliment learning
21	more fun
22	should be used rarely, not a main form of learning
23	good if aligned with school content
24	great idea
25	great idea
26	would help to learn better
27	distracting
28	would not mind if there is more traditional learning than game-based learning
29	good idea to an extent
30	absolutely not
31	can be beneficial to create a different learning experience
32	great - if not competitive
33	don't know
34	excited
35	good idea if balanced with theoretical learning (e.g. games after class)
36	may be beneficial is integrated with traditional teaching and learning methods
37	open to it
38	do not mind if balanced between games and traditional teaching
39	very helpful
40	would make learning more fun and enjoyable

The participants felt that implementing games in their learning was needed and that it was “the best way to help a student learn” (participant 3), since games are “fun and addictive” (participant 3). There was agreement on the fact that the repetition and

interactivity of gameplay could make learning and remembering the content easier, and that playing games in class would make them pay more attention for longer periods of time. They therefore showed a positive attitude towards playing the developed game-based learning app.

> It [implementing game-based apps into learning] would really depend on the actual implementation of the lessons [the content] and the impact they have on the game. The type of game [game content] and subject/module [class content] the game is developed for would also play a factor. But having a game to help improve/understand what's being taught would be good. [4]

> [game-based apps] will make lessons more interactive and fun. [8]

> [implementing game-based apps] is a good way to make lessons fun and exciting and it can encourage student involvement and participation. [9]

> [game-based apps] will make learning more enjoyable and push students to keep trying when they get answers wrong. [18]

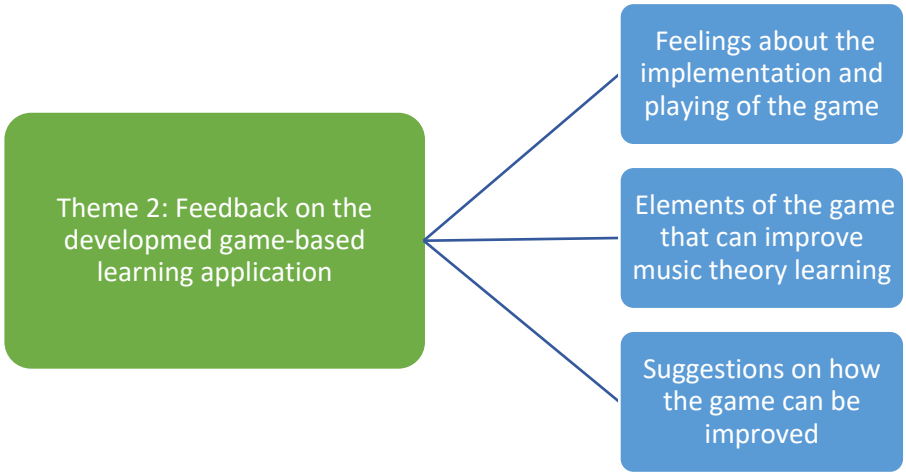
> I feel as if it [implementing game-based apps into learning] can be beneficial as it's a different learning experience and having unique learning methods can allow for one to be able to enjoy it more firstly, and secondly it may help people remember it [class content] more. [31]

5.2.2. Theme 2: Feedback on the developed game-based learning app

The second theme of the analysis included information about the developed game-based learning app. During this analysis three sub-themes were established, which are illustrated and discussed in figure 24 below.

Figure 21

Theme 2 sub-sections



5.2.2.1. Feelings about the implementation and playing of the game.

The questionnaire that was provided to the participants asked four questions on how they felt about the developed game-based learning app and its implementation in music theory teaching and learning.

First, they were asked how difficult the developed game-based learning app was (see table 16 below for the responses) and only one participant stated that it was difficult because of his understanding of music theory. Furthermore, the participants stated that the game was of “medium” or “easy” difficulty level, given that they understood the basic music theory

concepts that the game covers. Participants stated that the game was easy to play “apart from the note placements on the staff” and that it gets “boring after playing it for a while”.

Table 15

Participant responses on the difficulty level of the game

Participants views on the developed game-based app's difficulty level																																								
	Participant number																																							
Difficulty	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Easy																																								
Medium																																								
Difficulty																																								
Key:		No response																																						
		Response																																						

They were then asked to discuss how the implementation of the developed game-based learning app could benefit their music theory learning, of which the response was dominantly positive with only a few participants stating that it would not benefit their learning at all. The participants stated that implementing the developed game-based learning app would be “entertaining” and make their learning more “exciting”, “fun” and “enjoyable”. They also mentioned that it could increase their level of creativity, thinking, understanding and memory recall, as well as their overall feelings of inclusion and their motivation to interact more with the learning materials. Some of the participants’ responses are illustrated below, and a full summary of the responses can be seen in Appendix I.

> It [the developed game-based learning app] can change our ways of thinking and our level of creativity to the next level. [1]

> The game makes the environment of learning music theory interactive. It [the developed game-based learning app] does not feel like normal music theory because you are doing something else than just reading information. [5]

> It [the developed game-based learning app] can help to include and interest more people especially people with learning disabilities with regards to traditional learning methods. [20]

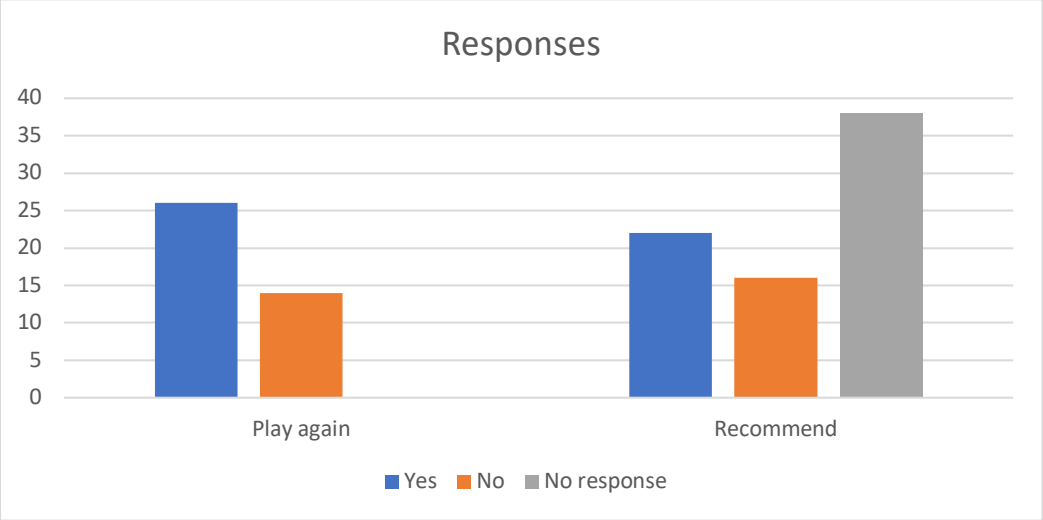
> I think by playing this game consistently it may result in a better understanding of music theory but people will quickly get bored of it. [24]

> I believe this game can make music theory learning a fun and interactive experience compared to how we traditionally learn. [26]

Finally, it was found that more than half of the participants stated that, once it has been adapted and improved, the developed game-based learning app would strengthen their learning by helping them understand, memorise and become more familiar with musical note recognition. The final two questions were quantitative, “yes or no” questions that asked whether or not the participants would play the game again in their future learning endeavours, and whether or not they would recommend it to other learners. These responses are illustrated in figure 25 below.

Figure 22

Responses to questionnaire questions 12 and 13



5.2.2.2. Elements of the game that can improve music theory learning.

The participants were asked to discuss any elements in the developed game-based learning app that they thought could benefit music theory learning. The analysis revealed ten recurring answers. Some elements that were mentioned by only a few of the participants include the game's simplicity, context, and concept. However, more recurring answers touched on the visual- and auditory elements of the game, such as the 3D environment and the keyboard and music staff. Participants 8, 14, 16,17, 20, and 25 (among others) also discussed the interactive game mechanics and how the scoring system is set up, even though it was not fully functional during the gameplay. Other elements in the developed game-based learning app that the participants thought could help the music theory learning process can be seen in figure 26 below.

> Having to interact with the piano [can help with music theory learning]. [8]

Its [the game-based learning app] interactive nature. [16]

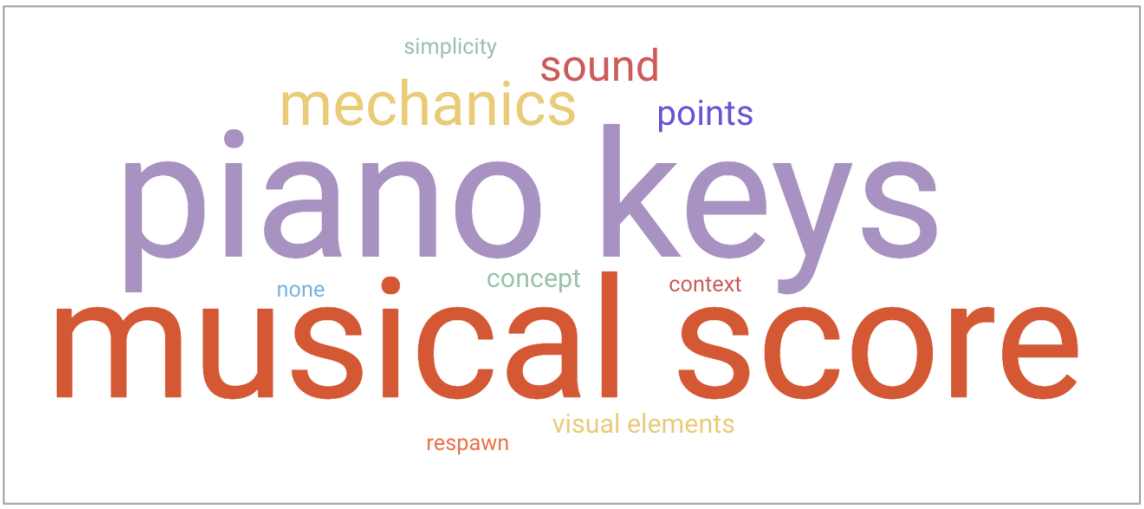
The main part of the game, where on selects the notes [on the keyboard] that is shown on the score. [17]

Having to select and identify the given notes, you will learn the notes much faster if motivated by the scoring system. [20]

The interactive learning by having a 3D environment is a great start. [25]

Figure 23

Elements in the developed game that could improve music theory learning



The visual representation above shows that the main elements of the developed game-based learning app that show potential in benefitting the music theory learning process are visual, such as the piano keys and musical score. Furthermore, the game mechanics, sounds, and points system were also frequently mentioned in the questionnaires. The links between these responses and those of the interview and focus group can be seen in the chapter six discussion.

5.2.2.3. Suggestions on how the game can be improved.

The final and most important section of the questionnaire was the question that addressed how the participants thought the game could be adjusted or improved for it to be appropriate for learning. The reason for this question was to gain insight on how the game can be improved to one day be distributed to music theory teaching and learning environments as a strategy to improve the learning experience.

Based on the participants' responses, the main game improvements can be implemented in the visual and auditory field, as well as in the game levels and feedback. Participants 7, 22, 25, and 38 stated that the game "lacks realism" and could benefit from additional lighting, customisable environments, and possibly the implementation of a first-person perspective.

> One could make an effort to make the gaming experience more fluid and a little realistic. Perhaps via the use of a first-person perspective. [7]

> If the graphics are improved and the game just looked better, people will be more interested and invested [in playing the game]. [22]

> Having a free roam aspect where the player can buy a home and customise his environment by earning currency by learning music theory. [25]

> It needs more interaction and should provide rewards to the consumer (points basically). The game can have non-player characters who dance every time you play a note. It [the game] can provide us with the correct answers if we have answered the questions wrong. [38]

From a visual perspective, some of the participants suggested making the character more personalised by adding different skins or an option to create an avatar. They also suggested adding non-player characters that dance and move around to help establish the “club environment” of the game, as well as graphics that show whether your answers were right or wrong (as seen in the above response by participant 38).

A common point for discussion in the questionnaire was the character movement and size of the keyboard and notes on the staff. The participants suggested removing the DJ booth to limit the movement to and from it as a method of point collection, and there was a general agreement that the keyboard and notes could be made bigger to increase the interactivity of the game. For the auditory enhancements, the participants mentioned the addition of background music to increase the realism of the game environment. They also commented on the addition of auditory feedback, such as chimes or horns that celebrate your wins and buzzers that indicates that you lost.

Finally, the participants feel that the game lacks the element of “a challenge” and that it needs more levels that become more difficult as you progress. They state that implementing time limits, more instruments, clefs and other musical concepts could also improve the challenge elements of the game and could increase the overall game interest. Figure 27 illustrates a word cloud containing the common elements that need to be improved in the game-based learning app, of which the bigger font sizes indicate the recurrence of this subject in the questionnaires.

Figure 24

Suggested improvements for the game-based learning app

Figure 27 above reveals that the main element that needs improvement in the developed game-based learning app is the lack of difficulty levels, as this is a common response in the questionnaires, as seen below.

> … There are no levels, rankings, etc. [3]

> Make it [the game-based learning app] more difficult as time progresses. [6]

> The game could have multiple different modes or levels so that the learner could choose what suits him/her best, allowing for more effective learning. [9]

> Adding more features such as instruments, characters and also levels. [12]

[Add some more] difficulty levels, multiplayer option, [and] practice mode. [19]

The other elements that are repetitive in the questionnaire responses are the graphics, interactivity, feedback, background music, and musical concepts. As the game is not developed to be commercially viable, these findings are only provided for the purpose of gathering insight on how the game could be improved to enhance the teaching and learning experience. However, by referring to these findings, the game can be adapted to prepare it for future distribution and study if needed.

Chapter 6: Discussion and conclusion

6.1. Introduction

This chapter describes the findings of the analysed data, as presented in chapter five. Three main themes emerged which were labelled as follows:

- Technologies used in music theory;
- Music theory understanding; and
- Developed game-based learning app.

Each of these main themes were then subdivided into further secondary themes that contain the coded data. The main and secondary themes are illustrated in table 16 below:

Table 16

Main and secondary themes

Main themes	Secondary themes
Technologies used in music theory learning	Apps
	Devices
	Online
	Software
	Frequency and feelings
Music theory understanding	Good
	Intermediate
	Needs improvement
Developed game-based learning app	Developed game and music theory learning

	Elements that can improve music theory learning
	Game difficulty
	Game improvement
	Play again
	Recommend

An interpretivist framework was adopted for this educational, design-based research study. The findings were derived from the links between the interview, questionnaire, and focus group responses. Furthermore, this chapter situates the findings of the study within the existing literature, with a focus on the game development process and the creation of an Octalysis model for the developed game-based learning app. Finally, each of the research questions (as mentioned in chapter one) are answered, and recommendations for further research are provided.

6.2. Discussion

6.2.1. Technology in music theory learning

The results indicate that out of forty participants, twenty-nine beginner music theory students at the tertiary creative media institute enjoy using technology to learn music theory because it is “very helpful”, “easier than paper learning”, and “helps with memory recall and easier access to learning information”. These findings support the statement made by Parasiz (2018) about how technology and apps can support effective teaching and learning, and potentially provide rich possibilities in educational settings.

The results further show that the participants use a variety of technological devices, apps, software and online platforms for three days or more when they are studying for the

subject. Among these technologies, the most commonly used technologies in the sampled environment are laptops, cell phones and mobile apps. These findings support the literature by Solfeg.io (2017) in which it is stated that students use some sort of technology, including laptops, smartphones every day, making the use of technology even more appealing in educational environments. To support technological learning, the participants stated that using technology increased their motivation to study for music theory, because their learning experiences were more effective, interactive, and enjoyable this way. These findings reinforce the statement in the literature by King (2012) on how it has become clear that technology is a vital element in music education in the 21st century.

A handful of students stated that they preferred learning with paper and books, as technology was “disruptive” and “distracting to their learning”. They nevertheless added that if implementing technology was not forced and was balanced in a way that supports their learning, they would be open to this change. Even though these students showed little interest in using technology, they were eager to complete homework activities using technology, rather than with paper and books. This contrast can be explained by referring to the findings in which 80% of the students indicated they enjoyed playing video games after school, and that approximately 72% use technology at least three days a week when studying.

These findings provide some evidence that all sampled participants were dedicated to using their technological devices in learning and homework activities, even if they stated they did not enjoy using it as part of their learning. A plausible explanation for this dedication could be found in the research by Himonides (2012b), in which it is suggested that in the present day it is not an option to become estranged from technology, and that using it as a tool in teaching should be embraced.

6.2.2. Game-based apps in music theory learning

The general response to implementing game-based learning in music theory learning was positive. The participating students stated that the interactivity of games make learning "fun and addictive" and that games should be implemented into their learning more regularly because it is "the best way to learn". The participants agreed that the repetition of gameplay makes learning and memory recall easier and more effective, as it is more interesting and holds their attention for longer than traditional learning methods. This cognitive engagement that was mentioned by the participants directly supports Mayer's (2019) discussion on how learning is a change in knowledge due to experience (for example, the experience of playing games). In the focus group (forty-four participants) the findings showed that thirty-two of the respondents enjoyed playing video games and thirty enjoyed playing educational video games. These findings could be another plausible explanation as to why the participants would enjoy game-based learning. However, this link was not explored in depth for this study.

In the literature, Mayer (2019) states that the cognitive approach to learning has five facets, of which all need to be included into a game to ensure effective game-based learning. One of the main facets mentioned is concepts. The research findings suggest a direct link to this statement, as the participants also stated – in all data collection methods – that content (or concept) was one of the most important elements of a game. This is especially important when referring to the focus group discussion on implementing games in the learning environment. Students were open to the idea, but constantly reiterated the importance of the game content. The participants stated that game-based learning can definitely reinforce learning if the game content is focused on the subject's learning outcomes and implemented as post-class activities rather than in-class.

To the participants, the most important elements of a game are the competitiveness, interest, game mechanics, and user-interface. As the participants discussed them, these

elements can be linked directly to the literature in which Schwartz and Plass (2019) discuss their integrated design framework for playful learning. This framework suggests that four types of engagement are required to make a game successful – namely affective, behavioural, cognitive, and social/cultural engagement. Table 17 below illustrates each discussed element and the type of engagement it falls under.

Table 9

Game elements and types of engagement

Game elements suggested by participants	Type of engagement as discussed by Schwartz and Plass (2019)
Competition	Affective engagement Sociocultural engagement
Interest	Cognitive engagement Affective engagement
Game mechanics	Cognitive engagement Behavioural engagement
User-interface	Cognitive engagement Behavioural engagement

First, some participants stated that competitiveness is an important element in a game and can have a positive influence on their game-play motivation. This however triggered a strong debate among the group. Some students argued against the motivational element of competitiveness and stated that they feel concern about competing against their classmates. They were not comfortable fighting to “be on top” and they felt like it would create a negative learning environment. On the other hand, Kapp (2012) states that competition and conflict in gameplay can increase the player’s efficiency and will motivate them to work hard to be “better”. Furthermore, the competitiveness element can be situated in the domain of affective and sociocultural engagement, as the interaction with other players

through game elements like competition or chat groups creates an emotional response that keeps the player motivated to play the game (Schwartz and Plass, 2019).

Second, the players mention interest as an important game element. This interest refers to multiple aspects including background music, the content or storyline, and the character, as without these the game will be boring and the player will lose motivation to play the game. The developer also discussed interest as being one of the most important elements of a game, saying that games have to be enjoyable and interesting enough to keep their players motivated to play. These elements are part of the cognitive and affective engagement, as the player searches for an intrinsic award such as character upgrades. Also, a game aesthetic, narrative and musical score that simulate reality and create an emotional connection to between their world and the gaming world is crucial in this regard (Schwartz and Plass, 2019).

The game mechanics and user-interface are the last two elements that were discussed in-depth by the participants and the developer. The participants mentioned the importance of game strategy (most efficient tactical approach) and player combinations, as the player needs to solve the game in different ways for it to remain interesting. The developer also reinforced the importance of well-developed game mechanics. Both he and the participants stated that the game interface needs to be easily understandable and make the gameplay effortless to strategise more effectively about how to overcome the challenge, which then directly stimulates cognitive and behavioural engagement (Schwartz and Plass, 2019).

6.2.3. Feedback on the developed game-based learning app

The implementation of the final iteration of the game brought forward some interesting results. All the participants, except one, stated that the game was easy or of medium difficulty level if you understand how to recognise notes. The student who stated that it was difficult stated that he struggled with note recognition. However if his knowledge of the topic

had been better, he would have found the game easy and helpful for studying. Of the forty participants, only twenty-six stated that they would play the game again, and only twenty-two would recommend the game to their friends or peers who struggled with note recognition in the future. These findings were interesting, considering that the predominant feedback on the game was negative: It was highly encouraged that the game would need to be adapted to make it more appealing to players.

The participants stated that there were some elements in the developed game that they thought could improve their music theory learning. The piano keys and musical staff were the most prominent answers provided in this regard. They mentioned that the interactivity and tangibility of the piano keys made their learning easier, as it implemented both visual and auditory feedback that helped improve their memory retention. They enjoyed the fact that they could visually see and hear the note on the staff and the keyboard once selected, and they stated that the movement in the 3D environment made the game more appealing than other music theory games and websites. Finally, the participants showed positive feedback on the game's simplicity and the ability to redo a level if they failed, which supports Kapp's (2012) suggestion that replays and do-overs help motivate players by giving permission to fail and retry without losing anything.

Even though the participants had some positive feedback on the game and the elements that they thought could benefit their learning, there was a significant amount of negative feedback on the game as well, which one can of course expect from a study like this one.

It is important to note, as mentioned before, that the game was not developed to be commercially viable and ready for implementation in music education. The game was developed purely to establish whether or not a developed game like this one could benefit the music theory teaching and learning environment, and to answer the research questions of this study. The developed game, in its imperfections, has fulfilled its purpose, and the findings suggest that the game will definitely be able to benefit music theory education. But

there are multiple suggested changes that need to be considered before the game can be deemed commercially viable.

The first observation made during the play testing was the fact that the game developer had not provided any rules or guidelines. The players had no guide on how to play the game, what the goals were and what they would accomplish by playing the game. This is an essential part of game design, as Kapp (2012) states that, without rules, the game does not exist since the rules guide and limit the player's actions and gameplay. The participants kept reiterating the importance of adding more challenges and levels to the developed game, as the game was boring and did not show any movement towards an objective. They suggested the implementation of multiplayer levels, practice modes, time limits, and increasing difficulty levels with each correct answer.

These participant suggestions support the literature by Kapp (2012), in which it is discussed that an instructional game can only be successful if the game has a set of goals that motivate and drive the gameplay. By adding time limits players will be more motivated and engaged, by feeling like they experience real-world work that needs to be achieved within a certain time to achieve optimal satisfaction (Kapp, 2012). Finally, implementing game levels and challenges, especially if they are reward-based, will increase gameplay and motivate players to gain more and more gameplay experience and knowledge (Kapp, 2012).

The participants continued by discussing the need to apply more interest to the game. They said that the game was "dull and boring" and needed more realistic aesthetics. They suggested that the developer should implement lighting that better suited the game environment, and maybe also a first-person perspective instead of the "boring character" used. These findings reinforce the importance of aesthetics in game design as discussed by Kapp (2012) and Dewey (2015). The game can thus benefit from some visual aesthetics changes, such as a larger keyboard that is realistic to the size of a real-world instrument, rather than just the current octave scale. On the staff, the note sizes can be adjusted and

placed more effectively, to ensure that there is no confusion as to which note needs to be selected on the keyboard. In further game iterations, more clefs (e.g. bass, tenor and alto) and instruments (e.g. guitar, drums, and flute) can also be implemented.

Furthermore, the participants advised the developer to add more non-player characters and background music, to better establish the club environment, to make it more visually and aesthetically appealing to the players. By implementing these changes, the game will not only be more appealing to the player, but will also create a story, hero's journey and curve of interest, as suggested by Kapp (2012) in the literature review.

By implementing a rewards system (more than just the current points system), with hooks such as leader boards, badges, game currencies or just a celebratory feedback response, the players will feel more motivated to perform and compete against their peers, making the game more enjoyable and addictive (Kapp, 2012). These rewards can aid in gameplay, as players will feel like they are receiving more positive feedback and reinforcement for what they got correct. By implementing virtual currencies or rewards like character skins, players will be able to virtually purchase game elements that can help with character and environment personalisation, making them feel more included as they can make the game "their own".

From having evaluated the findings, it is now clear that the positive feedback on the effectivity of the developed game-based learning app outweighs the negative feedback. Even though the participants had feedback on how to adapt the game to make it more user-friendly and enjoyable, their responses showed that the game has the potential to be an effective teaching and learning tool.

6.2.4. Situating the developed game within the Octalysis framework

In an attempt to illustrate the effectiveness of the developed game, an Octalysis Framework was created, based on the participants' feedback. To develop the Octalysis

framework in figure 28 below, an online Octalysis tool[38] was used to assign a rating from one to ten for each of the core drives and a participation quote for each. After considering the findings, it was decided that this framework will include participant quotations as the notes for each core drive. The frequency of the quotations and assigned codes were evaluated, and a decision was made on whether each quote was negative or positive, after which the following rating numbers were ascribed to each of the core drives:

Table 10

Core drives and ratings for the developed game-based learning app

Core drive	Rating
Epic meaning and calling	2
Development and accomplishment	1
Empowerment of creativity and feedback	5
Ownership and possession	1
Social influence and relatedness	2
Scarcity and impatience	0
Curiosity and unpredictability	1
Loss and avoidance	2

The total score of the game, based on the Octalysis framework, ended up being 40, which is extremely low for a developed game. The feedback on the Octalysis tool also stated that the developed game was a “weak experience and falling asleep”. It showed a weak presence of left and right brain core drives, which would cause players to lose intrinsic and extrinsic motivation and feel bored while playing it. The analysis of these findings confirmed

[38] https://yukaichou.com/octalysis-tool/

that the participants think that the game is in fact boring, and reiterated the participants' statements that the game needs improvement to make it more interesting and motivating to play.

Figure 25

Octalysis framework for the developed game-based learning app

The feedback provided by the participants, as well as the developed Octalysis Framework, shows a need for the game to be adapted in multiple ways before it can be commercially viable. However, the data has revealed some interesting findings and assisted in answering the research questions.

6.3. Answers to the research questions

The following section provides the answers to the research questions, of which the primary question asks:

How do the participants describe the development process and gameplay experiences of the developed music theory game-based learning application?

6.3.1. The game development process

During the interview with the game developer, it was revealed that there were multiple processes involved in the development of the game, and that when one overlooks one process or game element, the game will not be successful. The literature suggested multiple steps, platforms, and elements that are important in game-design, and after analysing the data it was seen that the game developer followed five steps in the development of this game.

The first step was focused on the collection of resources for the game. This is one of the most important processes in game design, as the resources stimulate the developer's ideas and overall content of the game. Once a developer has come up with a basic idea for the game content, it is essential for them to research the content that is required to make the game realistic and effective. Thereafter a developers can start brainstorming (step two) by coming up with the game's flow and story. During this stage, the developer does some rough sketches and starts planning which elements they will use and where they will use them. During the development of this game, the brainstorming process was slightly overlooked, as the developer struggled to come up with an effective storyline and the game ended up being completed without rules, goals and challenges.

The next important step to be considered is sketching and modelling. There are multiple software options that can be used during this process. For the development of this game, open-source software (Blender, Visual Studio, and Unity) was used. The fourth step includes

the timeline development, in which the developer plans each step and goal based on the provided play testing deadline.

Once the planning and timelines are complete, the development process begins. For this game, the developer used Blender to create 3D models of the character and game environment, after which these were imported into the game-engine, Unity. In Unity the developer could further expand on the environment design by adding objects, lighting and camera views. The developer could then programme all these objects by using the coding platform Visual Studio. In Visual Studio the developer used the C# coding language to programme the game mechanics, such as the character movements, the keyboard responses, and the audio playback. Once the first iteration of the game was complete, the game was exported for play testing and feedback, which is the sixth and final step of the processes in the game development.

During this final step, the game was play-tested five times, revealing that each of the five game iterations had some mechanical and visual problems that needed to be changed. Thus, after each test the developer received feedback that needed to be implemented. The fifth and final iteration was chosen for the data collection process because it was the most effective game that had the least mechanical errors and would be sufficient for the data collection.

6.3.2. The gameplay experiences

Throughout the focus group and questionnaire analyses the research findings revealed that the participants were keen to make use of game-based learning, as it is more enjoyable than traditional learning and can hold their attention for longer periods of time. The literature by Plass et al. (2015) suggests that implementing game-based learning can reinforce learning and effectively stimulate student engagement. Schwartz and Plass (2019) continue by discussing these types of engagement and how each essential game element can play a

role in the students' affective, behavioural, cognitive, and sociocultural engagement and development.

In higher education, games have been proven to be effective learning tools in fields such as medicine, business, and music (Javornik, 2020). Research studies by Barr (2019), Javornik (2020), and Jensen (2022) have shown how multiple educational video games, such as *Beats Empire*, can increase students' learning experiences. These researchers conclude by stating that game-based learning can make a remarkable impact on the learning environment. This statement is confirmed in this study's findings, as the students showed an extremely positive attitude towards game-based learning that made their learning experience more exciting and appealing.

The findings revealed that 72.5% of the sampled participants enjoyed using technology when they study, as it is more easily accessible and increases their learning ability. The students said that learning with technology helped increase their memory recall and that the use of technological devices such as laptops, cell phones, keyboards, and software made learning more effective and enjoyable. The other 27.5% of the participants stated that they preferred learning with traditional methods such as books and note taking. They were however not opposed to implementing technological learning and homework, as long as it was balanced with traditional learning methods.

When the participants were asked about game-based learning, the dominant response (72.7%) was also positive. They stated that games are fun and addictive and can thus make learning more enjoyable. They also stated that game-based learning was "the best way to learn", as it improves their motivation to study and increases their memory by incorporating a more visual way of learning. The participants felt that game-based learning can reinforce their learning and should be implemented more into their everyday learning environments.

Throughout the data collection process, only one participant stated that he found the game difficult due to his unfamiliarity with the topic. All the other participants stated that the

game was easy, or of medium difficulty level, if the player is familiar with note recognition. The participants stated that, if adapted as suggested, the game would be an effective learning tool – both interactive and visually and audibly more stimulating than traditional learning. They also mentioned that the game improved their learning because of its repetitive nature, and helped increase their creativity, understanding, and interest in music theory content.

To make the game a commercially viable product, the findings suggested a few changes that would need to be implemented. The game development process was followed similarly to that discussed in the literature. Thus, the required changes are mainly related to visual and mechanical game elements.

The participants stated that the game was boring and lacked realism and suggested future developers should implement more challenges and levels to stimulate their interest. They further mentioned that the game would benefit from a larger keyboard and notes on the treble clef, and also raised the possibility of implementing more instrument and clef choices to expand the target market. The implementation of feedback systems and rewards was also encouraged, as there are not enough motivational elements to show the player that they are correct or incorrect. Motivational banners, dancing non-player characters, personalisation options, or a simple leader board would make the gameplay more intriguing. Finally, the participants commented on the visual and auditory appeal, and stated that making the character personalised and adding background music, more appropriate lighting and multiple non-player characters would help create a more realistic club environment in the game.

Through implementing the suggested changes in further development stages, the game will be more effective for teaching and learning, as it will then have all the necessary elements that make a successful game, as suggested in the literature by Kapp (2012). The adapted game will then, after undergoing more testing, also have a higher rating on Chou's (2019) Octalysis framework, and thus be a more effective game overall.

This game is a heuristic model specifically designed as a method to help learn music theory note recognition faster and more effectively than traditional learning methods. In the philosophy of technology this game can be seen as a technological artefact, as it was made by a human with the goal of creating a practical solution to a problem (Verkerk, et al. 2015). Furthermore, the developed game can contribute to all themes of the philosophy of technology, as it is a piece of technology that was designed as an artefact, knowledge, a process, and a part of the human being.

Regarding the two cultures debate, even though it is not commercially viable, the game that was developed for the purpose of this study can act as a bridge between the humanities and science, as it is designed through implementing scientific methods, and contributes to the knowledge development of a topic within the arts.

6.4. Recommendations for further research

This study focused on the development of a game-based music theory app for beginner music theory learning. The game was not intended to be a commercially viable product, but rather a tool to investigate how the participants feel about technological and game-based learning. The aim of the study was to discuss developing this game, and using it to investigate whether or not it would benefit the learning experiences of the sampled students at the tertiary creative media institution. For any future research on this topic, the following recommendations can be considered.

6.4.1. Recommendation 1

The game-based learning app used in this study can be adapted based on the discussed guidelines in chapter 5.3, to investigate whether the game can impact the students' music theory results. Thus, the adapted game can be implemented into the students' weekly classes as part of a longitudinal study in which their test results are compared over a period with and without the game.

6.4.2. Recommendation 2

The study can be replicated in other educational environments than the tertiary creative media institution used for this study. The study can be conducted in primary, secondary, and other tertiary institutions, to establish whether or not the results would be similar or different depending on the participant demographics.

6.4.3. Recommendation 3

The developed game-based app can be adapted to incorporate more music theory concepts, after which it can be implemented into the music theory learning environment to establish whether game-based learning can benefit overall music theory teaching and learning, and not just beginner stages. The same recommendation can be applied using other previously developed game-based learning apps.

6.5. Conclusion

Even though there are many recommendations on how the game can be improved, the participants stated that implementing the developed game in a music theory teaching and learning environment would be a good idea (considering that it is improved). Their reasons for this are because game-based learning is more fun and interactive and they feel like it would improve their learning, increase their level of thinking, creativity and understanding of the topic at hand. They also felt like game-based learning is more motivating than studying with books, as it makes learning more exciting and opens the classroom up for more engagement and includes students who are more introverted or less likely to take part in classroom activities.

The study results have provided evidence that the developed game-based app could benefit the teaching and learning of music theory beginners, and that the participants are eager and open to using technology and games in their learning environments. Finally, it is feasible to say that if adapted appropriately, the developed game could be a commercially

viable product that can be implemented as a heuristic model into the music education environment.

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Appendices

Appendix A: Information letter to Managing Executive of the tertiary creative media institution Johannesburg

Letter of information for participation in research study: The development of a game-based application for teaching and learning music theory.

Dear Managing Executive

I hereby wish to request your permission to conduct research that involves the participation of the Higher Certificate and Bachelors of Sound Production students who have Applied Music Theory at your institute. This research project is in partial fulfilment of the requirements for the degree MMus (Music Technology) for which I am currently enrolled.

Aims of the study: The study aims to investigate the relationship between game-based technology and music theory education. A developed game will be made available to participating students and will be used in the teaching and learning process of the music theory module. The main focus of the study will be to assess whether technologies, like the developed game, can improve the teaching and learning of basic music theory concepts.

Research procedures: Myself as lecturer will implement the developed game into my weekly classes for a period of 1-2 weeks. The students will be required to play the game in class for a maximum of 10 minutes e. The students will be provided with information and guidelines on how to play the game beforehand. After the game-play period has ended the students will be asked to complete an online survey, which will take about 20-30 minutes of their time and will include questions related to their use of technology to learn music in and out of the classroom. The questions will also touch on the learners' experiences of learning musical theory concepts over a period of time whilst playing the game.

Confidentiality: All information will be treated as strictly confidential. Only the researcher and the supervisors will know the identities of the students involved, but this will not be revealed in any research outputs. All raw data –including the completed questionnaires and app data- will be stored in a password protected format at the University of Pretoria for a period of 15 years, after which they will be destroyed. During

this period, the information gathered -excluding the confidential data- may be re-used for further research.

Risks and benefits for participants: By participating in the research the students will help advance the knowledge and understanding of how technology and gamification can impact the teaching and learning process in music education. The app will be tested by myself, the developer, and fellow lecturers at the tertiary creative media institution before it is provided to participants. This testing phase will help to ensure that it has no negative impact on the skill development of the participating learners, and thus help to limit the risks of participating in the study Through participation the students may show an increased understanding in music theory after using the game, which in turn could increase their overall level of confidence and musicianship.

Participants' rights: Participation in the study is completely voluntary and they are free to withdraw at any time, and if they decide to withdraw there will be no negative consequences, nor will they need to explain their reason for their withdrawal. All participating parties are encouraged to ask any questions they might have about the study.

Consent: I hereby acknowledge that this research study has been explained to me. I understand what is required from the participating students and that they may withdraw at any time should they wish to do so. I understand that the participants' identities and details will not be made public at any time and will only be available to the researcher and the supervisors for the purpose of this study.

Please sign below the consent form below if you give your consent to this study being conducted at your institute.

Appendix B: Consent form from Managing Executive at the tertiary creative media Institution Johannesburg

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Consent form from Managing Executive at SAE Institute Johannesburg

By signing below you give consent for this study to take place at the SAE Institute in Johannesburg as explained in the information letter.

Darryn van Zyl		16 MARCH 2022
Name and Surname (SAE M.E.)	Signature	Date

Official Institution Stamp

Tarien van der Linden		16 March 2022
Name and Surname (Researcher)	Signature	Date

Contact details for researcher and supervisors:

Tarien van der Linden	Dr Miles Warrington	Dr Sonja Cruywagen
TarienvdL@gmail.com	miles.warrington@up.ac.za	sonja.cruywagen@up.ac.za

To access the information letter and signed consent form please go to the following link: https://drive.google.com/file/d/1H-2FS8kNuMNgkCHdjE6EHa89U5SUXy4j/view?usp=sharing

Appendix C: Letter of information to participating students

Dear student

My name is Tarien van der Linden. I am a student at the University of Pretoria and I am currently enrolled for a Master's degree in Music Technology.

Research topic: The development of a game-based application for teaching and learning music theory.

Aims of the study: The study aims to investigate the relationship between game-based technology and music theory education. A developed game will be made available to participating students and will be used in the teaching and learning process of the music theory module. The main focus of the study will be to assess whether technologies, like the developed game, can improve the teaching and learning of basic music theory concepts.

Research procedures: Myself as a lecturer will implement the developed game into my weekly classes for a period of two weeks. The students will be required to play the game in class for a maximum of 10 minutes every week. The students will be provided with information and guidelines on how to play the game beforehand. After the game-play period has ended the students will be asked to complete an online survey, which will take about 20-30 minutes of their time and will include questions related to their use of technology to learn music in and out of the classroom. The questions will also touch on the learners' experiences of learning musical theory concepts over a period of time whilst playing the game.

Confidentiality: All information will be treated as strictly confidential. Only the researcher and the supervisors will know the identities of the students involved, but this will not be revealed in any research outputs. All raw data –including the completed questionnaires and app data- will be stored in a password protected format at the University of Pretoria for a period of 15 years, after which they will be destroyed. During this period, the information gathered -excluding the confidential data- may be re-used for further research.

What will be expected of participating students? Your participation will involve using the provided game and completing an online survey. You will receive the game on the tertiary creative media institutions class computers and the researcher will provide you with guidelines on how to use it. You will have access to this game for two weeks and will be expected to use this app in your musical theory learning for 10 minutes a day for two weeks in your music theory class, after which you will be asked to complete an online survey. The survey will take about 20-30 minutes of your time and will include questions related to your use of technology to learn music in and out of your classroom. The questions will also touch on your experiences of learning music

theory skills over a period of time whilst playing the game. All information provided by participating students will be treated with strict confidentiality.

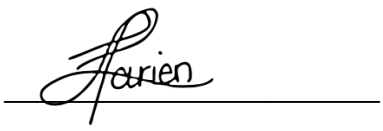
Approval: The study will only begin after ethical approval by the Research Ethics Committee of the Faculty of Humanities, University of Pretoria, has been obtained.

Risks and benefits for participants: By participating in the research the students will help advance the knowledge and understanding of how technology and gamification can impact the teaching and learning process in music education. The game will be tested by myself, the developer, and fellow lecturers at the tertiary creative media institution before it is provided to participants. This testing phase will help to ensure that it has no negative impact on the skill development of the participating learners, and thus help to limit the risks of participating in the study. Through participation the students may show an increased understanding in music theory after using the game, which in turn could increase their overall level of confidence and musicianship.

Participants' rights: Participation in the study is completely voluntary and they are free to withdraw at any time, and if they decide to withdraw there will be no negative consequences, nor will they need to explain their reason for their withdrawal. All participating parties are encouraged to ask any questions they might have about the study.

Consent: I hereby acknowledge that this research study has been explained to me. I understand what is required from the participating students and that they may withdraw at any time should they wish to do so. I understand that the participants' identities and details will not be made public at any time and will only be available to the researcher and the supervisors for the purpose of this study.

Kind regards



Tarien van der Linden

TarienvdL@gmail.com

Supervisor: Dr Miles Warrington
miles.warrington@up.ac.za

Co-Supervisor: Dr Sonja Cruywagen
sonja.cruywagen@up.ac.za

Appendix D: Informed consent of participating students

Letter of informed consent for students: Reply slip

Full name: _____

Research topic: The development of a game-based application for teaching and learning music theory.

I hereby give my consent to participate in the aforementioned research project and acknowledge that the data may be used in current and future research. I confirm that I understand what is required of me in the research project. I am aware that I may withdraw from the study at any time, should I wish to do so. I am also aware that all my information will be kept as strictly confidential.

_____ _____
Signature of participating teacher Date

_____
Signature of principal researcher

The following link can be used to access all the completed consent forms and questionnaires: https://drive.google.com/file/d/1aT-IMJ8yOiIrvrjXxmZMBGdD-QcLAdF8/view?usp=sharing

Appendix E: Memorandum of Agreement between researcher and collaborator

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Appendices

Appendix A: Memorandum of Agreement between researcher and collaborator

MEMORANDUM OF AGREEMENT
for Collaboration in Postgraduate Research study

This document should be read in conjunction with the following University of Pretoria policy documents which are available on the University website (http://www.up.ac.za):

***the University of Pretoria General Regulations** applicable to postgraduate study,*
***the University Code Ethics for Research** (especially section 3.4 and section 4.1 to 4.4),*
the University Plagiarism Policy,
the Intellectual Property Policy.

Postgraduate research information

Title of study	The development of a game-based application for teaching and learning music theory.
Supervisor	Dr. Miles Warrington
Co-Supervisor	Dr. Sonja Cruywagen
Researcher	Tarien van der Linden
Student number	16059892
Degree	MMus (Music Technology)
Department	Music
School	School of the Arts
Faculty	Humanities

University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 420 1234
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www.up.ac.za

SCHOOL OF THE ARTS
UNIVERSITY OF PRETORIA
FACULTY OF HUMANITIES

Initial - Researcher	TvdL
Initial - Collaborator	TV

School of the Arts

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Memorandum of Agreement between the Postgraduate Researcher and the Collaborator

The **COLLABORATOR** Tre' Visagie (name)

accepts and undertakes the following roles and responsibilities:

1. Abiding by the relevant rules and regulations of the University of Pretoria.
2. Taking account of the feedback provided by the researcher and the researcher's supervisors. N/A
3. Accepting responsibility for the development of a game that will be used in the data collection process of the researcher's study.
4. Providing the researcher with the necessary information regarding the development process and progress.
5. Adhering the deadlines as agreed upon by the researcher and collaborator to ensure the final product is ready once the data collection process begins.
6. Acknowledging that the collaborator may not take part in the research process and that they have no authorship to the study.
7. Informing the researcher of any absence or circumstances that could affect the research timeline.
8. Providing an alternative collaborator to ensure the development of the game will continue in the unlikely event that the primary collaborator has to withdraw from the study, and providing the alternative collaborator with all the information regarding the game development.

Initial - Researcher	TvdL
Initial - Collaborator	TV

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The RESEARCHER Tarien van der Linden **(name)**
accepts and undertakes the following roles and responsibilities:

1. Abiding by the relevant rules and regulations of the University of Pretoria.
2. Providing the collaborator with information on the conditions to be met in order to achieve a satisfactory end product in the development of the program.
3. Being accessible to the collaborator by attending scheduled meetings and answering questions related to the game development.
4. Assisting the collaborator by providing the necessary information and knowledge needed to achieve a satisfactory end product.
5. Communicating any information that the collaborator may need to develop the game and answering all questions with honesty.
6. Taking responsibility for the authorship of all information on the game development.
7. Accepting responsibility for the overall coherent structure of the final dissertation and submitting written work of a high standard.
8. Informing the collaborator of any absence or circumstances that could affect the research timeline.

_____

The RESEARCHER and the COLLABORATOR:

1. Confirms that we have read and understood the information provided in this Memorandum of Agreement.
2. Agree and accept its content for the duration of the period of study as specified below.
3. Accept and agree that the researcher will take sole authorship of all written work and that the final research products (e.g. dissertation, article, developed game) will form part of the University of Pretoria's Intellectual Property.

Initial - Researcher	TvdL
Initial - Collaborator	TV

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AGREEMENT

I agree and accept all information provided in this Memorandum of Agreement

Provisional deadline for first demo of the game: 26 February 2022

Researcher's signature: Tarien

Name of the Collaborator: Tre' Visagie

Collaborator's signature: _____

Initial - Researcher	TvdL
Initial - Collaborator	TV

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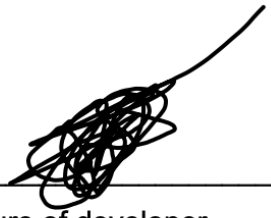
To access the Memorandum of Agreement between the Collaborator and Researcher please go to the following link:

https://drive.google.com/file/d/1i8ORhwoSNwjwj7dQW4rrR9D9JaSkiCQt/view?usp=sharing

Appendix F: Transcript confirmation - Developer

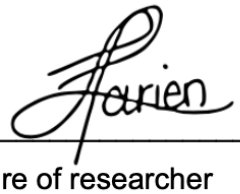
I hereby confirm that I have received my interview transcript and that responses to the interviewer's question has been accurately documented. My responses may be presented under the pseudonym "Developer" and I acknowledge that my personal information will be kept confidential. I am aware of my rights to access the data that I provided at any given time during the study.



Signature of developer

14 May 2022

Date



Signature of researcher

12 May 2022

Date

To access the transcript confirmation please follow this link:

https://drive.google.com/file/d/1b2LAmdJZX1JiOCuVSVuTVG8qXmyHy1QQ/view?usp=sharing

Appendix G: Interview schedule

The interview took place at 11:00 on 12 May 2022 between the researcher and the game developer. The researcher asked the following questions to the developer:

1. After I've provided you with the information you needed, how'd you come up with idea for the game?
2. How did you organize and plan the project with regards to the development timeline?
3. Throughout the whole development process, from the 3D modelling to the game export, what tools did you use to develop the game?
4. During the development process, did you download any assets or packs that helped you with the 3D modelling, or did you create everything yourself?
5. In your opinion, what do you think are the five key elements of a good game?
6. And then what is your opinion about things like rewards and motivational game elements?
7. Did you implement any of these elements that you mentioned in your game designing?
8. After developing the game, how did you test the prototype before you sent it for playtesting the first time?
9. Can you take me through the whole game design process, from where you came up with the idea to the final game export?
10. After completing and testing the first prototype, what was the main feedback you got?
11. For interview purposes please just indicate where you located the theoretical information needed and the audio clips for the game.
12. What were some of the challenges or difficulties that you experienced when developing and adapting the game?
13. Is there anything else that you want to add or can think of that was important during the development process?

To access the full interview transcript follow this link:

https://drive.google.com/file/d/1B3hzjoQ8kuXrIbdVDC4YLKsR7CqcBTYx/view?usp=sharing

Appendix H: Participant questionnaire

The questionnaire has been completed on Google Forms which students accessed through the following link: https://forms.gle/bdkbpbwqatCGwq3h6. The Google form is setup with the following sections and questions.

The development of a game-based application for teaching and learning music theory.

Thank you for participating in my study, Please answer a few questions below on how you experienced the game in as much detail as possible!

Section 1: Personal Information

This information will be completely confidential.

Name and Surname		
Do you have prior music theory experience?	Yes	No

Section 2: Use of technology when learning music theory

Please answer the following questions and provide examples of relevant technologies.
These technologies can include anything that you use when you study music theory, for example:
- Laptop, Tablet/iPad, cellphone, etc.
- Music apps e.g. metronome, recording app, etc.

1. What technologies do you use to study music theory, if you use any? Please list them here.
2. How often do you make use of any technology when studying music theory?
3. How do you feel about using technology when studying music theory?
4. How would you feel about having game-based applications implemented in your teaching and learning?
5. How do you feel if your lecturer gives you homework that you had to complete using only technology? (for example to play a music theory game or to compose something on a computer programme like MuseScore or Ableton Live)

Section 3: Experience of playing the game

6. How do you feel about your music theory understanding?
7. How do you think this game can change music theory learning?
8. What elements in the game do you think can help the music theory learning process?
9. How do you think the game can be adapted to improve learning?

Section 4: Difficulty of the game

10. How did you experience the difficulty level of the game?
11. Were there any elements of the game that you would change to make it easier or more difficult?
12. Would you play the game again to learn in the future? Yes No
13. Would you recommend the game to a friend if they needed help with music theory? Yes No

To access all the signed participant consent forms and completed questionnaires please follow this link: https://drive.google.com/file/d/1aT-lMJ8yOiIrvrjXxmZMBGdD-QcLAdF8/view?usp=sharing

Appendix I: Summarised questionnaire responses

Response editing													
Summarised response to questions													
Participant number	1	2	3	4	5	6	7	8	9	10	11	12	13
1	laptop	assignments	great concept	needed	convenient time-worthy	need more basic learning	changes our thinking and creativity	music context concept	NR	easy	appeal more context	Y	Y
2	laptop cellphone metronome	almost all the time	helps a lot	love the idea	shouldn't be forced, but homework is still encouraged	not too bad take a second to catch up	helps in understanding music theory adds fun and entertainment to learning	music score sounds	add more musical learning - not just the musical score	still learning not too bad	more vibe	Y	Y
3	laptop MIDI keyboard	Most of the time	highly effective uses visual and auditory learning	games are fun and addictive best way to help a student learn	okay. But would prefer game-based learning	NR	can improve music theory learning	learning the piano keys	not fun character is boring no levels or ranks	NR	personalisation popular song recognition	N	N
4	laptop Perfect Ear trainer YouTube	at least twice a week	very helpful	interesting - depending on how it is implemented and the content of the game it would be good	good fun way to test knowledge and creativity	struggling, but improving	encourage familiarisation with work will motivate us to want to achieve higher scores than before the game	needs pop-up notification of wrong answers and clues to the right ones	add a way of playing notes to identify on clef and piano	simple	maybe hearing and seeing the right answer to the notes you got wrong	Y	Y
5	laptop Perfect Ear trainer phone	always when studying music theory	easier than paper learning	repetition of gameplay will make it easier to remember	more eager to work technology makes working more effortless	decent understanding	more interactive environment different than learning with books and slides	staff to piano key conversion	more apparent GUI that shows you were right/wrong	not really difficult	different clefs	Y	Y
6	keyboard Perfect Ear trainer phone	often	assists in learning	if done right, learning can be more fun the risk however, is that it could take the fun out of gaming when it is seen as a learning tool	I would love it	fairly good struggling with some aspects	can help gain a better understanding of playing sheet music on the piano	note recognition piano keys	make it more difficult as time progresses	easy	increased difficulty levels	N	Y
7	Ableton FL Studio	often mostly FL Studio	I would feel more inclined to studying because traditional studying can be difficult and tedious	I associate games with leisure and relaxation and prefer not using it to learn	I would prefer it	it could be better improving	basic learning improved	could make use of auditory challenges and obstacles such as notes, intervals, chords or scale recognition	more fluid and realistic maybe first person perspective	wasn't really difficult musical staff looks confusing	None	N	Y
8	phone computer	almost everyday	helps a lot	will make lessons more interactive and fun	better understanding in note and chord recognition and composition	NR	help understand what was learned while learning more	piano interaction	No guidance to correct your incorrect answers - show the correct answer	easy if you have music theory knowledge	indicate the correct/ incorrect answers	Y	Y
9	computer YouTube Perfect Ear	whenever I am unsure of something	good especially when you are not in direct contact with your lecturer	good way to make lessons fun and exciting can encourage student involvement and participation	excited opportunity to learn something new and develop my skills	basic understanding - developing guitarist and drummer	better understanding more enjoyable learning experience	mechanics content	more levels choose different modes or levels that suit your learning	not very difficult	levels that get more difficult different game modes to choose from	Y	Y
10	laptop frequency checker app for singing recording app	as often as possible 90% of the time	helps with memory recall and easier access to learning information	would enjoy it would pay more attention for longer	quite happy gives chance to practice what was learned	reasonable enough to be able to play piano	can help some learners to pick up on the concepts of note recognition faster	practicing placing notes on the keyboard	remove the character and just select the notes on a keyboard	not difficult apart from note placements on the staff	notes on staff should be made more obvious and clear	N	N
11	laptop piano	always when studying music theory	happy to use it if it helps me learn, study and remember better	if balanced with traditional learning, yes as long as I move forward with my education	great if we are taught how to use it first	basic understanding	can help with improved understanding of music theory	NR	placement of notes and accidentals can be adapted to quiz format add more levels	easy	note visibility on staff character change chord/ song accompaniment to make it more fun	Y	Y
12	laptop cell phone	always	technology is a distraction and may make me want to do something else e.g. social media	it would be fun you can have fun and learn and experience at the same time	nice, but I like the practical/ theory balance	improving	exciting way to learn music theory	keyboard note recognition sharps/ flats	incorporate other instruments character change or options more levels	medium level	choosing instruments change in difficulty levels	Y	Y
13	laptop tablet phone	not a lot	I feel good because it help me learn more about music theory	it would give me more time than traditional assignments	if load shedding occurs it is difficult to complete tasks on time if using technology	improving	linked to learning outcomes so you can prepare for assessments	note recognition on the keyboard	inspector element that shows you when you are wrong	moderate	time consuming to move to DJ booth to get points if correct the booth it too far away	Y	N
14	laptop	everyday	just as useful as paper if the information is all there	could be counterproductive because gaming and learning work with different reward systems	happy more efficient work easier	very good	None	Note recognition	reward systems different piano styles different skins for character	easy	timing of notes (add rhythm) make it more difficult by adding more challenges	N	N
15	laptop cell phone	very often	okay, depends on my mood	wouldn't mind prefer game-based activities for homework	don't mind depends on resources	improving	don't feel like I would learn a lot from the game	None	more entertaining add adventurous elements	fine	boring	N	N
16	laptop phone computer	90% of the time	it helps me books are boring	does not sound appealing	alright it is quite standard nowadays	good if you have a grasp of the basics	don't know if it can	interactivity	NR	easy	No	N	N
17	phone laptop	once a week at most	prefer pen and paper	open to it if it makes learning easier	better than written assignments	basic beginner understanding	if adapted it would make learning easier	keyboard note selection	more instructional prompts and game modes	easy	remove character and club scene just make it a piano and score add rewards and points	Y	Y
18	laptop keyboard piano	most of the time	helps improve my understanding of note recognition	will help make learning more enjoyable and push students to keep trying when they get answers wrong	good challenges my creativity and helps me figure things out on my own	developing need to take time to study sometime I get confused	yes and no if improved it can help with note recognition	piano on the floor sheet music note recognition	NR	easy	more graphics more clefs	Y	Y
19	laptop YouTube Ableton Live ProTools	Every time I study	without tech I would struggle a lot more	could help students who struggle with music theory	would love it more fun to learn	not the best basic understanding lot to improve on	seeing both the score and keys will help with note identification and confidence in music theory skills	notes and keys points system ability to redo if you get it wrong sound of note when selected	difficulty levels leader boards multiplayer options practice mode	not too hard if you know the basics	add a timer difficulty levels	Y	Y
20	laptop	50% of the time tech used for note taking	positive tech helps me by making note more readable than handwritten notes	good for class environments - will compliment learning at home it would just be a distraction	good feels like I want to say "challenge accepted" opportunity to improve my skills could be problematic if students don't have access to tech at home	basic understanding do not remember much from content	can help with student inclusion and interest, especially for students with learning disabilities	selection and identification of note motivation gained from scoring system	more interesting personalised avatars more interactions	easy if you have basic music theory knowledge	more interactive more interesting boring difficulty levels	N	Y
21	laptop iPad	about once a week	helps a lot struggle with music theory learning in a book	more fun better memory recall visual stimulation	better than written assignments	quite well	good for practicing note recognition on the treble clef	movement interactive keyboard learning in a different way	longer keyboard that corresponds with the amount of notes in the staff bigger notes ion the staff	very easy boring after time not a lot of competition	more competition background music character more interesting	Y	Y
22	Perfect Ear cell phone	rarely only when using the Perfect Ear app for practice	could be helpful if not the main learning method	should be used rarely, not a main form of learning	fun if for extra learning activity now an then not for regular homework	decent understanding guitar (2-3 yrs)	helpful for visual learners more for secondary practice than primary learning	interactivity tangible not just reading in a book	improve graphics more interesting	very easy	longer piano	N	Y
23	laptop Perfect Ear phone	3-4 times a week	makes learning easier more information than a book more to offer than books	good if aligned with school content will help learn and understand better and easier	good because it is practical opportunity to learn and practice more	intermediate	can help understand music theory better more practical learning	background music better graphics	rewards	easy	more realistic	Y	Y
24	iOS apps for music theory training - aural trainer; music tutor; aural wiz YouTube	almost everyday more fun and interactive	positive easier to remember and recall information	great idea apply to only a few sections of learning, not all the time	like it love the idea note everyday or for every activity	good but not confident	consistent repetition of playing the game can provide a better understanding boring after a while	piano keys staff interaction points	NR	easy if familiar with basic music theory content	time limits	N	Y
25	note transcription apps	most of the time	very useful shouldn't be overdone	great idea game is fun and interactive	would enjoy especially if it linked to software e.g. Muse Score to track progress and develop personalised ideas	decent understanding	can be great if updated/ changed	interactive 3D environment	free roam earn currencies through learning so you can build and customize your environment	decent/ easy	time limits game forum competitive environment	Y	Y
26	laptop phone	everyday	helps a lot for studying and research	would help to learn better more engaging and interactive	enjoy homework like this	basic understanding grade 1 piano theory before SAE can improve	can make music theory more fun and interactive	visual activating the notes (movement) helps learn and remember faster	polish it up a bit make it easier to interact with	not too difficult functionality issues make it difficult	easier if user interface is improved sound design can make the experience better	Y	N
27	laptop YouTube	always YouTube videos used to reinforce learning	depends on the technology laptop and YouTube helps me	distracting	would not work for me can find more info in books and journals technology limits your amount of resources	not good 40% improving	can help with faster note recognition and memorisation	simple straightforward it asks what is required and delivers a response immediately	improve graphics add background music	difficult for me easy if you understand music theory	difficulty levels more interesting more competitive improve graphics	Y	Y
28	laptop phone	almost always	teach make it easier to learn and study	would not mind if there is more traditional learning than game-based learning	would not mind	not confident	it would change my learning for the better by increasing my will to learn (motivation) and help with better memory and information processing - I am a visual learner	better point system incentives/rewards (motivation)	improved graphics easier navigation comment/ complements (feedback)	fair (medium)	No	Y	Y
29	phone Perfect Ear	at least twice a week	great way to remember	good idea to an extent learning shouldn't be only game-based	not the same game/ technologies everyday	improving	more creative and enjoyable learning easier to memorise	keyboard staff	more enthusiastic and interesting	easy	add more notes to the staff	N	Y
30	aural training app	sometimes online music quizzes	useful I prefer pen and paper	absolutely not music theory can't be translated through games	happy to compose on Muse Score I prefer to write sheet music on paper	very good	I don't think it can it is a bit boring and childish	notes on the staff	changes: - scene - graphics more sound more interactive	not difficult at all	change everything, the game is inefficient	N	N
31	computer phone Perfect Ear Clefs (app)	10% of studying with technology	definitely useful implement more easy access most apps have everything I need	can be beneficial to create a different learning experience unique learning method improves enjoyment and memory recall	ideal for homework - increased productivity	intermediate no prior experience	good for efficiency in note identification	movement onto keyboard (interactivity)	could improve it is more interesting than traditional learning adds the objective of being able to score more points than before	very easy and simple	increased difficulty levels after correct answers red light on wrong keys no more movement to the DJ booth	Y	N
32	EarMaster	Playing an listening to each note on applications	great visual and auditory stimulation	great - if not competitive	cool and easy if I'm familiar with the technology	great now able to understand and read notes	will help with ability to hear and know what notes you are playing correctly	sound	will improve if not competitive	NR	add background music/ sound	Y	Y

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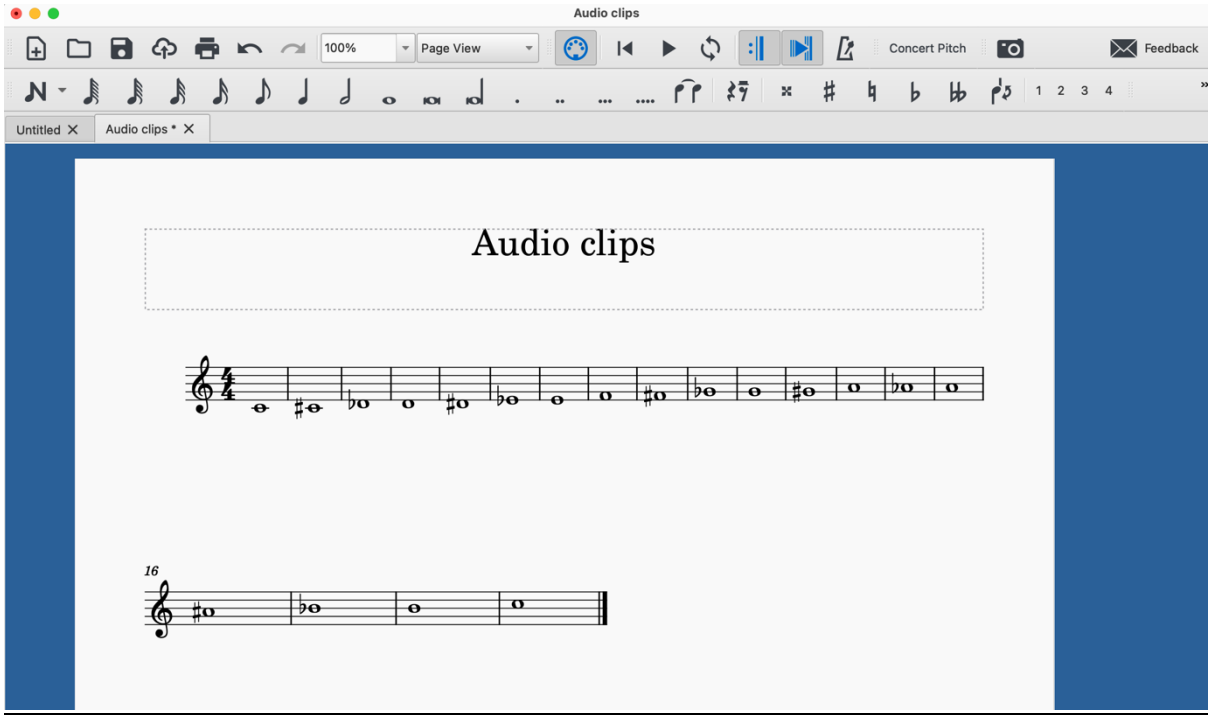
Appendix J: Music theory game resources

a. The following link contains all the resources provided to the game developer before and during the game development process:

https://drive.google.com/drive/folders/1yH081aMSI9DfJIz7OM6tvIVPt3wKHZAE?usp=sharing

b. MuseScore audio clips development process

1. MuseScore opened up and a new session created with a Treble clef and a 4/4 time signature.
2. Each note value inserted onto the staff as whole notes (4 beats each)



3. Each note exported as a .wav file and uploaded to the following google drive link: https://drive.google.com/drive/folders/1EWwR543GtxDMQzT1r99gXl5fn2zRhpQV?usp=sharing

Appendix K: How to download the game files

The following link can be used to access the downloadable .zip files:

https://drive.google.com/drive/folders/1SynyrA0dbE2GrXQJBOYblfzEPq9sl70D?usp=sharing

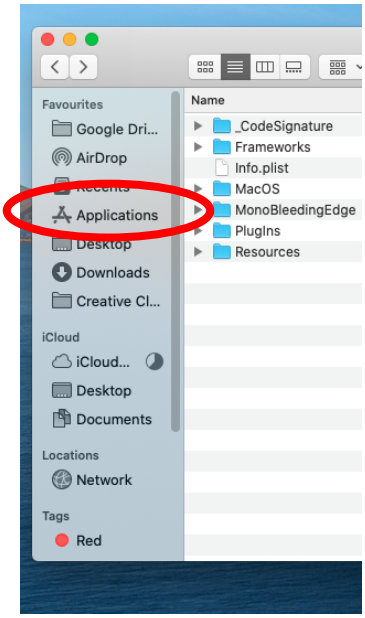
Once downloaded procees to opening the files.

To open the game file on Windows simply unzip and open the file.

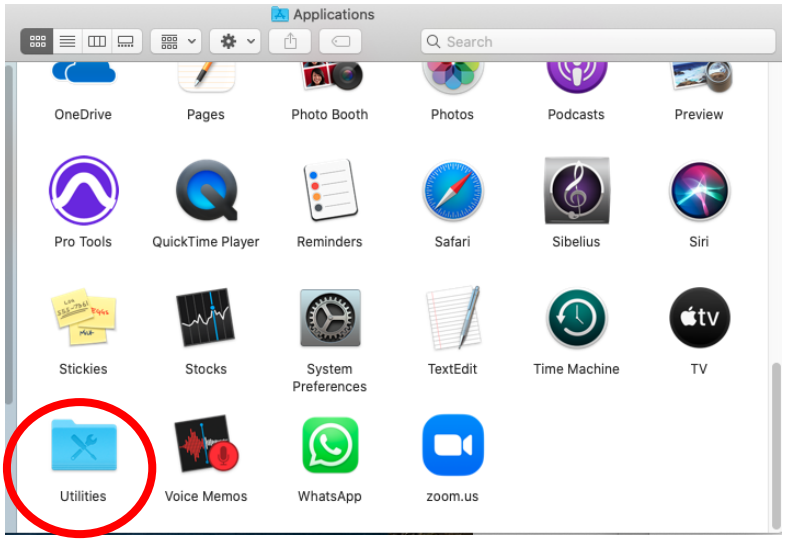
To open the game file on Mac, please follow the steps below:

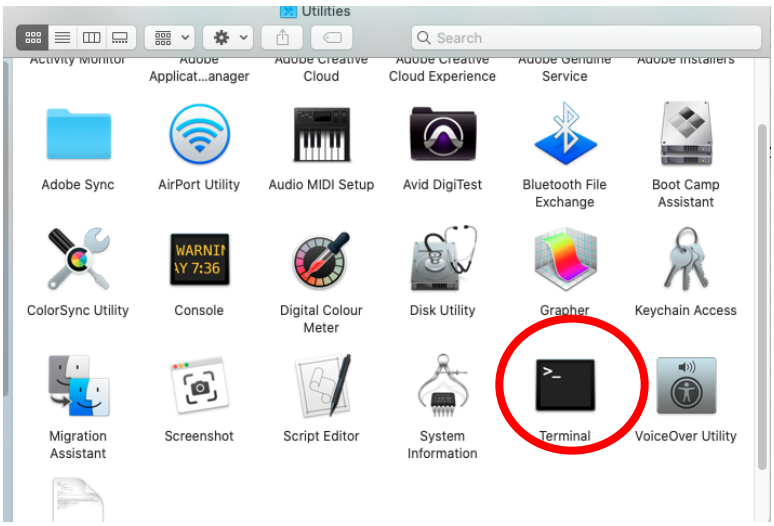
1. Download the zip file labelled “macbuild1app.zip”
2. Unzip the file
3. Open the Terminal on Mac
   - Go to your finder menu

- Click on Applications

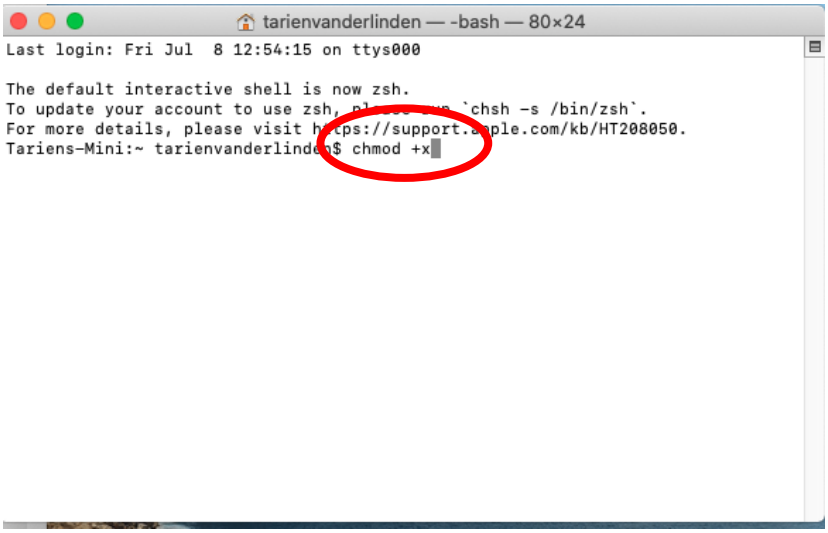


- Go to the Utilities folder and open the Terminal application

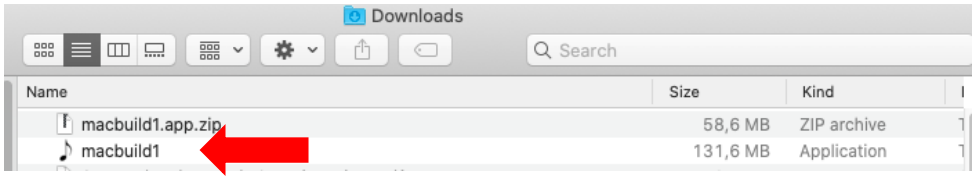




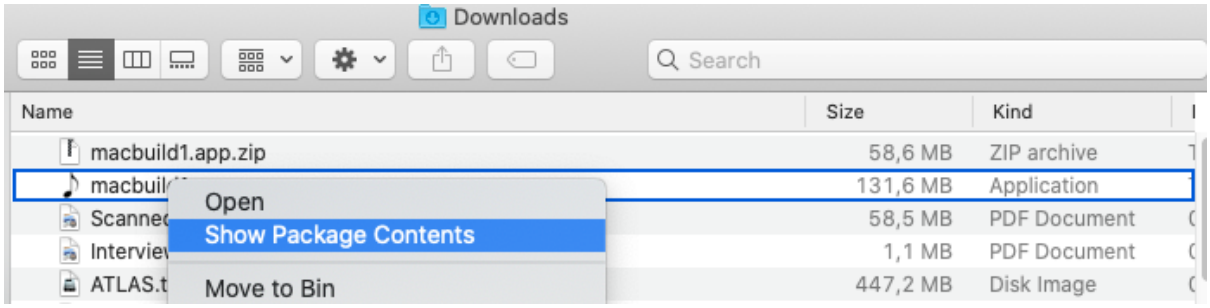
- In the terminal type (without the quotation marks) “chmod +x”



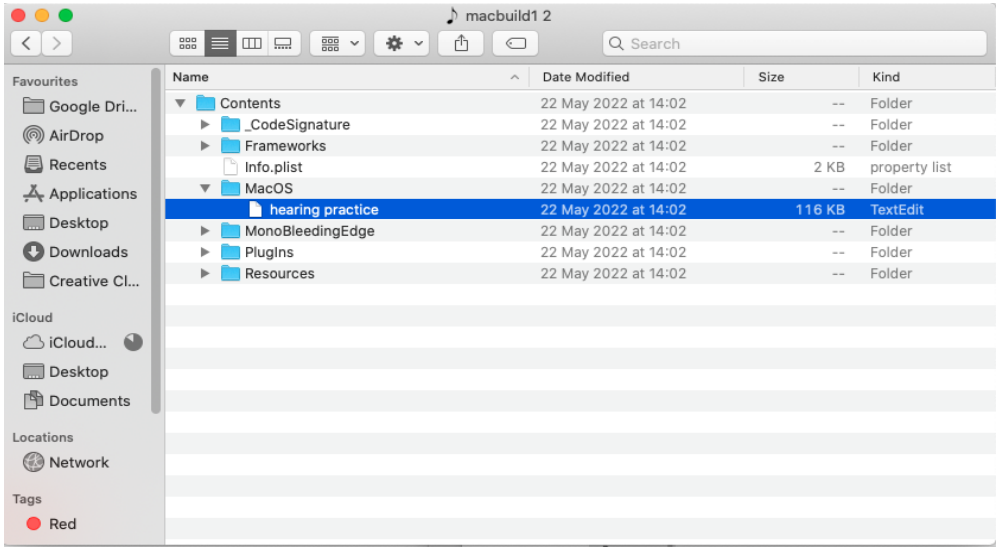
4. Go to the unzipped game file in the Downloads folder

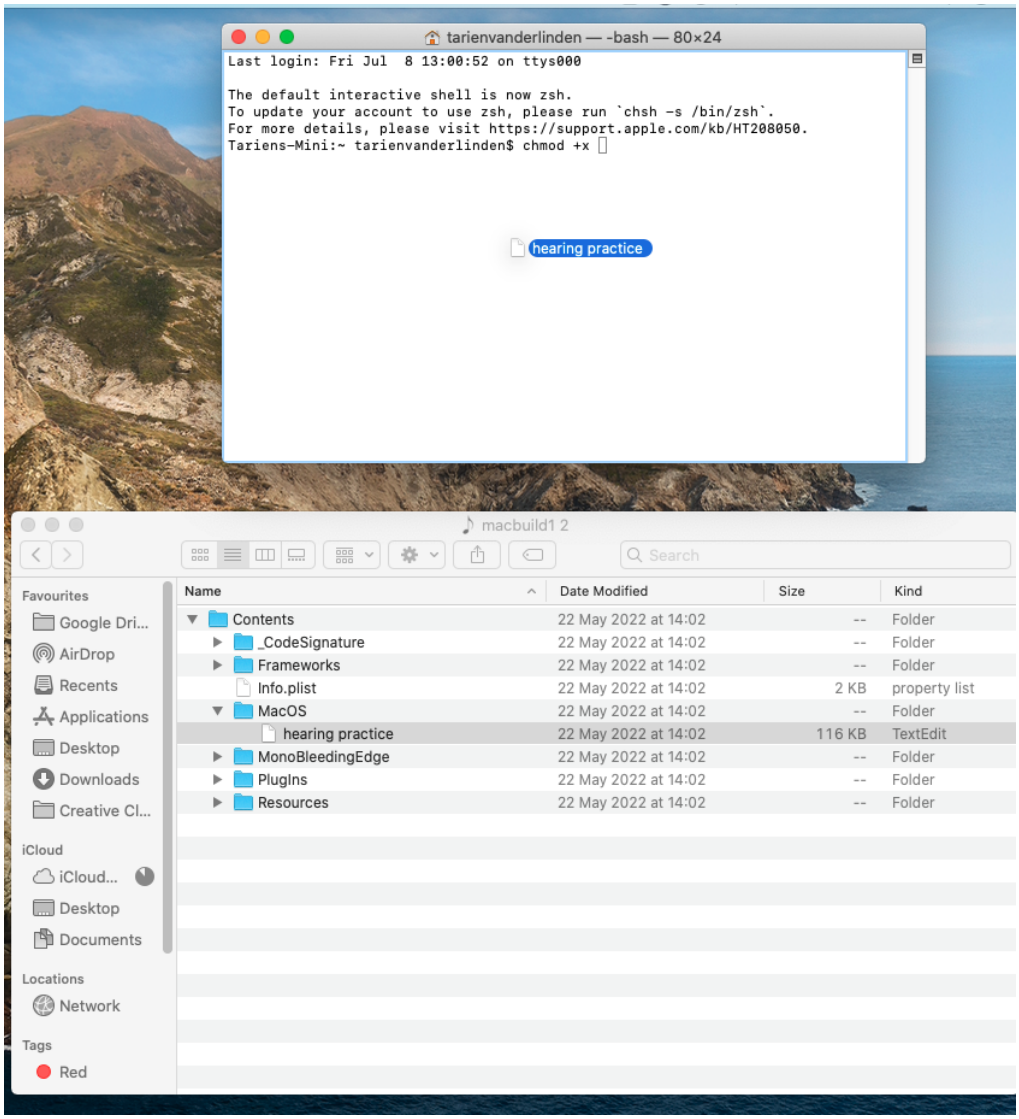


5. Right click on this file and click on “Show Package Contents

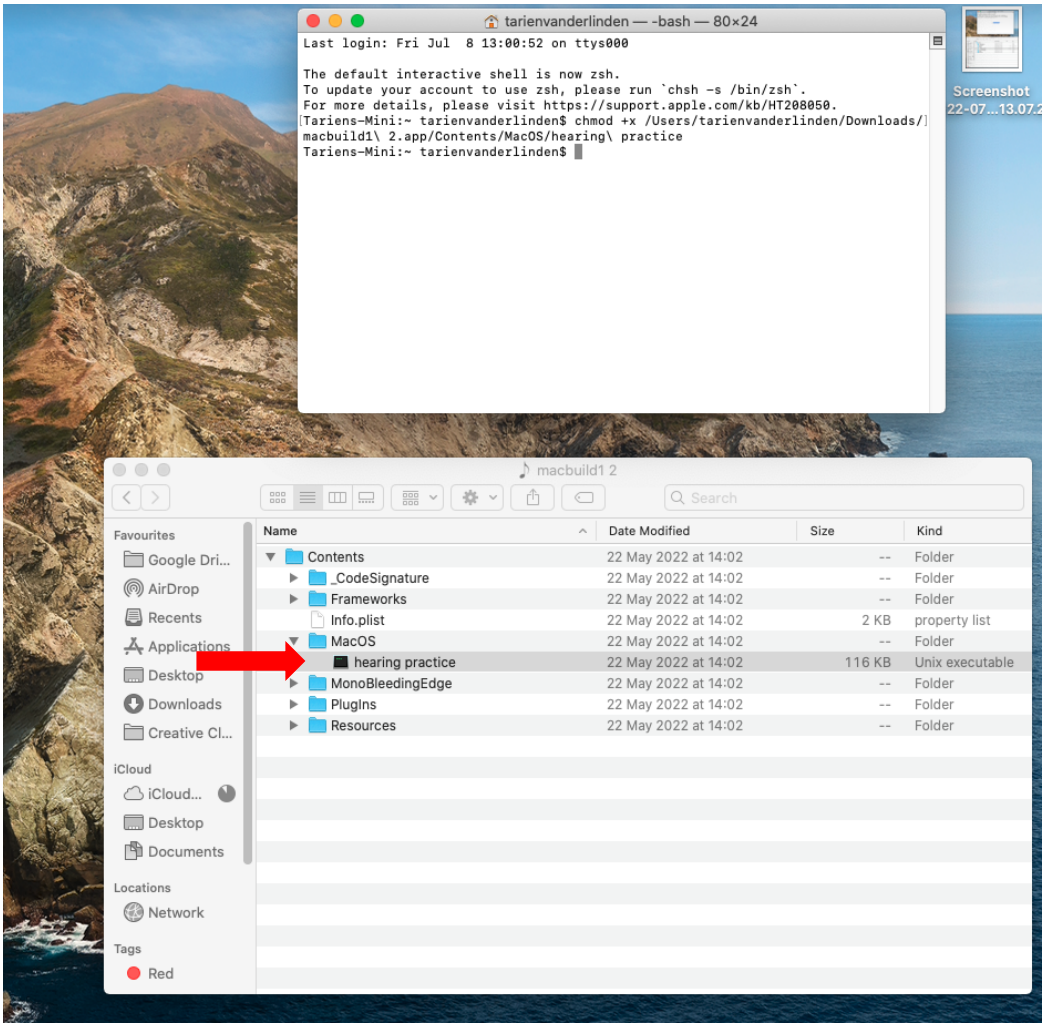


6. Go to “Contents” > “MacOS” and drag the file named “hearing practice” into the terminal



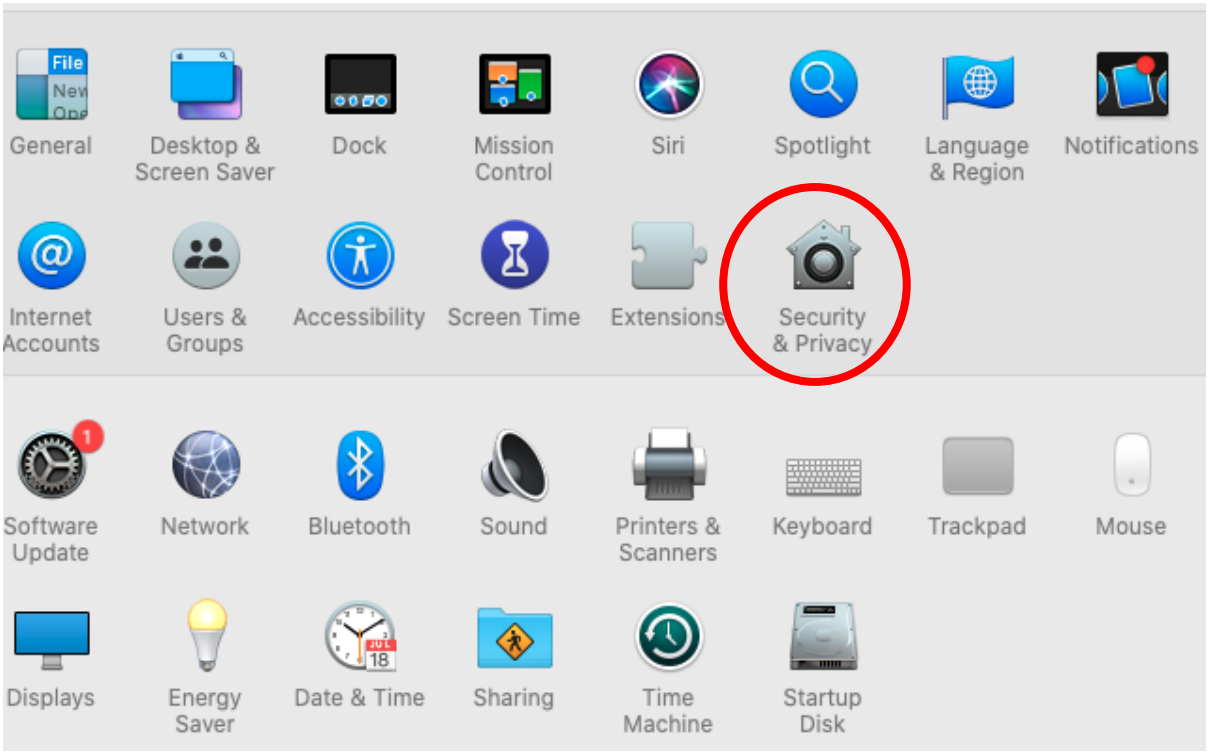


7. Press the enter key in the terminal
    - You will see the hearing practice file icon changing to a black box containing the abbreviation “exec”



8. Double click on this file to open the game
   - If the game does not want to open due to it being downloaded form an unidentified developer follow the instructions from point 9.

9. Go to your System Preferences and click on the “Security & Privacy” icon



10. Go to General and Click on the button that says “Open Anyway”
11. Go back to the game file an double-click to open the file

Appendix L: How to play the developed game

1. Open the game file
2. Press START
3. Use the arrow keys to move the character around the space
4. Look at the staff at the bottom of the screen and try to identify the indicated pitches
5. Move your character to the keyboard on the floor and step on the correct key that corresponds with the notes in the staff
6. Once you found the correct keys, press SHIFT to select the.
   - Once selected the key will turn green and the note will be heard through your speakers or headphones
7. Once you have selected both keys, move to the DJ booth and press the SPACE bar to see whether you were correct and get points
   - If you are correct, you will get 1 point in the top left corner and the staff will change
   - If you are incorrect no points will be added and the staff will remain the same. Try again.

Appendix M: How to open the source files of the application development

The following link can be used to access the .zip file containing all the game development files:

https://drive.google.com/drive/folders/181N5WvYdxImndVOaqERf5ZQo1u7LunOr?usp=sharing

Appendix N: Drive link to all development, ethics and analysis documents

The link below contains the following files:

- Developed game
    - Accessing the game development files
    - Game build (Exports)
    - Game development files
    - Opening the Unity game file
    - Playing the developed game
- Codebook
- Consent forms and Questionnaires
- Focus group transcription and codes
- Institution Information letter and Consent
- Interview analysis
- Interview transcript confirmation
- MOA Collaborator and Researcher
- Questionnaire edited responses

To access these files, click on the following link:

https://drive.google.com/drive/folders/10Qr91tXaTXBcvJcVZalVWN2aVsD5CuqE?usp=sharing

Appendix O: Descriptions of existing music theory games

Musictheory.net and Tenuto

Musictheory.net is a website that provides players with free online music theory lessons and the option to purchase their enhanced exercise application, Tenuto, on your mobile device (Musictheory.net, 2000-2021). It offers multiple lessons and exercises on music theory basics (like note values, clefs, rests, etc.) to advanced musical harmony, with a focus on aural training and development. Exercises are set up to display note names or note values and ask the player to select the correct answers based on the exercise output (Musictheory.net, 2000-2021).

Musicards

Musicards is an online platform that provides learners with note recognition flashcards. These flashcards focus on practising recognising note names on the treble-, bass-, alto- and tenor clefs (musicards.net, 2002-2022).

Theta Music Trainer

Theta music trainer is a website with a catalogue for ear training and music theory games focused on the pitch, tonality, scales, intervals, and more. Each of the activities in this catalogue has a specific learning outcome that helps increase the learning experience.

EarMaster

EarMaster is music theory software that teaches the fundamentals of music theory. Even though this software is a commercial product, there is a free version which gives

access to the beginner's course. This software provides multiple lessons and exercises relating to beat, rhythm, note recognition, and instrumentation, amongst others (EarMaster ApS, 1996-2022).

Solfeg.io

Solfeg.io is a music education app which students can easily access by signing up for free. The app works well when incorporated into a digital, interactive whiteboard, for the app has a library of various popular songs and includes the complete notation for vocal and instrumental parts. The app allows you to mute certain voice parts in the music to help focus a specific part and also illustrates the various sections of the songs that are being played (Sia Solfegio, 2020).

PerfectEar – Ear Trainer

PerfectEar is a free mobile app used as an exercise platform for aural training skill development. It includes topics of note names, note values, intervals, chords, and more. The website-based app for Perfect Ear, called T*one Savvy,* can be accessed by the teacher if subscribed, to set assignments and check student scores online (Crazy Ootka Software AB).