How Difficulty Affects Player Engagement in Digital Games

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Bachelor of Information Technology
Graduate Diploma in Screen and Media

Supervised by Dr Brett Wilkinson

Submitted to the College of Science and Engineering

in partial fulfilment of the requirements for the degree of

Master of Information Technology

College of Science and Engineering

Flinders University – Adelaide Australia

2020

Keywords

Challenge Level; Cognitive Evaluation Theory; Digital Games; Difficulty; Dynamic Difficulty Adjustment; Flow states; Game engagement; Player engagement; Self Determination Theory; Video Game Design; Video Game Difficulty; Theory of Flow.

Abstract

It is anecdotally known that game difficulty plays a significant role in determining player engagement with digital games, yet no consensus has yet been reached on the exact nature of this relationship. Scholars investigating this link typically focus their studies around already established psychology research in broader theories investigating intrinsic human motivation. The psychology field's 'Theory of Flow' is the currently accepted standard by which this relationship is investigated, yet the exact nuances of this association require considerable future research. This study proposes an experiment approach which can be utilized to investigate this relationship directly, providing valuable insight into this important area.

A video game was created for this purpose, which tracked gameplay metrics, player demographic variable data and game engagement data. This data was then analysed and investigated to determine this experiment approaches ability to discover the exact nature of the relationships therein. This study also provides some tentative discoveries into which demographic variables may be integral in deciding a player's propensity to be engaged with a digital game.

With a stronger understanding of which attributes contribute to a player's enjoyment and engagement with a digital game, developers will be able to produce higher quality products, able to capitalize on these relationships. This research informs future work to utilize an experiment approach like that proposed in this study. This approach can be used to determine the specifics of how difficulty affects player engagement in digital games, and how game developers can enhance the enjoyment and longevity of their products.

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: [removed]

Date: 06/11/2020

Acknowledgements

I would like to thank first and foremost my supervisor, Dr Brett Wilkinson, for his unending patience, constant reliability and willingness to go above and beyond for any of his students. His passion is contagious and always reminded me how exciting this project was to work on. I would also like to thank my mother, Dr Julie Mitchell and her partner Mr Ian Hendy-Pooley for their constant support and encouragement, even when my panicked phone calls regularly interrupted their dinner time. Thank you to Mr James Keal for aiding me throughout the project with interpreting complicated statistics in prior works and for assisting me in navigating the foreign world of Python data visualization libraries. Finally, thank you to all of the anonymous participants who gave up their time to participate in the study. It wouldn't have been possible with you.

Chapter 1: Introduction

This chapter provides a narrative to introduce the thesis (section 1.1) then outlines the background and context (section 1.2), research goals (section 1.3) and purpose (section 1.4) of this research project. Finally, section 1.5 includes an outline of the chapters included in this thesis.

1.1 INTRODUCTION

Modern day gamers often look to video games of the past for nostalgia. It is not an uncommon anecdote for gamers to sentimentally announce their disdain for the difficulty of modern day games, for 'back in their day, games were so much harder'. Although likely fuelled purely by nostalgia and ego, this anecdote actually does highlight an important locus of uncertainty which haunts many modern day game developers midnight sessions of rumination. This locus includes such questions as; "Is my game too easy? Will anybody want to play this if it's too hard? What can I do to make this game more engaging for players? Have games really gotten too easy?".

Despite this common anecdote, we can actually find a recent trend of popular video games which deliver extreme difficulty as part of their suite of primary features to attract players and keep them engaged. These titles include games such as 'Super Meat Boy (2010)', 'Flappy Bird (2013)', the 'Souls' series (2009 - 2018), 'Getting over it with Bennet Foddy (2017)', 'Jump King (2019)' and many more.

So why is it that experienced gamers and casual gamers alike, regardless of gaming platform, seem to often be attracted to games with extreme difficulty? Why is the opposite also true? Why do so many people also flock to relaxing games like 'Animal Crossing (2020)' and 'Stardew Valley (2016)'? What role does difficulty have in motivating a player to have continued engagement with a game?

1.2 BACKGROUND AND CONTEXT

This study investigated the nature of any existing relationship between the difficulty of a digital game and how engaged players are with that game. Research into intrinsic human motivation has been pursued in the field of psychology and philosophy for many years (Chen, 2007). At the pinnacle of this research exists the 'Csikszentmihalyi's Theory of Flow' which poses that to optimize engagement with a task, the challenge level of the task must be appropriate to the capability of the user engaging with that task (Holt, 2000). When it comes to research investigating the relationship between difficulty and engagement in digital games, researchers typically call upon this theory of 'flow' to explain the relationship (Sarkar & Cooper, 2019). Flow is still the standard by which we research engagement in digital games. This is despite many research projects discovering a far more nuanced relationship between difficulty and engagement. These nuances include such varied attributes as player demographic profiles (Fraser et al., 2014; Pérez et al., 2015), player autonomy (Leiker et al., 2016; Smeddinck et al., 2016), player's self-perceived competency (Alexander et al., 2013; Schmierbach et al., 2014) and dynamic versus static difficulty adjustment (Altimira et al., 2017; Missura & Gärtner, 2011). Theories from the field of psychology used to investigate intrinsic human motivation are also commonly applied to this area, with *Self-determination theory* (SDT) and *cognitive evaluation theory* (CET) (Przybylski et al., 2010) amongst the most popular. However, attempts to quantify either difficulty or engagement in the context of video games has still reached not reached a true consensus on a formal definition for either 'difficulty' (Aponte et al, 2011) or 'engagement' (Schoenau-Fog, 2011).

1.3 RESEARCH GOALS

This study contributes towards addressing the key knowledge gaps in this area by conducting first hand research from the position of a game design researcher rather than from a psychological perspective. To achieve this, this study proposes, and validates an experiment approach which is able to gather data to address some of the major research gaps in the area. If future researchers are able to utilize this

experiment approach to discover that difficulty as a standalone metric has a considerable influence on player engagement, or identify which demographic variables are major contributors to engagement, this could significantly impact the current hierarchy of priorities game developers hold on game design elements for player engagement.

The research goals of this project are broken into the following three objectives:

1. *To propose and validate an approach to identify the relationship between game difficulty and player engagement in digital games.*

For the purposes of this research, a digital game was developed with a variety of difficulties, and participants were asked to first fill out a demographic questionnaire. They were then asked to play the game, after which they filled out a 'game engagement questionnaire'. The game itself tracked gameplay metrics such as how difficult players found the game to be (or at least, how much they struggled to succeed), the number of times the player restarted the game and which game difficulties the game was played on. The metrics collected by the game were compared with the results of the participants' post-game engagement questionnaire to investigate the prevalence of a relationship between the game's difficulty and reported levels of player engagement.

2. *To contribute data towards quantifying difficulty and engagement in digital games*

Metrics and telemetry data collected during gameplay were used to quantify the level of difficulty of the game and the perseverance evident in players. The in-game metrics, telemetry and post session survey were used to determine how often the player replayed, or retried the game and how satisfied they were with the

experience. These two data groups were used to address the second research objective.

3. *To identify and measure the relationship between select player demographic variables and player engagement.*

Player demographic data was gathered through the pre-game demographic survey filled out by all participants. This data was used to provide comparisons between participants, identify relationships between select demographic variables and engagement, and to potentially suggest player type similarities.
After conducting an in depth literature review and discovering that 'Csikszentmihalyi's Theory of Flow' was the standard by which the relationship between difficulty and engagement are researched in digital games, the ultimate research hypothesis of this project was that:

'*Appropriate difficulty enhances player engagement through establishing a flow state in digital games'.*

1.4 PURPOSE

The primary benefit which this research brings to the game development process itself, is reframing the current typical hierarchy of game elements which developers understand impact player engagement. There is quite some conjecture on exactly which elements impact player engagement in a digital game, however through using the experiment approach proposed in this study, researchers will be able to collect data which can indicate which attributes play the most essential roles in player engagement. This will be of benefit not just for our understanding of how game elements impact player engagement, but it will reframe the existing static approach developers use when planning games using a 'game design document'. Another point of value this project brings to the field of game design

research, is that it may re-frame the current trend in research from being an adaption of human motivation from a psychology research background, towards a more game design specific focus. The potential commercial benefits for the game industry from this research may be of great value, as a major focus of the game market revolves around player engagement. Having a better understanding how we can impact player engagement as game developers could change how games are designed from the ground up.

1.5 THESIS OUTLINE

This thesis is broken up into 6 major chapters, starting with this introduction (Chapter 1) followed by the full literature review (Chapter 2). The methodology behind the design and development of the research tool is then covered in Chapter 3. Chapter 4 outlines the research design and experiment process. Chapter 5 then breaks down the results gathered through running the experiment and provides a preliminary analysis of the data gathered throughout this project. Final statements about the limitations, success and the contributions made by the project are summarised in Chapter 6.

Chapter 2: Literature Review

This chapter contains the full review of this thesis. It begins with a historical background (section 2.1) then outlines some of the important research trends in the field of player engagement in digital games (section 2.2). After this, studies linking game difficulty to player engagement are detailed (section 2.3), followed by prominent research trends into dynamic difficulty adjustment (section 2.4). Studies which have worked to define 'difficulty' (section 2.5) and 'engagement' (2.6) are then investigated. Finally, section 2.7 provides a summary of this chapter and outlines its implications.

This literature review illustrates the significance of this project as related to current game design research trends. Scholars investigating a relationship between a digital game's difficulty and the engagement of players typically focus their studies around already established psychology research in broader theories investigating intrinsic human motivation. Research into dynamic difficulty adjustment (DDA) has touched upon the relationship between engagement and difficulty, however a lack of research into precisely defining difficulty as a measurable parameter in digital games has been observed by researchers. Despite many studies in cognitive psychology exploring a relationship between the challenge level of a task and how motivated subjects feel to engage with the task, a research gap exists in applying this concept to digital games. If it is discovered through this study that difficulty as a standalone metric has a considerable influence on player engagement, this could significantly impact the current hierarchy of priorities game developers hold on game design elements for player engagement.

2.1 HISTORICAL BACKGROUND

The human fascination with playing games and having fun has been a focus of study and interest that can be traced as far back as Aristotle, when he posed that personal happiness and pleasure are what we seek above all else (Chen, 2007). For the relatively young field of digital game design research, when investigating why

we play games, scholars typically call upon the wisdom of the much older academic field of psychology; specifically in the area of intrinsic human motivation (Holt, 2000).

Throughout the 2000's, when it came to investigating player engagement, the term 'player engagement' itself was used with extreme non-specificity to describe a wide range of concepts including enjoyment (Hunicke, 2005), self-reported levels of 'fun' (Chanel G., 2008), time spent simply interacting with a game (Fischer & Benford, 2009), immersion (Qin et al., 2010), or even simply the number of times the game is played (Sampayo-Vargas et al., 2013).

It is worth noting that a minor trend in research also took place, in which a player's physiology was monitored while they played games of varying difficulties, in order to assess how they were affected by the experience physiologically. This can be seen in Liu's 2009 study, which revolved around player profiling generated by physiological data of how anxious a player felt at any given moment and adjusting the difficulty accordingly (Liu et al., 2009). Girouard's 2009 study which monitored player brain activity while they played various difficulties of the game 'Pac-Man' also demonstrated this trend, and was somewhat successful at identifying which difficulty the player was playing on based on the collected data alone (Girouard et al., 2009). Following this trend, the physiology of players was monitored through EEG based emotion recognition in Park's 2014 study, which presented a novel difficulty control system based on the recognition of the players emotions (Park et al., 2014). Bianchi-Berthouze also later investigated the physiology of players' body movements as they interacted with games as an indication of engagement, concluding that player engagement can be enhanced by using controllers which better support the body's natural movements (Bianchi-Berthouze, 2013).

2.2 RESEARCH TRENDS IN PLAYER ENGAGEMENT STUDIES

Despite early research such as Holt's 2000 work equating player engagement to be linked to a psychological 'flow state' (Holt, 2000) and Chen building upon this

research (Chen, 2007), it wasn't until around 2010 that a research field standard developed, with scholars effectively calling upon existing research into intrinsic human motivation to investigate player engagement.

It was in works such as Przybylski's 2010 study, which investigated a player's motivation to engage with a game by calling upon the psychological models of *self-determination theory* (SDT) and *cognitive evaluation theory* (CET) as a basis for their research, that we begin to see this trend develop (Przybylski et al., 2010). In the context of player engagement, CET is used to pose that player motivation is rooted in satisfying a fundamental need for *competence*, *autonomy* and *relatedness* (Przybylski et al., 2010), while SDT is used to look at why players are *intrinsically motivated* (engaging with the task for its own sake*)* to play video games, as opposed to being *extrinsically motivated* to engage with a game by some form of end state (Przybylski et al., 2010). Their research ultimately concluded that video game engagement can be effectively studied through the lens of SDT and CET (Przybylski et al., 2010). Harrigan also arrived at similar conclusions, including that a players sense of autonomy enhances their engagement, but they arrived at these conclusions through the focus of existing research in slot machine game design and how these strategies in enhancing player engagement could be applied to non-slot machine games too (Harrigan et al., 2010). This research field was also further validated by Orvis, when their 2008 study discovered that there indeed does seem to be a link between the difficulty of an educational game and a player's motivation to have continued engagement with it; however it must be noted that this research was focused solely on the field of educational games (Orvis et al., 2008).

It was in this same era that we can see papers, such as Qin's 2010 study, begin to arrive back at the idea of 'flow' to evaluate game engagement as was outlined in Holt's previously discussed 2000 work (Qin et al, 2010). It is through this idea of game engagement revolving around 'flow states' that the strong relationship between a game's difficulty and its potential to engage players emerges. Csikszentmihalyi's theory of 'flow' poses that for a player to become enthralled in

a ‘flow state’ (a state of intense engagement / immersion) the challenge level of a task (its difficulty) must maintain a fine balance with the individual’s level of competency (Chen, 2007).

2.3 LINKING GAME DIFFICULTY AND PLAYER ENGAGEMENT

While flow had by now become the primary focus of research into player engagement, investigations into its links with difficulty had begun to be theorized. Research into exactly what ‘difficulty’ was conceptually within video games was still ongoing, and papers such Aponte’s (2011) work were still attempting to formally define what ‘difficulty’ is in this context. As we can see through Aponte’s literature review, there was still a clear lack of a precise, formal definition of difficulty at the time (Aponte et al, 2011). Juul (Juul J., 2009) had also previously investigated the issue, and interestingly in their research appeared to arrive at the discovery of flow states without having directly researched flow, outlining their observation as follows:

> “I initially discussed a contradiction between the observation that players want to win and the observation that players prefer games where they lose some, then win some. This leaves us with several opposing considerations indicating that games should be both easier and harder than they are” (Juul J. 2009, pg. 9).

This discovery further validates flow states as a path of research into player engagement, as it appears that multiple avenues of research into game difficulty will arrive at the discovery of flow states, even if the research doesn’t approach the problem from the perspective of intrinsic human motivation. Additionally, it also validates the research area of quantifying difficulty as very much requiring significant future work.

2.4 RESEARCH TRENDS IN DYNAMIC DIFFICULTY ADJUSTMENT

Despite these researchers’ best efforts, the term ‘difficulty’ in the context of video game studies still remained formally undefined. However, research into difficulty had exploded in popularity, with the caveat that this popularity was in the very

specific direction of Dynamic Difficulty Adjustment (DDA). DDA is the method of adjusting a games difficulty over time (usually based on player performance metrics) rather than using static difficulty selections such as ‘easy’ and ‘hard’ modes (Kuang & Lextrait, 2012). This research included discoveries such as Missura and Gärtner’s 2011 study which concluded that DDA often performed almost as well (and occasionally superior) to a static difficulty system in a game and was worthy of future research (Missura & Gärtner, 2011). Um had also previously investigated the area of DDA in their 2007 study, however rather than investigating the area from the perspective of player engagement, this paper simply looked upon the problem from a software development perspective of enhancing the product lifecycle of a game through the use of DDA (Um et al., 2007). It is worth noting that Hunicke’s older 2005 paper, had also investigated the area of DDA with a focus on how to dynamically adjust a games difficulty without disrupting the player’s experience (Hunicke, 2005).

With this popularity in the research area, many novel approaches to designing DDA systems began to emerge. This is evidenced by the approach Yin took in their 2015 study, which investigated DDA by developing a somewhat successful DDA model which was based around training an artificial neural network with player data which would dynamically manage the difficulty of the game (Yin et al., 2015). Jennings-Teats proposed another novel DDA model in their 2010 paper, which looked at the impact of level design on difficulty. Their model was named ‘polymorph’, and it dynamically changed the actual terrain and obstacle layout of the game, rather than simply adjusting difficulty related metrics as they claim the majority of existing DDA models did at the time (Jennings-Teats et al., 2010).

Contrary to some DDA research, such as Altimira’s 2017 study which found DDA to be superior to static difficulties in enhancing player experience (Altimira et al., 2017). However, while investigating autonomous difficulty selection in their 2016 study, Leiker arrived at the conclusion that autonomy over which static difficulty a player played the game on, resulted in higher levels of player engagement than a typical DDA model (Leiker et al., 2016). Smeddinck’s 2016 research also

investigated autonomous difficulty selection, arriving at the same conclusion; that players preferred the game if they were able to choose their difficulty (Smeddinck et al., 2016). These results provided more evidence towards player profiling and SDT / Flow directed research being very valuable in the pursuit of player engagement. Contrary to these results, Khajah, in their 2016 study, arrived at the conclusion that covert difficulty adjustments, that is, changing the difficulty of the game without informing the player, resulted in superior player enjoyment levels than overt difficulty adjustments (Khajah et al., 2016). A potential explanation for these differing results can be found in Lomas' 2017 study, which discovered that the impacts of a self-selected difficulty system on player motivation depends on the actual difficulty being selected. They found that moderately difficult selections resulted in higher motivation, while in blind difficulty assignment; easier difficulties were more motivating (Lomas et al., 2017). This study analysed the problem in great depth, discovering that the act of merely labelling difficulties affected player engagement, and that a player knowing that they are playing the easiest difficulty of a game detracts from their overall experience and engagement. This study points out that they were never able to specifically identify any way in which difficulty itself impacts player motivation.

Debates over the advantages and disadvantages of DDA systems were growing stronger, and Alexander attempts to tackle the problem in their 2013 study by directly comparing the two (Alexander et al., 2013). Amongst a variety of fascinating results, they discovered that player enjoyment (and potentially engagement) was greatly bolstered by how well the players felt they performed, with a higher performance resulting in a higher reported level of enjoyment of the game. Their results were consistent with the theories of SDT / CET and Flow, demonstrating that these theories of intrinsic human motivation may still be our strongest theories for investigating player engagement and difficulty.

2.5 DEFINING 'DIFFICULTY' IN DIGITAL GAMES

While DDA research was beginning to take the forefront position in the field of game difficulty research, other generalised investigations into difficulty were still

ongoing. One such was Fraser's 2013 study which looked to define exactly what game elements contribute to difficulty, ultimately identifying a set of contributors including the behaviour of non-player characters, item placements and similar metrics (Fraser et al., 2013). Wehbe also conducted a comparable study in 2017, identifying which factors of a 'platformer' game contribute the most to its overall difficulty (Wehbe et al., 2017). Berseth in 2014 similarly looked at difficulty through level design, mapping out what paths players chose to take through levels (and the locations of failures) to map out what and where difficulty was most prevalent (Berseth et al., 2014). Building off of their 2013 paper (Fraser et al., 2013), Fraser in 2014 conducted another extremely similar study to discover which gameplay factors most introduced difficulty, but expanded upon the original premise by also investigating how different player types found different obstacles more or less difficult (Fraser et al., 2014). Yun had also investigated the idea of profiling players to adjust difficulty to their specific player type in their 2010 study, linking difficulty and player engagement through a lens similar to that of Przybylski's SDT and CET research (Przybylski et al., 2010), and Fraser's player profiling research (Fraser et al., 2014). Yun found that regardless of the actual difficulty level, their engagement could be bolstered by having a sense of autonomy and competency (Yun et al., 2010). At this time, a minor trend had begun to emerge in game difficulty research around these types of player profiling considerations. Kuang and Lextrait, while investigating DDA systems, discovered that player demographic differences played a far greater role in game engagement / enjoyment than a standard DDA system does, concluding that gathering data about player demographics and dynamically adjusting the game according to player profiling is a far more effective design path than the development of a simple DDA system based on gameplay metrics (Kuang & Lextrait, 2012). Pérez arrived at the same conclusion, when they discovered in the production of their 2015 DDA system, that difficulty adaption based on player profiling was far more effective in increasing enjoyment and the duration of their play sessions (large factors contributing to engagement) than a DDA system which didn't take player profiling into account (Pérez et al., 2015). In 2016 while investigating research into developing a DDA system based on profiling players around the big five

personality traits, Nagle also arrived at the same conclusion; that player profiling is far more useful for designing a game's difficulty system than traditional methods of simply measuring performance metrics (Nagle et al. 2016).

2.6 DEFINING 'ENGAGEMENT' IN DIGITAL GAMES

Similar to the papers which tackled defining exactly what 'difficulty' was in terms of game design, Schoenau-Fog's 2011 research tackled the issue of defining exactly what 'engagement' is as they highlight the fact that it is a term which is used with a wide variety of definitions (Schoenau-Fog, 2011). They arrive at the conclusion that player engagement is related to flow, gameflow, presence, immersion, pleasure, motivation, enjoyment & fun. Their detailed literature review points out that:

"The diversity of explanations regarding related concepts, the variety of definitions and the different empirical investigations associated with player experience and engagement illustrate the complex nature of the concept of engagement" (Schoenau-Fog, 2011, p. 4).

The paper attempts to break down engagement into a series of steps, and concludes that although engagement is very multifaceted, the most important factor is a desire to keep playing. Boyle in 2012 similarly presented us with a systematic review of the literature surrounding engagement, and although not arriving at a concise definition of engagement, they did highlight the need for future works to investigate both the positive and negative sides of player engagement, as it is rarely investigated (Boyle et al., 2012). Both Mun's 2015 study (Mun, 2015) and Smith's 2017 study (Smith et al., 2017) represent research in this direction, as both investigated player engagement from the perspective of the consequences that increased engagement with a digital game can have on other unrelated facets of the players life. Mun discovered that increased levels of player engagement in a game can result in a positive boost of increased creativity in tasks performed after playing. Smith conversely identified a negative relationship between increased player engagement with a game, and disrupted sleep schedules in adolescents when given control over their bedtime. These papers were among a number of studies

which conducted investigations into player engagement from some very novel angles, and some of these papers such as Lomas' 2012 study struggle to find meaningful results without extensive future research (Lomas et al, 2012).

In recent years there have been a number of papers which build off of all of this existing literature, finally arriving at the conclusion that exploring the relationship between difficulty and player engagement is an important area of research for game design scholars. These studies include Schmierbach's 2014 study which combined existing research into SDT and Flow theories in order to explore the relationship between difficulty and enjoyment (Schmierbach et al., 2014). Their research indicated that game enjoyment can be influenced not only by player demographics, but also by allowing players to succeed while appearing to be challenging. This study also indicates that existing literature points towards more challenging games being inherently less enjoyable, even for more skilled players. The paper concludes that there is a potential for literature to overestimate how much players enjoy being challenged. Khajah similarly investigated which game design characteristics most contributed to player engagement in their 2016 work, and discovered that among these characteristics, there did indeed appear to be a relationship between difficulty and engagement (Khajah et al., 2016). Also in 2016, Klarkowski investigated the relationship between challenge and skill (such as the relationship which can carry a player to a flow state), discovering that players typically have a preference for challenge which exceeds their skill level, rather than a skill level which exceeds the challenge level, which previously discussed studies had theorized would be optimum (Klarkowski et al., 2016). Sarkar and Cooper also investigated this relationship in their 2019 study, by using function composition to analyse difficulty curves within games, discovering that different difficulty curves do in fact appear to have some impact on game engagement, using engrossment with the task and being in a 'flow state' as indications of engagement in this case (Sarkar & Cooper, 2019).

2.7 SUMMARY AND IMPLICATIONS

The existing literature in this area has overwhelmingly indicated that future study into player engagement and video game difficulty is very much needed. What has been learned about game engagement is that while there is still no formal definition of the term, we do have an understanding of the fundamental concepts which contribute to engagement. It has also been learned that game engagement is a fundamental consideration for game development and a somewhat measurable metric. While there still is not a clear, global definition of difficulty in the context of video games, progress has been made into discovering which game attributes contribute to the difficulty of a task. It has been learned that difficulty too, is a somewhat measurable metric and that it is an essential contributor to player engagement.

There certainly seems to be a relationship between difficulty and player engagement, however the existing literature and research in the area concludes this either as a secondary finding of their primary research (being noteworthy and worth investigating in future studies), or concludes it via reviewing such papers. This highlights the need for a study to investigate the relationship between difficulty and engagement directly. As a part of the research undertaken in this project, this relationship was investigated directly, through the measurement and analysis of game difficulty data and its effect on player engagement (a process which past papers have identified as being an essential future study). The existing literature has also revealed that there appears to be a very important relationship between player demographics and engagement. Player demographics and profiling appear to be a fundamental piece in the puzzle of how players engage with games and it seems that they could play an even more pivotal role in player engagement than difficulty alone. In future studies collecting player demographic information will be essential to arriving at accurate results when investigating engagement, as the relationship is too strong to be ignored. For this purpose, this research project collected demographic data to investigate the prevalence of this relationship directly. Many of the past studies also indicated issues with data collection, in how

they defined player engagement, and how they determined whether a player was engaged or not. Many of these studies simply asked players whether they subjectively had fun, or they measured a single metric such as playing time to determine engagement. As part of the research undertaken through this project, evidence has been found that the use of a 'Game Engagement Questionnaire (GEQ)' would be far more appropriate for this task, and so used a well validated GEQ model to determine player engagement, rather than relying on self-reported levels of engagement or single metric analysis (Brockmeyer et al., 2009).

When it comes to researching engagement, Csikszentmihalyi's Theory of Flow has revealed itself to be the standard by which researchers in this field measure the relationship between difficulty and engagement. There has been some evidence to show it to be a reasonably reliable indicator of player engagement, however further research is still required. For this reason, this study analysed its results for any evidence of flow states influencing player engagement. *Self-determination theory* (SDT) and *Cognitive evaluation theory* (CET) have also both shown to be effective and important tools for researching engagement and difficulty. It will be essential for any future research into game engagement and difficulty to utilize these prevailing theories in their research methodologies. The field appears to be arriving towards a clear understanding of what exactly game engagement is and how difficulty relates to it, with future research needed to unearth the specifics of this relationship. This project addresses this research gap directly, by proposing an experiment methodology which can be utilised to reveal many needed insights into this research area.

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Chapter 3: Research Tool Methodology

This chapter outlines the methodology behind how the research tool 'Chicken Wings' was designed and developed, beginning with an overview of the design process (section 3.1) which breaks down the design decisions which were made throughout the development lifecycle of the research tool. Section 3.2 then details the major gameplay mechanics and design decisions. Finally, section 3.3 breaks down the asset development methodologies employed throughout the development life cycle of the research tool, 'Chicken Wings'.

3.1 OVERVIEW OF THE RESEARCH TOOL 'CHICKEN WINGS'

To investigate the research hypothesis that '*Appropriate difficulty enhances player engagement through establishing a flow state in digital games'*, a research tool needed to be designed and developed to collect pertinent data. This tool required functionality to quantify the engagement of game players across multiple difficulty settings in order to identify whether a flow state had been achieved, and whether the difficulty setting of the game had impacted a player's engagement level. The tool needed to gather three separate sets of data. Those three sets include the *demographic data* of experiment participants ('players') to examine what attributes may be having an impact on player engagement, *gameplay metrics* to quantify how difficult an individual player found the game, and *engagement metrics* to determine how engaged the player was with the game.

The research tool ('Chicken Wings') created to collect this data was a 'two-dimensional horizontally auto-scrolling' digital game playable on a home computer. 'Horizontally auto-scrolling' describes the camera of the game which automatically moves horizontally, displaying the game's protagonist as they traverse the game world, and 'two-dimensional' describes the game world in which the player can only move on a horizontal or vertical axis. The following section details the methodologies used for creating this research tool including design procedures, asset development methodologies and programming standards.

3.1.1 Game Setting

Chicken Wings is set in the modern day (the year 2020) in a small chicken farm located in rural Ireland. This setting was chosen as it provides a number of unique obstacles and enemies which would be appropriate for the protagonist of the game to overcome, while also featuring sprawling green fields and blue skies which make the game visually appealing and easy for players of any gaming experience level to comprehend at a glance.

3.1.2 Game Genre

Chicken Wings is an arcade style game similar to 'endless runner' games such as 'Flappy Bird' and 'Swing Copters'. 'Endless runner' games typically involve a protagonist character which traverses the game world horizontally with an auto scrolling camera, collecting items and avoiding obstacles and enemies endlessly. Chicken Wings has a clear differentiation from most other games in this genre, in that Chicken Wings features some unique mechanics, a clear story and narrative, character designs and a scripted ending. This game genre was chosen due to its proven success at both attracting and maintaining the interest of casual game players and "hardcore" gamers alike (Dogtiev, 2020). It was in the best interests of the experiment for inexperienced gamers to be able to immediately comprehend the basic mechanics of the game and how to play so that the difficulty of the task was primarily influenced by the intended sources, rather than grappling with understanding the game controls.

3.1.3 Game Story

The game follows a protagonist named 'Cluck Aldrin'; an Irish rooster who dreams of flying higher than the clouds. The story follows his lofty dreams of being the first bird on the moon. The primary antagonists of the story are the Irish Ravens who find the proposition of a rooster flying anywhere laughable. These Ravens are joined by foxes and hawks in the roster of enemies in the game.

The game begins with Cluck breaking free of the confines of his chicken coop, and follows him running through fields, over rural structures and walls, flying off of

cliffs and eventually flying into space, reaching his goal of being the first bird on the moon.

3.1.4 Game Themes

It is common for farmers in Great Britain and Ireland to run into many dangers when cultivating a chicken farm, namely factors such as wild predators which break into their farms and eat their chickens. These predators include such animals as foxes and minks. Chicken Wings utilizes the natural predators of the typical Great British farm chicken as in-game enemies, along with providing stationary obstructions to block the player's path as are common in endless runner type games.

The primary philosophical theme of Chicken Wings explores the common motivational trope of following one's dreams, aiming high and making something of one's life, recognizing aspirations and the importance of family and belonging. Philosophically Chicken Wings represents the core theme of following a pursuit for one's passions despite the odds, and despite the criticism of others. This game was designed for a mass audience primarily playing on mobile devices, touch screens and in browser windows. Chicken Wings is a game which was designed to be appropriate for both adults and children, despite the research experiment itself involving only adult participants due to ethical concerns.

3.1.5 Game Characters

'Cluck Aldrin' is the main character of the game. Cluck is a rooster who dreams of being an astronaut and one day looking down on Earth from the moon. The name Cluck Aldrin is homage to the famous American astronaut Buzz Aldrin. The game begins with Cluck escaping the confines of his pen and follows his adventure into space where a satisfied Cluck concludes his adventure.

The Ravens can be considered as having more character than the fox or hawk enemies, as they are essentially the primary antagonists of the story, directly antagonizing the game's protagonist Cluck, and telling him that he can't fly to the moon.

Although initially designed during the planning phases and outlined in the game design document, the chicken flock which Cluck watches over do not feature in the final game. Initial plans were for the flock to be visible during the start and end cut scenes of the game, however during scoping discussions, this content was culled due to required work for very little content.

3.2 GAMEPLAY DESIGN AND MECHANICS

The core gameplay mechanics of Chicken Wings revolve around keeping Cluck out of danger while he traverses the map. This is managed by the player avoiding obstacles and enemies by making Cluck flap, fall, walk or glide. The player may optionally collect cobs of corn which are placed periodically throughout the map to bolster their score, however this isn't a core gameplay mechanic as the collection of these corn cobs isn't required to play the game to its completion. The game would have a full playtime of two minutes and thirty-five seconds (2:35) if the player had a perfect run, colliding with no obstacles or enemies. This is the same across all difficulties of the game.

The soundtrack of the game is closely linked with the level design. The soundtrack features two chorus sections, both of which involve some unique and major gameplay changes. The build up to each of the chorus sections involve Cluck running faster and the entire game speed slowly increasing, including making obstacles and enemies move towards the character faster. This forces the player to be extra vigilant and agile during these sped up sections. The game will reach its maximum speed when the song chorus starts, forewarned by a large onscreen text alert that instructs the player to prepare to keep Cluck airborne. During the chorus section, Cluck will begin to fly slightly higher than usual over the background fields, with the ground which is usually at the base of the screen disappearing out of view, forcing players to keep Cluck airborne for the entirety of the chorus section. After the chorus finishes, there is a slow-down section in which the game speed will slowly decrease back to its usual speed and normal gameplay will resume.

3.2.1 Controls

The game is entirely played with the mouse if played on a computer, or with touch screen controls if played on a tablet or mobile device. This is to keep the gameplay simple and easy to understand for players of all levels, and to increase the ease of testing the game on multiple platforms. Mouse events and touch screen events are programmed identically, reducing the coding overhead and interface complexity if onscreen buttons were required for controls to simulate keyboard or controller inputs.

There are four major types of movement which a player can utilise. The most basic form of movement is walking. If the player does not make any inputs with their mouse, Cluck will simply walk along the ground.

The second type of movement is ‘flapping’. To make Cluck flap his wings, the player may click their mouse (or touch the screen on a tablet / mobile device). This will cause Cluck to fly slightly higher, with several ‘flaps’ required to move Cluck to the top of the screen. Whether Cluck is walking on the floor, or flying at the time, he may flap his wings to rise higher on the screen. Any time Cluck is not flapping he will fall until he is walking on the floor.

The third type of movement is gliding. If the player holds down the mouse button (or holds their finger on the screen on a touch screen device) Cluck will keep his wings extended, slowly gliding and losing elevation until he reaches the ground. This will slow Cluck’s falling speed dramatically. It is worth noting that there are obstructions which require this functionality to be utilized in order to pass them in the harder difficulties of the game; however in the easiest difficulty the gliding mechanic is not required to finish the game successfully.

The fourth type of movement is falling. If Cluck is in the air and the player makes no inputs, Cluck will fall until he reaches the ground. This movement mechanic is distinct from gliding, as Clucks rate of descent is significantly faster if his wings are not extended.

3.2.2 Perspective & Camera

The game was played in a 1280px by 720px window. This is a common resolution for smart phone games, and so makes it easy to port the game to multiple platforms without the need for extensive re-coding or considerations where aspect ratio and resolution are concerned. If played on a PC or MAC the game was played in a window of the fixed 1280px by 720px size with no option to rescale the window.

The in-game camera appears to follow Cluck as he traverses the map, automatically scrolling until the end of the map. Technically speaking, both the camera and Cluck are in reality remaining stationary, with the obstacles, enemies and background layers moving towards Cluck. The reason for creating the game this way is to make level editing and manually placing obstacles and enemies in the level editor a very controlled environment with incredibly precise placements. This is an important aspect to consider, as each difficulty of the game must require a quantifiably different level of player capability to traverse effectively.

The background was split into several layers which ‘parallax’ against one and other. For a background layer to ‘parallax’, is for the layer to be displaced at a different apparent position than its surrounding background layers according to the viewer’s line of sight. This gives the illusion of depth in the background of the game, as background layers which are further away from the player’s view point move slower than background layers which are closer.

3.2.3 Obstructions and Enemies

There are a number of obstructions which if collided with, will result in a game failure event for the player (forcing the player to start the game again from the very beginning). Thematically, these objects are inspired after obstacles which could be typically encountered in the game’s setting of an Irish field. These are also obstacles which a rogue rooster would typically need to overcome in this scenario.

Obstructions / Obstacles

The first obstacle which the player will encounter is a simple wooden fence. These are typically used to fence off paddocks and fields in rural areas. This is an obstacle which will appear regularly throughout the game from start to finish. It blocks off

the ground portion of the level, forcing the player to slightly jump, using the flap mechanic, in order to avoid it.

The second obstacle which the player is likely to encounter is the 'house' obstruction. This house is a typical, small rural brick house which could be encountered in Irish farmlands. This obstacle covers both the bottom, and middle portions of the playfield, forcing players to elevate Cluck to the top quadrant of the screen in order to avoid colliding with it. The house has the most complex shape and mechanics among all obstacles, as it features two chimneys which elevate higher than the roof of the house, which can both be collided with. This obstacle has the added mechanical complexity of allowing Cluck to walk upon its roof and chimneys. This mechanic allows for the complicated placement of enemies between the two chimneys, forcing the player to engage in quite accurate placement of Cluck to avoid all of the obstacles in this area.

The third obstacle featured in Chicken Wings, is the large rock, or boulder obstacle. This obstacle takes up the middle and lower portions of the screen, forcing the player to elevate Cluck to the top quadrant of the screen. The complexity of this obstacle comes from its sloped right hand side, allowing for level design requiring the player to glide accurately down its sloped side to avoid enemies placed behind it.

The fourth and final static obstacle which the player can encounter in Chicken Wings is the stone wall obstacle. The stone wall is functionally identical to the wooden fence obstacle, covering only the ground portion of the screen, however it is wider and extends slightly higher than the wooden fence obstacle, providing a unique challenge to overcome, and providing more opportunities for creative level design.

Enemies

The first enemy the player will encounter is the 'raven' enemy. This enemy is themed around the Irish Raven and in the narrative of the game they feature as the primary antagonists. The raven enemy can be found at any elevation in the game, and if collided with from any angle (head on, above or below) will result in a

failure state, forcing the player to restart the game. The raven is the most common enemy throughout the game and can be placed in a number of creative and difficult patterns, requiring unique gameplay strategies and manoeuvres to overcome.

The second enemy the player can encounter is the ‘fox’ enemy. Thematically this enemy is based on the common Red Fox, prevalent in Great Britain, and well known as a pest for chicken farmers. These enemies are restricted to standing on the ground; however they will periodically jump into the air, launching themselves upwards. The peak of their jump is in the upper portion of the middle quadrant of the screen, forcing the player to either fly above them, or walk below them while they are airborne. This requires forethought and strategy from the player, as they will have time to analyse the foxes jump arch before facing them head on.

The third and final enemy in Chicken Wings is the ‘Hawk’ enemy. Thematically the hawk enemy is based on the high flying bird of prey. The hawk enemy can only be encountered, during one of the two ‘chorus sections’ of the game. During these sections, no other obstacles or enemies will be present and the player will only need to avoid the hawks which appear in great numbers at all heights, forcing the player to think quickly and react fast.

Score System and high score table

Chicken Wings features a high score system which keeps track of all scores set by players on each difficulty of the game. On the browser based version of the game, these scores would be stored in a file on the server, whereas on the PC version of the game, the high score file was stored on the local computer. When the player dies in game (when Cluck collides with an obstacle or enemy), after a short animation of cluck falling off of the screen, the high score table will be displayed. Each high score table only displays the scores achieved on the same difficulty on which the participant is playing.

Score in Chicken Wings is calculated based on two factors. The first factor is how far into the game the player survived. This is decided by keeping track of a game time metric. Throughout the game, there are collectable objects themed around cobs of corn, which the player may collect in order to increase their score. These

corn cobs are placed strategically, to either encourage risky gameplay from the player, or to make the recommended path through a complicated set of obstacles clear to the player. To calculate a player's score, both of these factors are converted to a percentage (the percentage of the total possible time survived, and percentage of corn in the game collected), these two percentages are then combined and presented as that percentage out of 1,000,000 possible total score. For example, if a player survived for exactly half of the game and collected exactly half of the corn in the game, their final score would be 500,000. The full formula for calculating a player's score can be found below (equation 1), where *S* is the current score, *D* is the current distance travelled, *C* is the current number of corn collected, *Dtotal* is the total maximum distance a player can travel and *Ctotal* is the total amount of corn on the game level.

$$S = 1e^6 \times \frac{1}{2}\left(\frac{D}{D_{total}} + \frac{C}{C_{total}}\right)$$

Equation 1. Formula for calculating player score

3.2.4 Data Collection Protocols

Chicken Wings stores two files in which gameplay metrics, survey questionnaire results and demographic information are stored.

User Account Data file

Each game player has a user data file saved which is unique to them. User account data files contain all information pertaining to a particular user. The file is a text file with a file name that is a user's anonymous ID number. The first line of the file is a comma separated list containing: the game difficulty assigned to the player, followed by all of their demographic survey answers (separated by commas). After this first line, all following lines of the file represent a single game session. Each line is another comma separated list, with the first value being the session's ID

number, followed by each of the player's responses to the game engagement questionnaire for that session. A de-identified example of a user account data file can be seen in Appendix A.

Gameplay metrics data file

Each time a player dies in the game, an entry is made in the gameplay metrics data file. Each line of this file represents one time that a player has died in the game. Similarly, to the user account data file, each line of this file is a comma separated list. See section 3.3.6 for more detail into data collection protocols. An example of the data stored in the gameplay metrics data file (or 'death log') can be found in Appendix B.

3.3 ASSET DEVELOPMENT METHODOLOGIES

The design process of the game began with the development of a 'Game Design Document (GDD)'. The game design document acted as a highly descriptive software design document, unambiguously detailing all aspects of the games design, from its narrative to its art assets. The GDD served as an initial focal point for establishing a detailed outline of all gameplay, narrative and aesthetic assets which would be required in the final game. The GDD was split into several major sections, each of which are detailed in the following sub sections.

3.3.4 Art and graphic asset development

The process for creating the game's art assets began with the creation of the game design document and collection of reference images for each enemy, obstacle, scene and character in the game. The first step was creating a cartoon representation of the real-life reference images of each object, using 'shapes' in Adobe Photoshop. The reason that 'shapes' were used were so that they could easily be animated in 'Adobe After Effects' once the character model was finished, with each shape having its own 'layer' in Photoshop as can be seen in Figure 1.

These layers were retained when imported into ‘Adobe After Effects’, creating a smooth workflow capable of producing rather detailed animations.

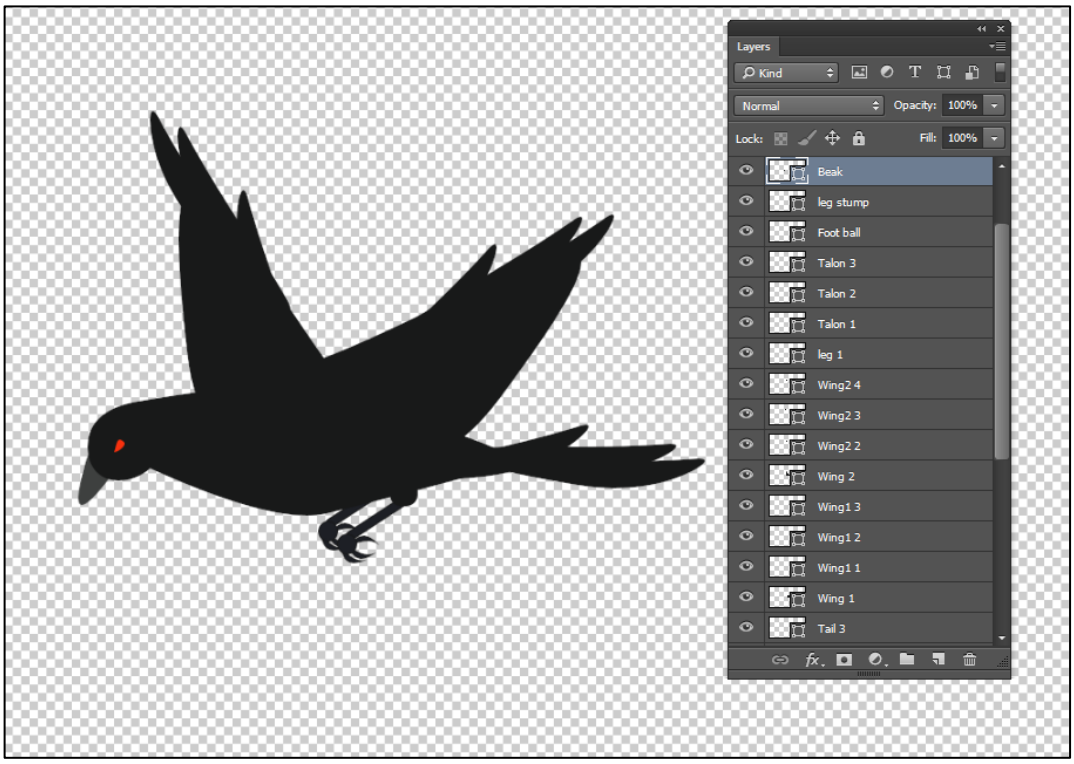

Figure 1. A game ‘sprite’ image built in Photoshop using ‘shapes’.

Once the initial sprite image had been drawn and assembled, they were then animated. Most obstacles and enemies in the game only had a single animation, since the game was an ‘endless scroller’, enemies were always moving so they did not need an idle or attack animations. However, the main character was an exception, requiring a set of animations including flying (flapping), gliding, walking and running. Animations were created in Adobe After Effects, where the Photoshop files were imported directly with the layers intact. From here they were animated layer by layer, using key-frames in After Effects as can be seen in Figure 2.

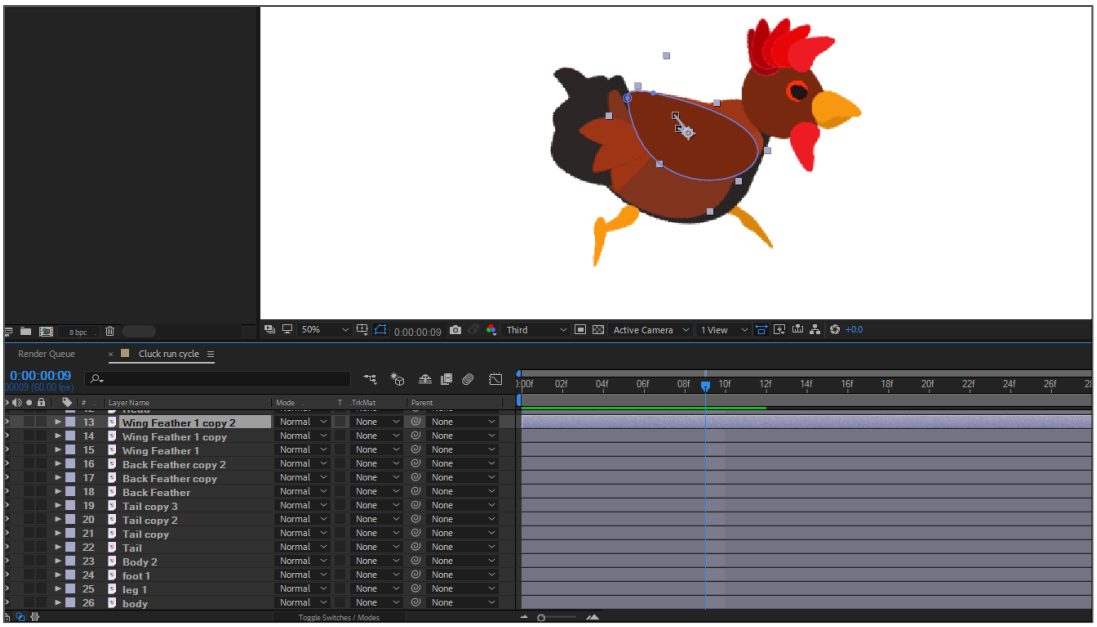

Figure 2. A game sprite being animated in Adobe After Effects

After the full animations were finished, they were exported as ‘animated Gif’ files, which were then opened in the game development IDE and split back into their individual sub images for final editing as can be seen in Figure 3.

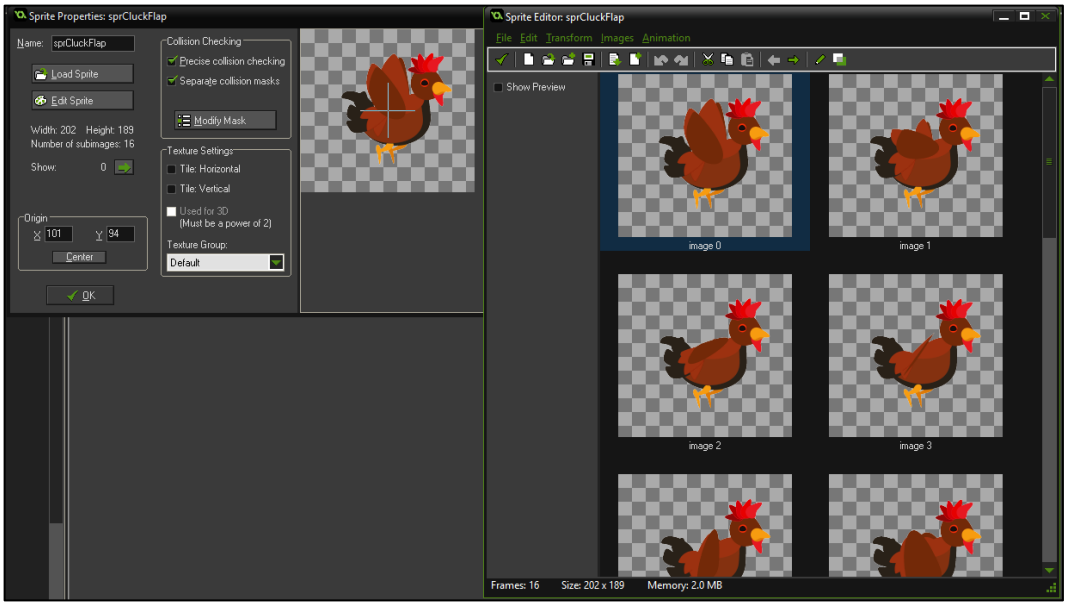

Figure 3. A finished game sprite in the game development IDE

The background art of the game was inspired by real life reference images of Irish countryside, as was outlined in the game design document. The process for building these backgrounds was to first draw them layer by layer using the same art

style as the game sprites (Photoshop shapes). The reason they were drawn layer by layer, was so that parallax scrolling effects (i.e. each layer of the background moving at separate speeds to give the illusion of depth) could be achieved. This also meant that the backgrounds needed to repeat seamlessly, as the game was an 'endless runner' type game, meaning that the same backgrounds would be scrolling and repeating throughout the entire game, as seen in Figure 4.

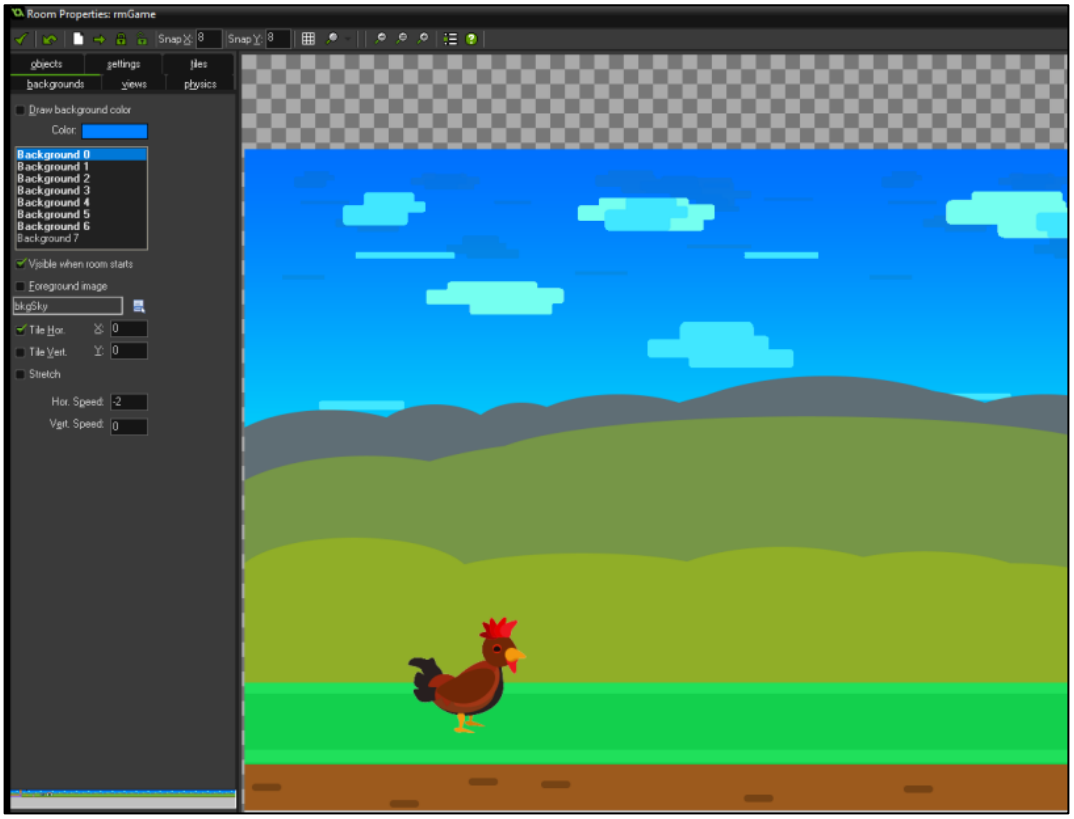

Figure 4. All 7 background layers visible in the level editor

3.3.5 Music and sound asset development

The game music was written first on a piano, with the basic catchy theme tune being written. After this the full song had to be filled in, with rises and falls to match the emotive story of the game in real time. The length of the song also had to be written specifically to ensure that it matched the planned play length of the gameplay.

The song was split up into several key sections to match the intended emotive feel of each section; with intensity build ups which matched the intensity build ups of the scrolling / story in the game. The main theme was first written with a basic four chord structure in the first chorus, with the second chorus keeping the same melody but changing the chord structure in a very subtle way to make it more emotive (as this matches the moment that the protagonist has finally made it to their goal). This project was assembled in the "FL Studio" digital audio workstation (DAW) as can be seen in Figure 5. Each pattern contains several instruments and splits the song up into key sections.

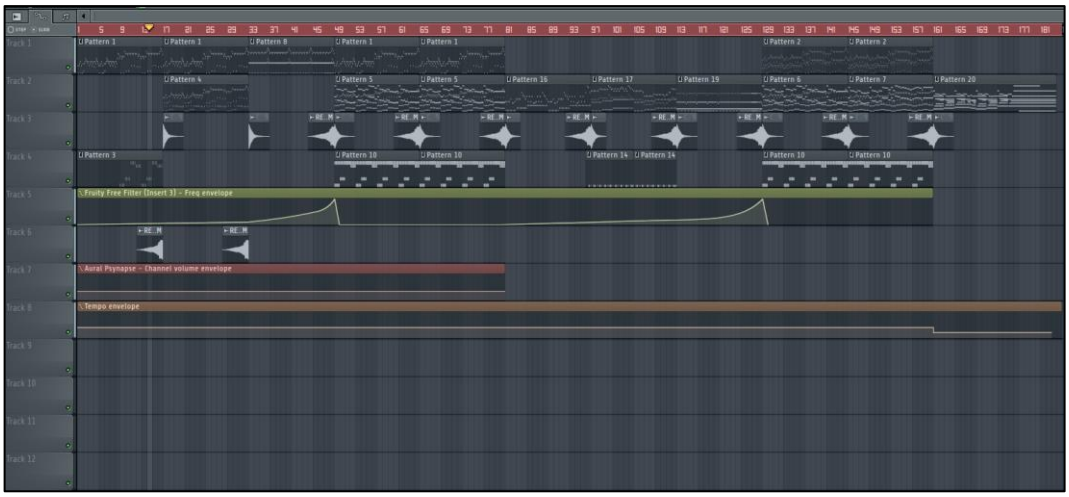

Figure 5. The game's theme song being composed in the DAW

3.3.6 Data Collection Protocols

To answer the primary research questions of this project it was investigated whether the reported player engagement of participants was influenced by the difficulty setting that they played the game. Key data for answering these research questions needed to be gathered by the game and by the questionnaire responses. The following section details which questions were posed during the project's design phase in order to determine specifically what data needed to be gathered by the game.

Question 1. "*Did participants log more play time on certain difficulties than on others?"*

Data gathering requirements identified: Total play time, session play time, user difficulty.

Question 2. "*Did participant's questionnaire results indicate stronger engagement with certain difficulties more than others?"*

Data gathering requirements: Total difficulty play times, post-game engagement questionnaire results.

Question 3. "*Were the participants more engaged when playing a difficulty appropriate to their skill level?"*

Note: To determine this, failed attempts (in game "deaths") could be compared to play time and reported engagement levels during these sessions. This could then be compared to the average results from this test across all participants. This indicated whether struggling to survive brought the player back for more play time and whether it impacted their engagement levels.

Data gathering requirements: Session death count, session play time, user difficulty, game engagement questionnaire results.

Question 4. "*Were the results consistent across all participant demographics?"*

Note: Although not essential to determining any relationship between difficulty and engagement, this allowed screening for demographic related biases and relationships in the project's results.

Data gathering requirements: Pre-game demographic questionnaire results, post-game engagement questionnaire results, gameplay metrics.

Final data collection variables identified: As a result of the process, the following variables were identified as being necessary to be gathered by the game as participants played:

Total play time: How long this participant has played in their lifetime (regardless of any particular session).

Total difficulty play time: How long this participant had played each difficulty setting throughout their lifetime (regardless of the current session).

Total difficulty failure count: How many times this participant had failed ("died") on their difficulty setting in total (throughout all play sessions).

Session difficulty failure count: How many times this participant had failed ("died") on their difficulty setting during the current session (since signing into the game).

User Difficulty: What difficulty setting this user had been randomly assigned and was playing on.

Session difficulty play time: How long this participant had spent playing their difficulty in the current session (since signing into the game).

Session play time: How long this participant had been playing in the current session (since signing into the game).

Session ID: Each session was given an incremental ID number so that its unique data could be analysed effectively.

Lost sessions: This value indicated how many sessions' data were lost due to disconnecting from the game without filling out the questionnaire after playing (or losing connection).

Questionnaire status: This indicated whether the questionnaire was filled out or not. If the player lost their internet connection (or quit without filling out the questionnaire) the in-game data would still be saved, however it would not be used outside of analysis, specifically looking at lost session data.

3.3.7 Programming and code design methodology

Throughout the development of Chicken Wings many considerations were given to keeping the code elegant and easy to navigate. These principles included utilising the effective use of object inheritance to avoid code duplication or inefficient design. Examples of this can be found in all obstacles and enemies being children of an 'obstruction' parent object which was used to determine collisions with the player and object movement tied to the game speed. All major global game variables such as the current game time and current game speed were tracked by over-arching control objects, with the highest level of these being the 'master

control' object, which remained persistent throughout all game scenes and kept track of data relating to the player such as their ID and their score. Both the pre-game and post-game questionnaires had a dedicated control object which managed the player's responses and displayed the correct interface at any time. These objects were also responsible for writing to the player's data files. Overall, through the effective use of encapsulation, inheritance and the general use of Agile code design principles, Chicken Wings was kept clean and efficient with the goal of making it very easy to expand upon for future research endeavours in this area.

Chapter 4: Research Design

This chapter covers the concepts behind the research design itself, including all decisions made and actions taken to develop the actual experimentation methodology. It begins with a breakdown of where participants were recruited from and what requirements they satisfied (section 4.1). Following this the actual instruments used to collect data are explained, including all surveys and questionnaires and telemetry data files (section 4.2). This is followed by a section explaining how the data was processed and analysed (4.4). The chapter concludes with a breakdown of the ethical considerations and limitations applied to this study (section 4.5).

4.1 PARTICIPANTS

This project was granted ethics approval by the Flinders University Human Research Ethics Committee (Project ID: 8662). Additional discussion about ethics requirements will be covered in section 4.5. Participants were recruited from available staff, postgraduate, and undergraduate students at Flinders University along with any members of public who are part of the gaming online social group (Adelaide's Really Good Gathering of Gamedevelopers (Argggh!)), Flinders' student societies in video games, computing and robotics, and engineering. To minimize pressure to participate or perceptions of coercion and obligation, focused solicitation of specific individuals was not conducted. Rather, open invitations were cast where interested individuals were able to contact the researcher for additional information, or to simply attend and participate. The lead researcher on this project recruited members of the public from the previously discussed online gaming related social group, and to mitigate any conflicts of interest or biases, any participants with a specific identified personal relationship with the researcher were excluded from the study. All participants recruited were at least 18 years of age. The final number of participants in the study was twelve, with four participants

randomly assigned to the easy difficulty, four to the medium difficulty and four to the hard difficulty.

The basis for recruitment to the study was that the participant was over 18 years of age and has the capability to play a simple online game (playable with just a touch screen or mouse). There was no specific demographic being actively sought out, however it was expected that many of the participants would have been gamers, students or those interested in video games enough to actively engage with the study.

4.2 ONLINE PARTICIPANT RECRUITMENT

All recruitment of online participants took place in the online 'Argggh!' community. A post was made in their online social group which explained that a research project was taking place in which participants would be asked to play a small game which would collect metrics about how they play, and that after playing the game they would be asked to fill out a short survey. Public posting to advertise game projects is allowed in their forums, so the lead researcher posted the advertisement in the appropriate channel. The advertisement which was posted to the online group was identical to the physical recruitment poster which can be seen in Figure 6.

4.3 PHYSICAL PARTICIPANT RECRUITMENT

All offline recruitment of participants took place at the Flinders University Tonsley Campus. A poster (Figure 6) was made which explained that a research project was taking place in which participants would be asked to play a small game which would collect metrics about how they play, and that after playing they would be asked to fill out a short survey. This poster was pinned up on several pin boards throughout the campus.

Figure 6. The experiment's advertisement poster

4.4 INSTRUMENTS

4.4.1 Demographic Survey

As was identified in the literature review process, there is a severe lack of research into what player demographic variables impact a player's engagement in digital games. The literature review also discovered multiple research projects which provided evidence that player demographic variables potentially impacted player engagement even more heavily than difficulty itself. For this reason, it was important for this research project to gather the pertinent demographic variables which could potentially impact player engagement. Analysis could then be used to determine what impact demographics would have on the data gathered by the game. Little research has been conducted into identifying what these variables are, so the choice of which variables to include, were those which were commonly used when analysing video game player demographics (Morris, 2020). The actual design of the demographic questions, and the options participants had to choose from to

answer these questions were informed by academic research into effective, comprehensive and inclusive approaches to demographic data collection (Fernandez et al., 2016). The final demographic survey consisted of six questions, each of which had multiple options to choose from, most of which allowing multiple options to be chosen where necessary. The questions sought information on the gender of the player, their game play experience (frequency and length of play), the types of devices they play on, their age and their education level. The questions and options included in the final demographic questionnaire can be found in Appendix C.

4.4.2 Game Telemetry Data Collection

As a participant plays Chicken Wings, their data is collected by the game and stored in a game telemetry file. This file tracks each time they died, where they died (y coordinate and game time), the current date and time of their death, and the difficulty which the participant was playing on. These values are written as a comma separated list, with each line of the file containing one such list. The following table shows what data is included in this comma separated list.

Table 1. Game telemetry data file layout

participantID	sessionID	gameTime	Y coordinate	Date	Time	Difficulty

This data was important to track as it provides valuable information to aid quantifying where in the game players were struggling the most, and on which difficulties. This data can be compared to the game engagement questionnaire data gathered from the same gaming session in order to identify whether there were any links between how much a player struggled (how many times they died) and how engaged they ended up being with the game.

4.4.3 Game Engagement Questionnaire

The literature review revealed that game engagement is quite under-researched, and no truly well validated standardized methodology has yet been identified to quantify player engagement in digital games. There have been a number of

physiological monitoring methodologies tested, but nothing conclusive has been discovered by any of these avenues of research. The current most well validated methodology for quantifying player engagement in digital games has been identified by a research team who investigated the use of a standardized 'game engagement questionnaire (GEQ)' (Brockmyer et al., 2009). This research project proposed a standardized questionnaire which was well validated and could be used to provide insight into the engagement of players in a digital game. This questionnaire was used in the current study and was filled out by all participants at the end of their gaming session (whether they won the game or not). The questionnaire includes 16 questions answerable on a three point scale with 'no', 'maybe', and 'yes' options. The full game questionnaire included in Chicken Wings can be seen in Appendix D.

4.5 ANALYSIS METHODOLOGIES

4.5.1 Data coding and analysis methodologies

This pilot study investigates the research area and aims to contribute towards validating the experiment approach. This research project makes no strong claims towards conclusively answering the over-arching integral questions discovered through the literature review but aims to provide useful data which can be expanded upon by future studies to make more conclusive discoveries. For this reason, the analysis methodologies enacted through this study focused heavily on the gathering of useful data, the validation of the experiment approach to generate integral data, and to identify the research area's knowledge gaps and inherent importance to the field.

There are two primary deliverables which this research project aims to contribute through the data it has gathered and its analysis process. The first of these deliverables is data pertaining to the relationship between difficulty and engagement. This will be presented in the format of graphs, generated by comparing player engagement data and gameplay telemetry data relating to how difficult the player found the game, and what difficulty setting the player was allocated. The second deliverable is data pertaining to player demographic data

variables and how they impact engagement. A Bayesian graph will be presented, demonstrating the relationships between the demographic variables of the participants, and the participant's reported levels of game engagement.

All data collected by Chicken Wings is arranged within data files containing comma separated lists. These data files were constructed to make extraction of data by the selected data visualization tools as effortless as possible. Examples of these data files can be found in Appendices A and B.

4.5.2 Statistical analysis technologies

To provide insight into the data collected and generate the primary graphs to be included in the resulting contributions of this project, a tool called 'Seaborn' was used. Seaborn is a popular Python data visualization tool, able to provide keen insights into a data set, by producing a variety of different data visualizations.

To generate the Bayesian graph, which sought to identify the relationships between player demographic data and reported levels of player engagement, a Python library named 'CasualNex' was utilised, which combines machine learning and domain expertise for casual reasoning. Within CausalNex the 'DAG with NO TEARS' structure learning method was used for Bayesian inference (Zheng et al., 2018).

4.5.3 Analysis Strategies

The primary deliverables of this project revolve around validation of the research area and contributing useful data to be included in the analysis of future studies in this area. In depth analysis of data with meaningful conclusions will not be possible with the limited data pool collected by this study alone; however preliminary analysis will be conducted to discover (inconclusive) surface level trends which emerge within the data sets. This preliminary analysis will be conducted using the aforementioned data visualization and Bayesian analysis tools.

4.6 ETHICS AND LIMITATIONS

Some participants may know the researcher by an online handle in game design / gaming social groups online, or on a personal campus as a classmate or friend on

campus. To minimise pressure to participate or perceptions of obligation, focused solicitation of specific individuals was not conducted. Rather, open invitations were distributed in online social groups where interested individuals could contact the researcher to participate. The lead researcher on this project was recruiting members of the public from online gaming related social groups, however, to mitigate any conflicts of interest or biases, specific identified personal relationships were excluded from the study. The supervisor of the project, Dr Brett Wilkinson, was not involved in the recruitment process and did not have any influence over where recruitment occurred. Brett had no contact with the individuals who chose to participate and each participant was logged in an anonymised form within the collected data. Participants were assured that all efforts would be implemented to ensure their anonymity if they agreed to participate. As indicated in section D4A of the Ethics application, any people identified as having direct or personal relationships with the lead researcher were not allowed to participate or be recruited. At the stage of request of additional information this type of individual would be advised that they would not be able to participate in the game evaluation at that stage. When a participant identified that they were willing to take part in the study and provide their consent, they were assigned an anonymous random identifier that did not have any relationship to the participant. The identifier was randomly generated and not stored or associated with the participant in any way. All participant information was entirely anonymous. The researcher themselves did not know the identity of anybody who has participated in the study.

Chapter 5: Results & Analysis

This chapter details the results of the study, and the preliminary analysis which was carried out. Section 5.1 details how a Bayesian network graph was generated to identify the relationships between the integral data points of the study. Section 5.2 then begins a breakdown and tentative analysis of the results, framed around the research objectives of the project outlined in chapter 1. Finally, section 5.3 provides a breakdown and tentative analysis of the demographic variables identified through the results of the project, and the relationships present within the data.

5.1 BAYESIAN NETWORK RESULTS

In order to identify what relationships existed within the data and the strength of these relationships, the Python library 'CausalNex' was used to perform a Bayesian analysis on the data and generate a Bayesian Network graph (Figure 7). The first step to accomplish this was to prepare the data, converting it into a well labelled csv file, and then loading it into the code of the CausalNex program. The threshold was then adjusted to remove the weaker links between variables, as only the strongest, most pertinent links throughout the dataset needed to be visualised. The next step was to remove any erroneous relationships in the dataset which didn't make sense or were not pertinent to this experiment. An example of one such identified relationship was between the difficulty on which a participant was randomly assigned and their typical choice of gaming platform. Any erroneous or irrelevant relationships such as this were identified and culled from the network resulting in a clean Bayesian Network which could be used to identify the prominent relationships within the data.

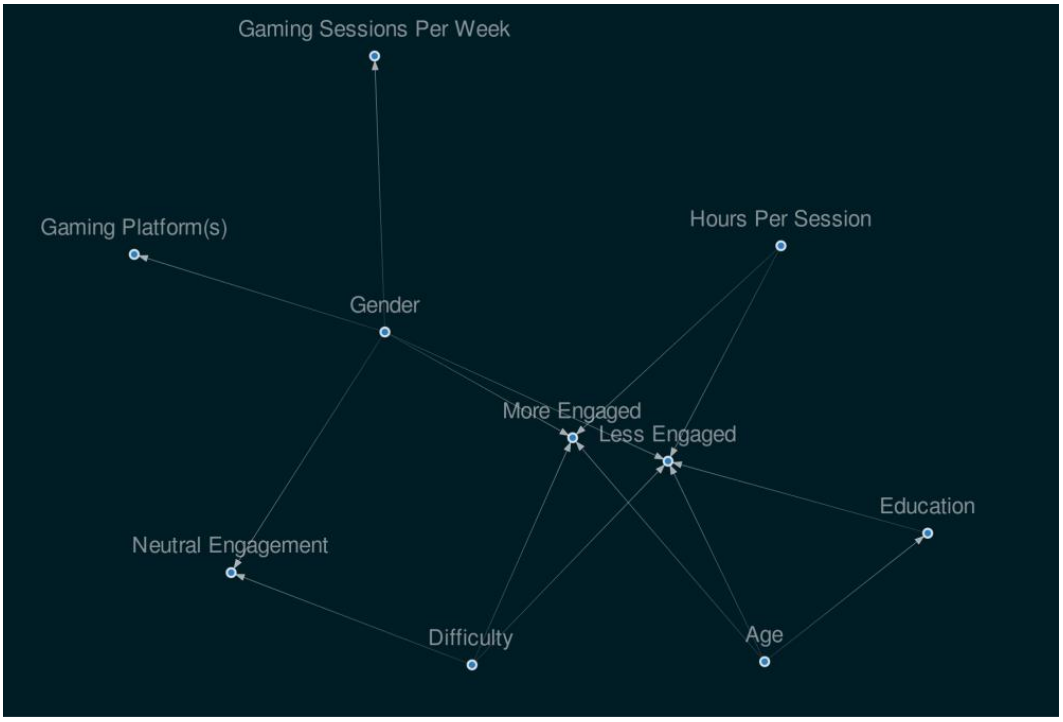

Figure 7. The Bayesian network graph generated by CausalNex

The Bayesian Network graph revealed which data was the most applicable and which relationships between variables were the strongest. This then informed which graphs would need to be generated to provide the most insight into investigating this project's hypothesis and research goals. This includes graphs generated to demonstrate the relationships between engagement and difficulty played, participant age, highest educational attainment, gender and gaming experience (hours per session & sessions per week). Additionally to the important demographic variable relationships identified in the Bayesian analysis, graphs were also generated between the number of times a player died and their reported levels of engagement. This will be used to identify a link between how challenging a player found the game and how engaged they were.

The relationships identified in the Bayesian network have been split into several graphs providing insight into how each of these variables affected player engagement. In each of the following graphs, player engagement is represented by bars extending on the horizontal axis. Each bar is split into three segments, with each quadrant representing answers which indicated levels of 'lower engagement',

'neutral engagement' and 'higher engagement' respectively (from left to right). Figure 8 demonstrates how these graphs may be interpreted.

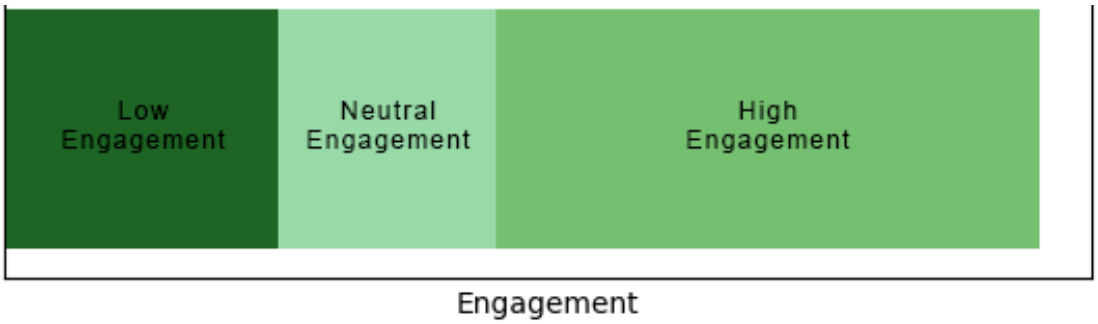

Figure 8. The three segments of a player engagement bar

5.2 DIFFICULTY'S EFFECT ON PLAYER ENGAGEMENT

The first graph generated can be seen in Figure 9, and displays the relationship discovered between the game difficulty on which participants played Chicken Wings, and their resulting reported levels of engagement.

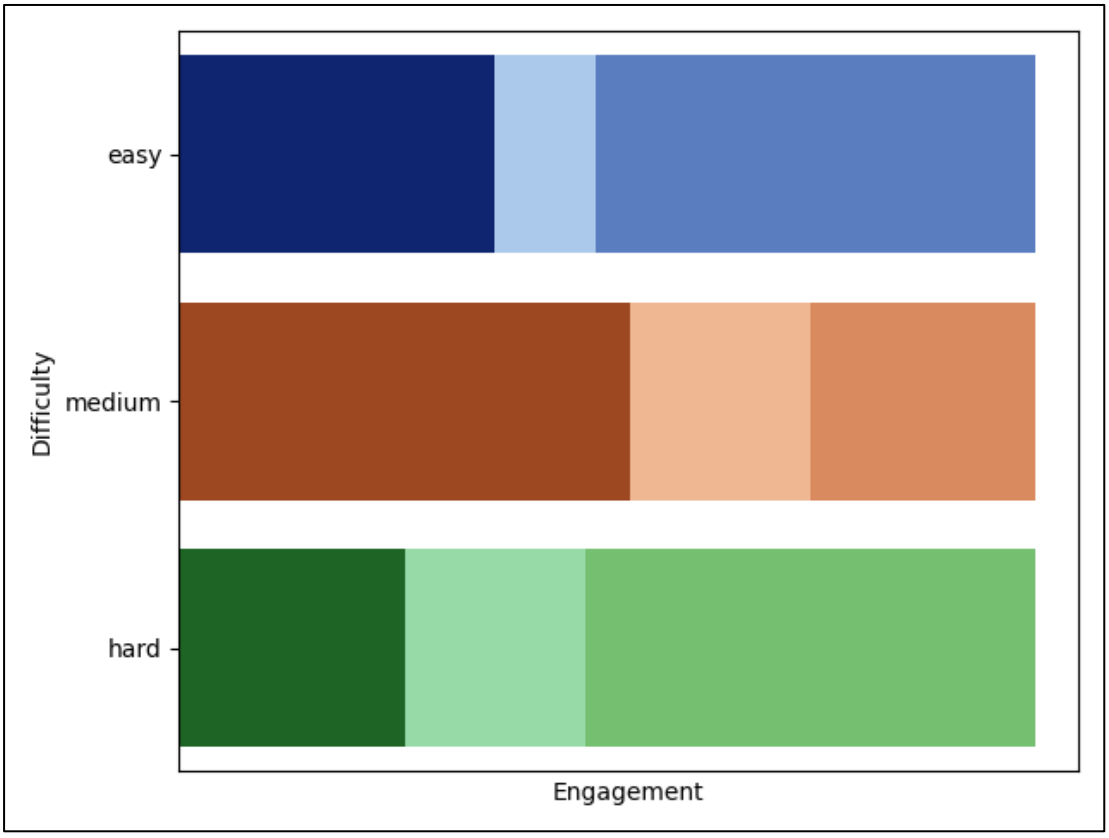

Figure 9. Game difficulty played vs engagement

Despite several papers identified within the literature review suggesting the theory of 'Flow' as an appropriate tool for understanding the relationship between difficulty and player engagement (Holt, 2000; Qin et al, 2010), this was not directly reflected in the results of this study. Player reported levels of engagement were higher on the easy and hard difficulties of the game compared to the medium difficulty. Although not necessarily providing evidence to support flow states, through the Bayesian analysis and the data presented in Figure 9, this study has found preliminary evidence supporting the claims of prior research projects which have identified a potential relationship between the difficulty of a game and player engagement with that game (Orvis et al., 2008; Khajah et al., 2016; Sarkar & Cooper, 2019). These results also match the discoveries made in Juul's 2009 paper which indicated higher levels of engagement with the easiest and hardest difficulties of a game, and to some extent Klarkowski's 2016 paper which identified that games with challenge levels which exceed a player's skill level were preferred by players (Juul J. 2009, pg. 9; Klarkowski et al., 2016).

Throughout this study, players were unaware of which difficulty of the game they were playing and were provided with no agency over their difficulty choice. It is recommended that if this experiment model is used in future, additional difficulties should be included in the study to allow for this agency over difficulty choice as evidence has been found that this can greatly impact player engagement (Harrigan et al., 2010; Leiker et al., 2016; Smeddinck et al., 2016; Lomas et al., 2017). It is worth noting that although there is a lack of definition into exactly what difficulty is in the context of games (Aponte et al, 2011), the difficulties in Chicken Wings were verified by eight separate play-testers during development and the results found in Figure 11 further validate the easy and hard difficulties as being somewhat appropriately scaled.

This experiment methodology has produced results consistent with what was established through the literature review and expected to be answered through the first research objective. The results have shown that this experiment methodology is indeed able to provide some much needed insight into the relationship between

difficulty and game engagement in a digital game. It has also been somewhat successful in addressing the second research objective of this project, which is:

> *"To contribute data towards quantifying difficulty and engagement in digital games."*

As was identified throughout this study's literature review, there is a clear lack of a precise, formal definition of the term 'difficulty' in digital games (Aponte et al, 2011). Because of this, the approach which was taken in Chicken Wings to quantify how challenging each of the difficulty settings in the game were, was to first have eight play-testers play through the levels during development, and to tweak them appropriately when the players reported that they felt the game levels did not reflect the appropriate level of challenge. To monitor how difficult the levels were for participants throughout the actual experiment, a 'death log' was kept, which recorded the time and location of each death. A scatter plot of the full 230 entry death log generated throughout the experiment can be seen in Figure 10. This figure shows the player's Y co-ordinate versus the game time. This graph may be interpreted as a literal snapshot of the entire game level with each dot representing the location of a player's death. Green dots are deaths on easy difficulty, blue dots are deaths on medium and orange dots are deaths on hard difficulty.

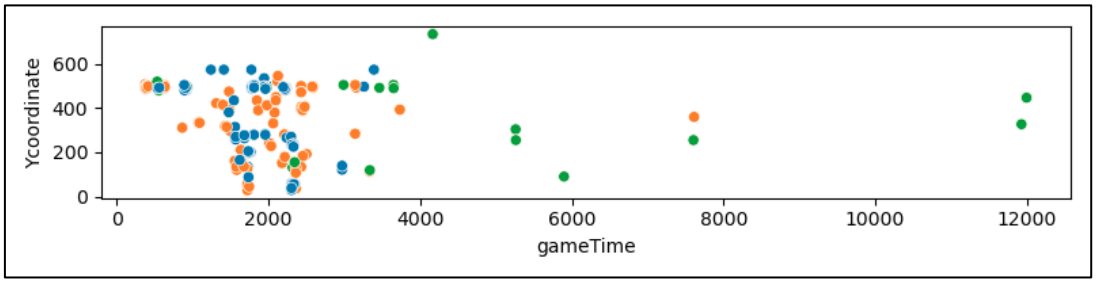

Figure 10. Player death Y coordinate vs current game time

The large majority of deaths occurred at the beginning of the game levels, with easy difficulty standing out as having deaths spanning a far larger extent of the game level than either hard or medium difficulties. It is unclear why players stopped playing at the particular area of the map where they did, as there is no specific obstacle in this area which can be directly correlated to the player's

concluding their gaming session. In future studies following this experiment model, further questioning of the player's reasons for stopping play and their general thoughts at the time of concluding their gaming session would provide some much-needed insight. Despite having a comment box provided to the player at the end of the game engagement questionnaire, asking the player specific questions here would have enhanced the insight we sought into individual player's motivations. It is worth noting that Chicken Wings also did not track successful play throughs of the game, another feature which should definitely be included in future studies to provide further insight into whether successfully finishing the game impacted player engagement or satisfaction.

The data from the death log was used to establish an insight into how many times players died on each difficulty setting of the game. Figure 11 shows the average number of deaths on each difficulty setting of the game, providing a preliminary impression into how much players appeared to struggle on each difficulty.

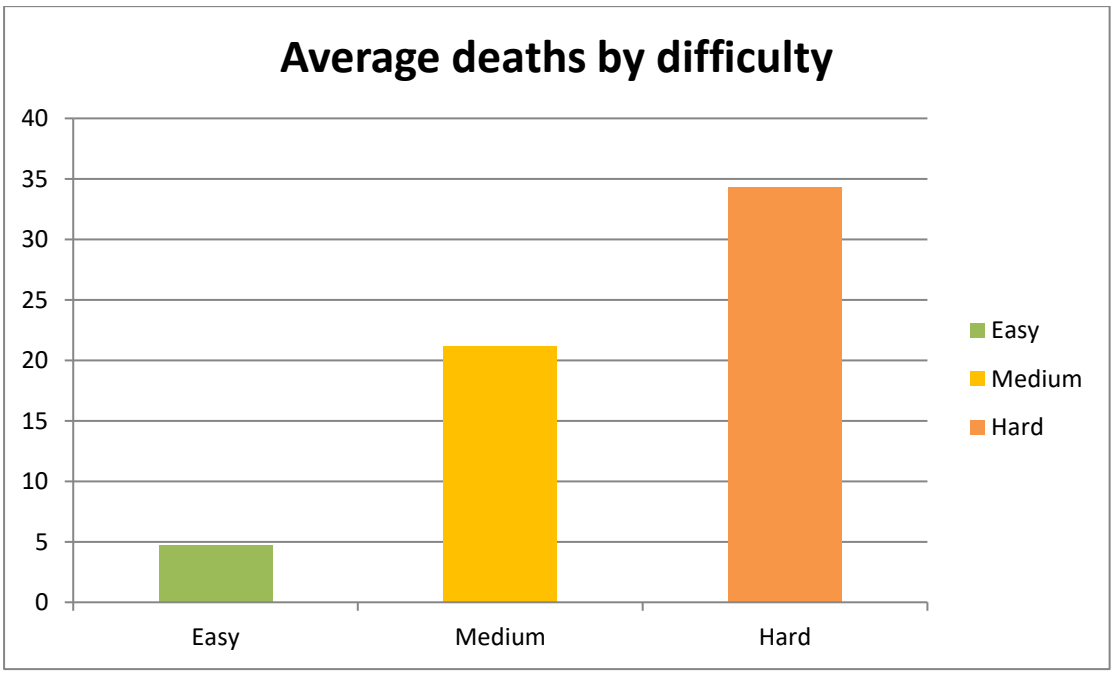

Figure 11. Average deaths by difficulty level played

The insight which this data alone can provide into quantifying the difficulty of the game levels was very limited, even when there is such a clear disparity in the results as there is between the average deaths of the easy difficulty and of the hard difficulty. There is a major consideration which has to be made when viewing this data, which is that Chicken Wings only tracked the time and location of deaths. Chicken Wings did not track the time at which a player began a game session, nor when they successfully completed the game. Future projects following this experiment approach should track the date and time when a player's sessions starts and when they successfully complete the game in order to gather a deeper insight into the player experience.

Although not tracking the time which a session started, or when it was successfully complete, Chicken Wings did track the date and time of each death in the death log. When the average time players spent playing each difficulty is visualized we can see that it bears some similarity to the average death counts of each difficulty as is seen in Figure 12. In a larger scale experiment, the data presented in this graph may actually provide a deep insight into player engagement alone, as some studies covered in the literature review identified the desire to keep playing as the most important factor when determining player engagement (Schoenau-Fog, 2011, pg. 4; Fischer & Benford, 2009).

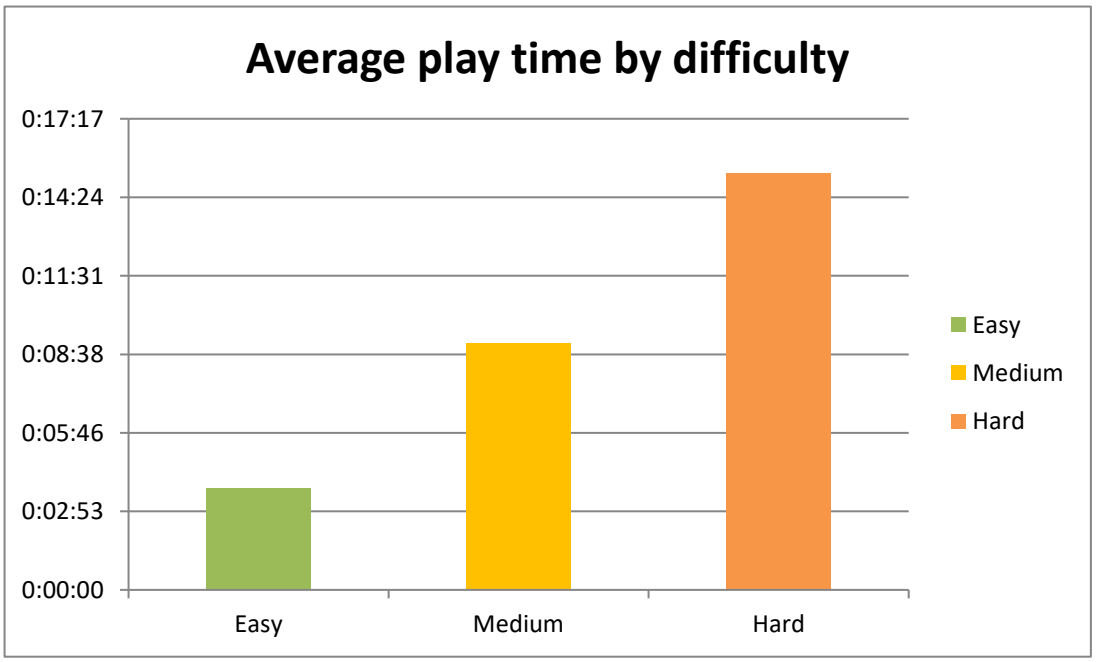

Figure 12. Average play time by difficulty level played

In order to effectively identify how much player's struggled on average, the data of these two graphs had to be combined to analyse how many deaths a player experienced per five minutes on average for each difficulty. This overcomes the weighting which average play time naturally applies to the number of deaths accrued. Figure 13 shows the average deaths per five minutes of play time for each difficulty setting.

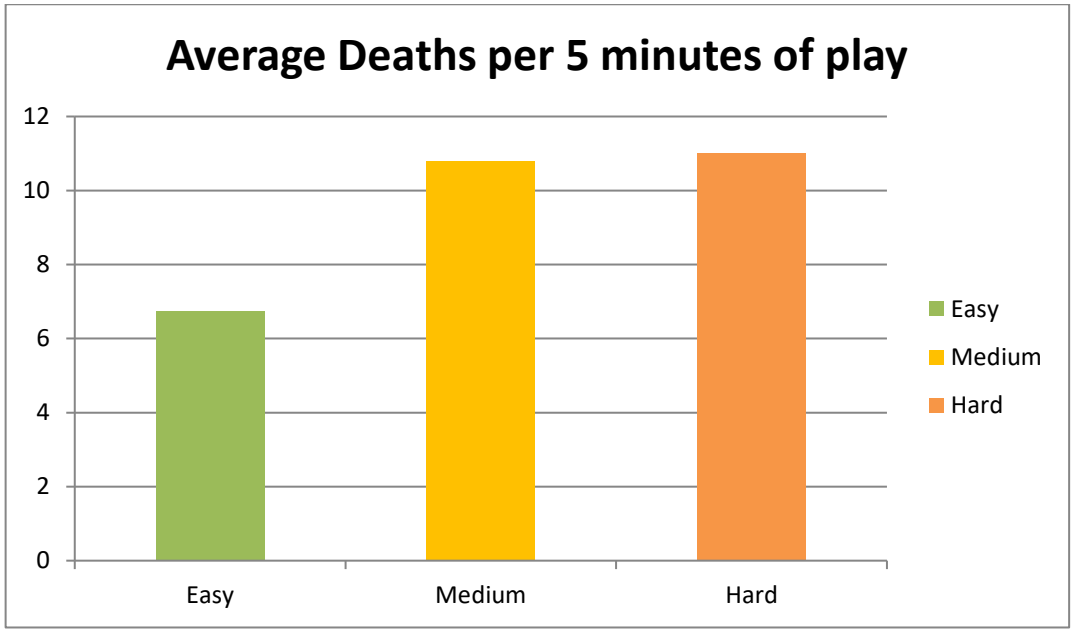

Figure 13. Average deaths per five minutes of playtime

With the adjustments made on Figure 13, we can see that despite players spending less time playing the medium difficulty (Figure 12) and reporting lower levels of engagement with medium difficulty (Figure 9), they accrued almost exactly the same number of deaths as on hard difficulty per five minutes of play time. There are a number of potential reasons for why this occurred. The literature has revealed one such potential reason, in identifying that game enjoyment can be influenced by allowing players to succeed, while appearing to be challenging (Schmierbach et al., 2014). Self-identified performance and competency has been equated to higher levels of enjoyment and engagement with digital games (Alexander et al., 2013). When a player feels like they have autonomy and competency they will typically feel higher levels of engagement with a game (Yun et al., 2010). From the play testers feedback a tentative insight can be provided into the fact that despite the

experiment data reflecting that the medium and hard difficulties were very close in challenge level, for the average player they may have felt very different. As the game's play testers identified medium difficulty as 'feeling' like it had a medium challenge level and hard difficulty 'feeling' like it had a hard challenge level, small successes on the hard difficulty may have given players a stronger sense of competency than those on medium difficulty.

The easy difficulty of the game was clearly considerably easier than either of the other difficulties, yet still managed to maintain a similar level of player engagement as hard difficulty did, as can be seen in Figure 9. When it comes to investigating how difficulty settings impact player engagement and satisfaction, despite players typically having a preference for a challenge level which exceeds their skill level, rather than a skill level which exceeds the challenge level (Klarkowski et al., 2016), it has been found that in the case of blind difficulty assignment (like that in Chicken Wings) an easier difficulty can provide a player with higher levels of engagement (Lomas et al., 2017). It would appear that in the case of Chicken Wings, a player's engagement may have indeed been more heavily impacted by their own perceived levels of competency than by the real difficulty of the game itself.

5.3 DEMOGRAPHIC VARIABLE EFFECTS ON PLAYER ENGAGEMENT

The third research object of this project was:

"To identify and measure the relationship between select player demographic variables and player engagement."

A number of the studies identified in the literature review revealed that player demographic differences can play a very strong role in determining player engagement (Schmierbach et al., 2014). It has also been observed that different types of players find different things difficult (Fraser et al., 2014). The strong links between a game's difficulty and how engaging it is to players cannot be investigated fully without considering these important demographic variables,

some of which according to the literature, may have a greater effect on a player's engagement than even that of a game's difficulty (Kuang & Lextrait, 2012; Pérez et al., 2015; Nagle et al., 2016). For this reason, Chicken Wings is able to track key player demographic variables and compare them against one and other. It is also able to provide insight into their overall impact on a player's engagement with the game. The following section will provide several graphs which demonstrate this experiment's capability to reveal these relationships.

The graph seen in Figure 14 displays a potential relationship which was identified between how avid of a gamer a participant was, versus their reported engagement level.

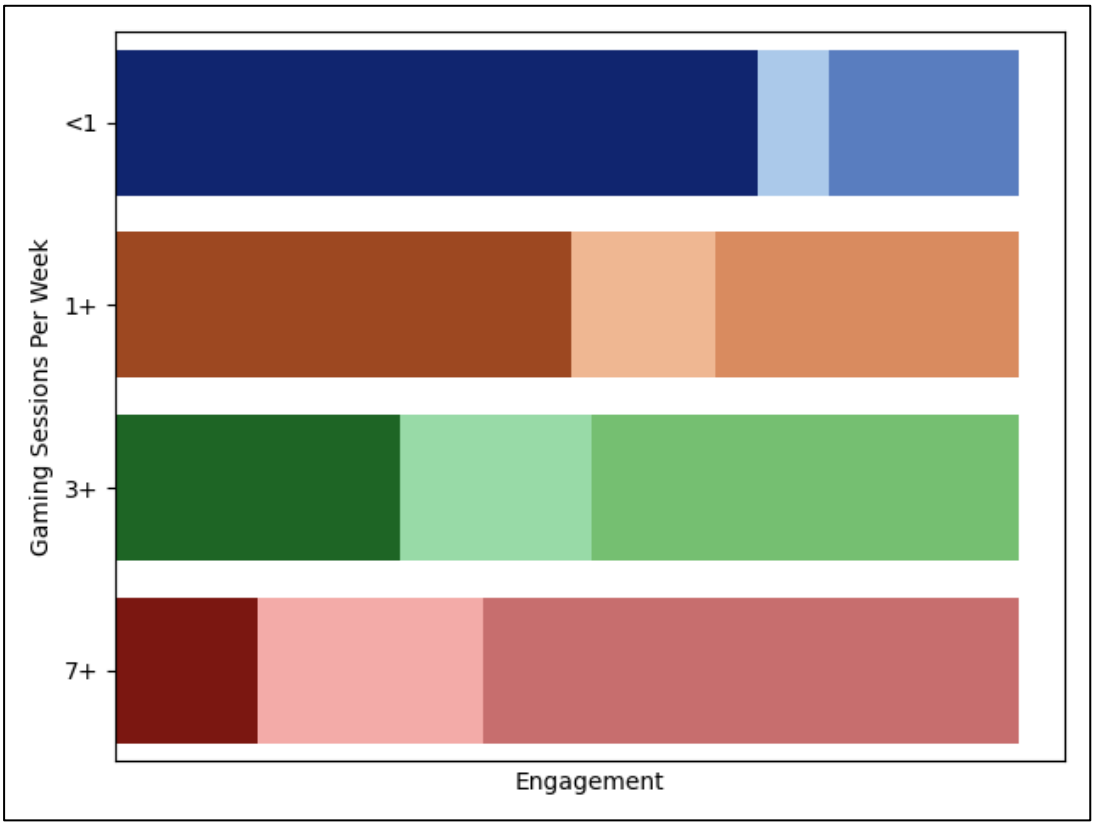

Figure 14. Gaming sessions per week vs engagement

It is immediately apparent that there does seem to be a clear trend in the data, with more avid gamers being more engaged with the game, increasing with the more gaming sessions that they typically engage in per week. The clear trend in this data indicates a strong potential for future research using this experiment approach to

discover important insights into which demographic variables are the most integral in predicting player engagement, and further validates the existing literature which identified that player profiling is integral in understanding player engagement. The graph shown in Figure 15 shows how long participants typical gaming sessions were versus how engaged they were with Chicken Wings.

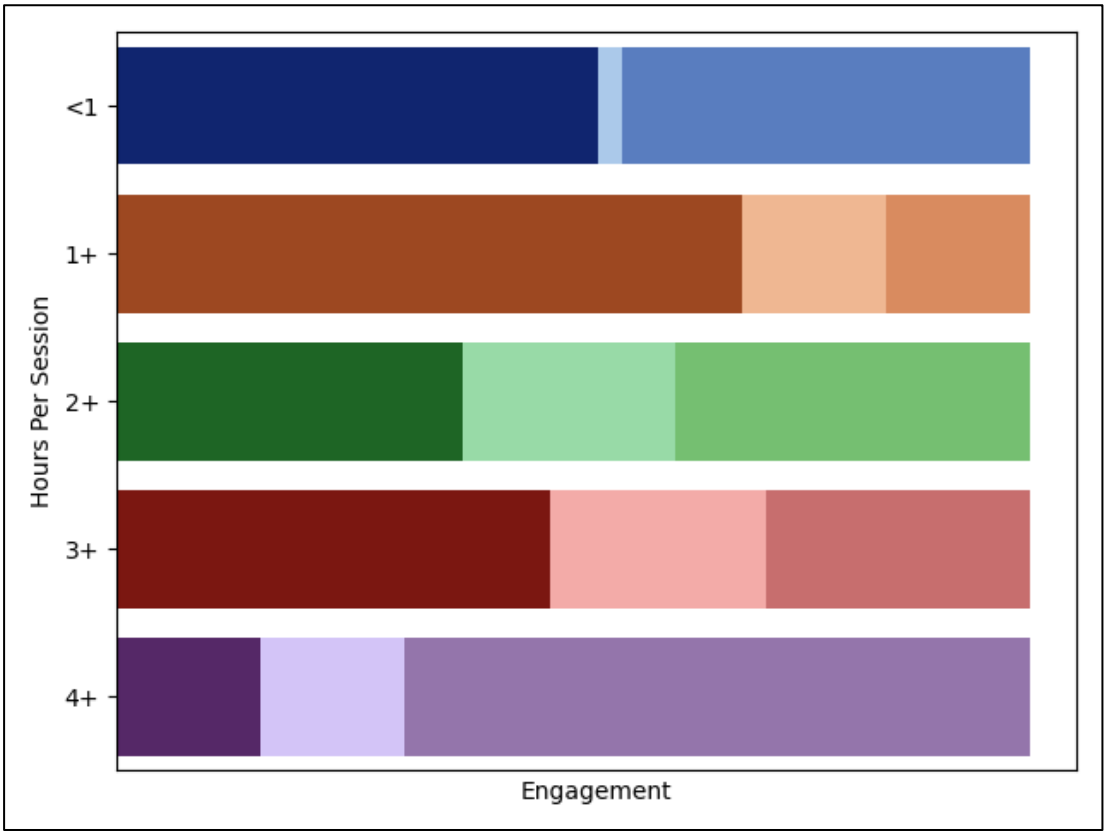

Figure 15. Hours played per gaming session vs engagement

If we look to the Bayesian network graph in Figure 7, we can see that there does not appear to be a strong link between how often participants engaged in gaming sessions, and how long their gaming sessions typically were. Although the data displayed in Figure 15 was conceptually similar to the data displayed in Figure 14, it clearly had a much more varied impact on engagement and was relatively unrelated. This demonstrates yet again how important it is for future research to utilize these methodologies to identify not only the relationships between player

profiling variables and engagement, but also the relationships between these variables themselves as when actually measured, they may expose valuable results worthy of further study.

The next demographic variable graph generated can be seen in Figure 16, which displays the results of how engaging Chicken Wings appeared to be for different age groups.

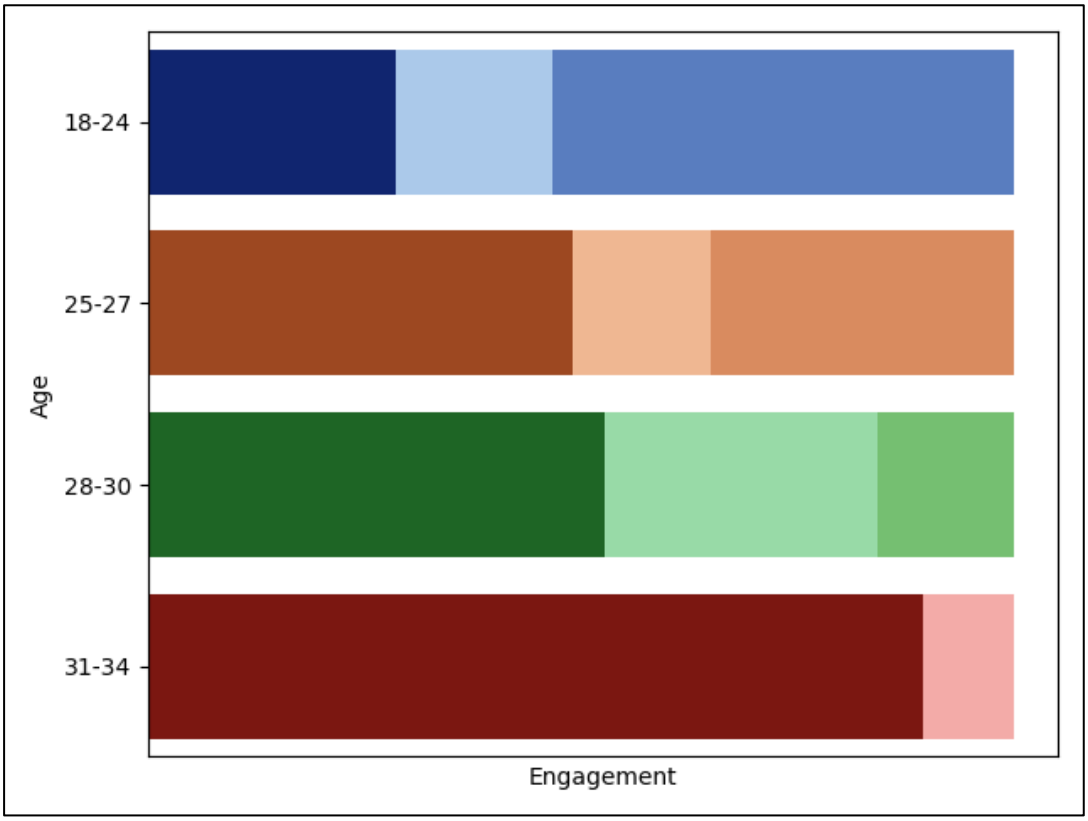

Figure 16. Participant age groups vs engagement

Once again, the graph in Figure 16 has demonstrated a visible trend between a key demographic variable and player engagement, with participants reporting lower levels of engagement the older they were. The same cannot be said for all of the demographic variables, however. Figure 17 displays the education level of a participant versus their reported level of engagement.

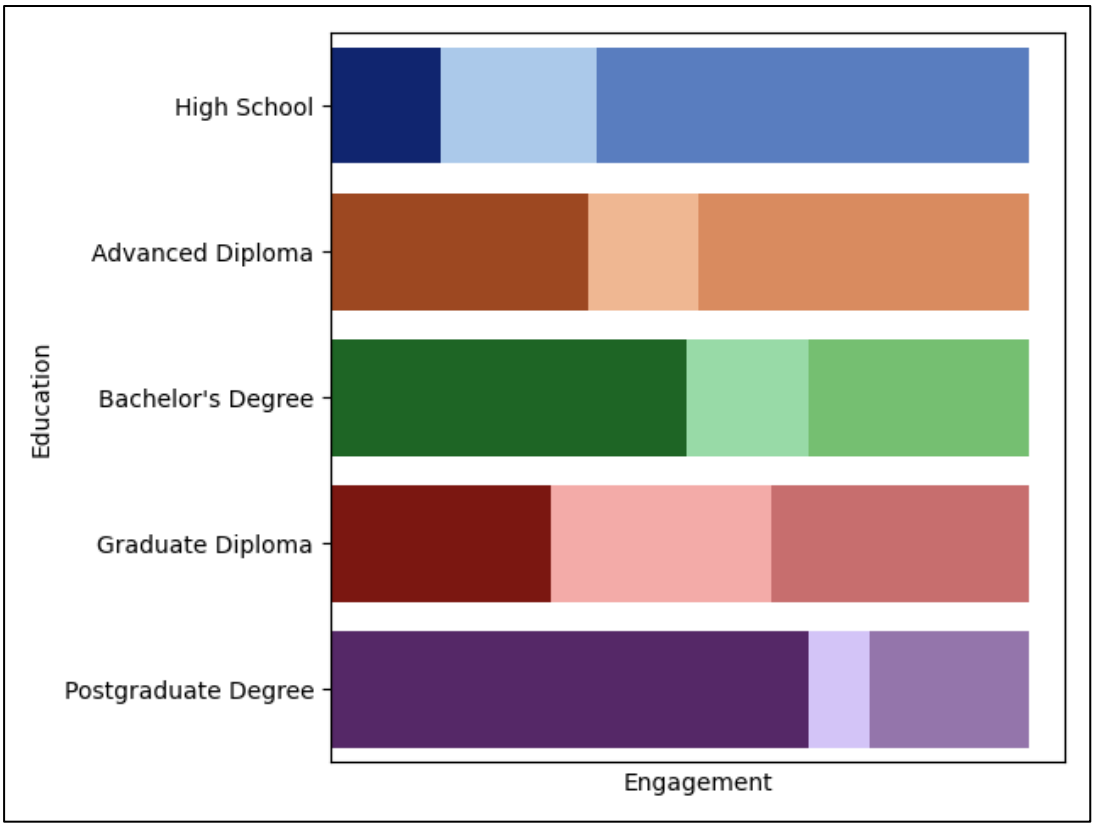

Figure 17. Participant education level vs engagement

Although demonstrating a minor trend, it clearly did not appear to have as strong of an impact on player engagement as some of the other demographic variables such as that shown in Figure 14. The same can be said for the graph in Figure 18, which shows the data on the potential relationship between player gender and engagement.

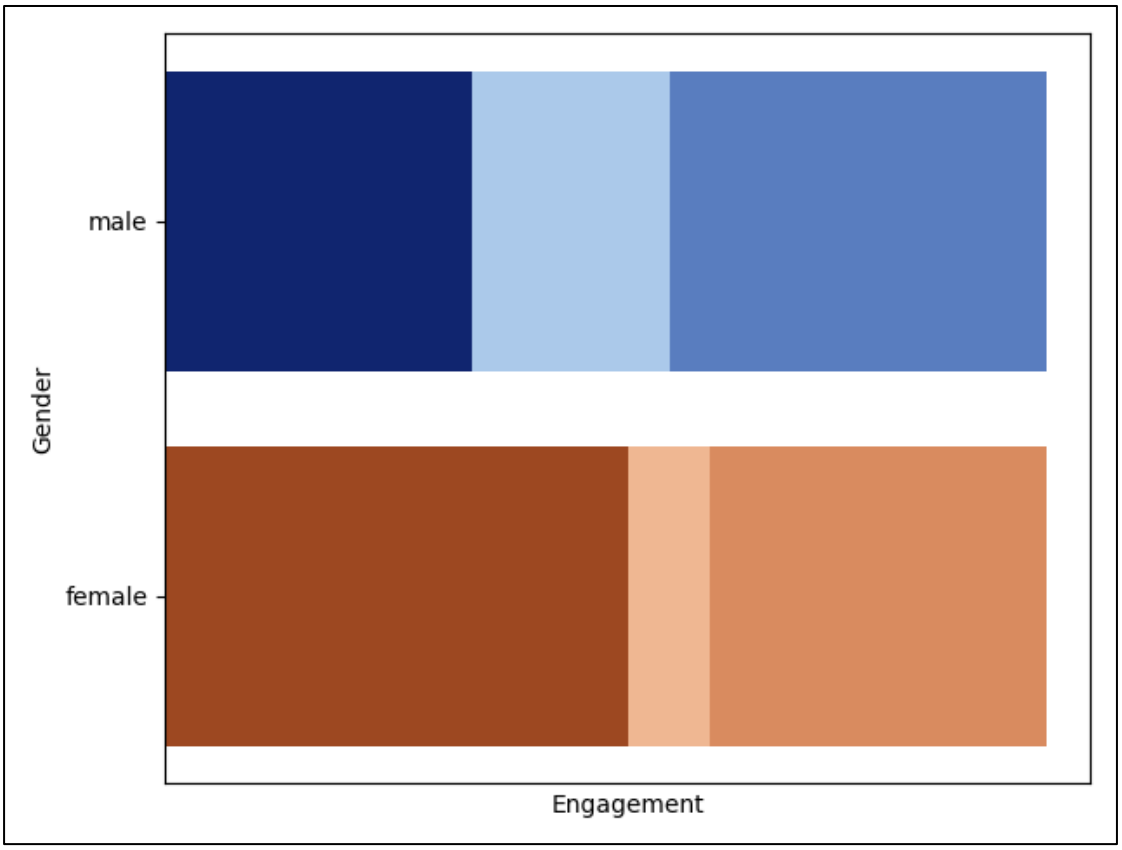

Figure 18. Gender vs engagement

Although only two genders are seen on this graph, participants did have several additional gender options to choose from which in the case of this experiment went unchosen. It must be restated at this point, that a major constraint of this experiment was its scale. None of the results obtained from this experiment can be used to draw any strong conclusions about which demographic variables are the most important in deciding player engagement. The lack of participants in the study renders data such as is represented in these graphs inconclusive. This study has however proposed and validated the ability for the experiment approach to provide insight into key variable relationships, and given a larger scale experiment and deeper analysis, provide a wealth of much needed and sought after knowledge in this area.

Chapter 6: Conclusions

This chapter details the limitations, conclusions and recommendations for future work in this area. Section 6.1 details the major limitations of this study, followed by section 6.2 which covers the major recommendations this study has identified for future work. Finally, the chapter concludes with section 6.3 which provides some concluding remarks and important takeaways from this project.

6.1 LIMITATIONS

The major limitation of this experiment was the lack of scale. None of the results obtained from this experiment can be used to draw any strong conclusions about which demographic variables are the most important in deciding player engagement. The lack of participants in the study renders all data collected as inconclusive.

A second limitation of the experiment was that the only circumstance under which the game tracked the dates, times and locations were in the case of in-game deaths. Chicken Wings did not track the time at which a player began a game session, nor when they successfully completed the game. This meant that no information could be gathered to better understand how game success, or full play time affected engagement.

A third major limitation of the study was that difficulty assignment was randomized and blind. Players had no agency over difficulty choice and were never aware of which game difficulty they were playing. Agency over difficulty has been found in existing literature to have a strong relationship with player enjoyment and potentially engagement. This limits the potential for further investigation into player autonomy and self-identified competency as being contributors to engagement.

6.2 RECOMMENDATIONS & FUTURE WORK

This experiment approach has shown that difficulty may in fact be a somewhat quantifiable metric, and it is recommended that future research investigating this knowledge gap use a similar methodology to the experiment approach proposed in this thesis to quantify difficulty in the context of 'failed number of attempts at success'. It also must be noted that measurements of difficulty as simply 'the number of failed attempts at success' only allows for a very shallow analysis of the difficulty metric. Future work needs to be done to quantify difficulty and define what exactly it is in the context of digital games. Similarly, although the game engagement questionnaire used in this study was quite well validated, future work still needs to be done on identifying and quantifying game engagement as a measurable metric in digital games.

The current accepted standard for investigating game engagement in digital games is Csikszentmihalyi's Theory of Flow, but similarly to a number of existing pieces of literature, this study has found results which may indicate that flow should not be the primary focus for studying this area. Future work needs to be done investigating flow and its ability to predict game engagement, and for this, it is recommended that future researchers may follow an experiment approach based on the methodology proposed in this study.

If future work does utilize the research approach proposed in this study, it is highly recommended that additional difficulties should be included in the study which allow for player selection of the game's difficulty, as evidence has been found in existing literature that this can greatly impact player engagement. Future studies following this experiment model should also include further questioning of the player's reasons for stopping play and their general thoughts at the time of concluding their gaming session, as this would provide some much needed insight into their goals and desires.

Despite having a comment box provided to the player at the end of the game engagement questionnaire, Chicken Wings did not prompt participants to provide any particular type of feedback. Asking the player specific questions here to

prompt more directed responses would have enhanced the insight given into individual player's motivations. In the case of this project, as the only prompt with the text box was to share any additional thoughts, most players did not provide any feedback which could be utilized to provide additional insight into their motivations. Future work should prompt some specific answers here. Additionally, future projects based on this research approach should also include tracking successful play-throughs, and total play time of players as this could provide deeper insight into how play time and success rate impacts engagement and satisfaction.

The discoveries that further research using this experiment approach can make, would significantly impact the current hierarchy of priorities game developers hold on game design elements for player engagement. With a stronger understanding of how difficulty affects player engagement and what elements contribute to a game's ability to satisfy players, the standard approach to game design and development could be substantially altered. For this reason, it is important that far more research is conducted in this area, especially using experiment methodologies similar to the one proposed in this thesis.

6.3 CONCLUSION SUMMARY

This research project has proposed, and to some extent validated, an experiment approach to effectively collect key variables which may be used to identify the relationship between a game's difficulty and player engagement. To achieve this, a research tool in the form of a game called 'Chicken Wings' was created which gathered gameplay telemetry of experiment participants who were asked to play the game. This data was combined with data collected by a demographic survey, and post-game engagement questionnaire which were built into the game. This data was then analysed and investigated to discover whether it may be effective in determining the relationships between difficulty, engagement and key player demographic variables. The project has shed further light on existing literature calling for more work to be done in this area, and somewhat verified an approach which may be taken to achieve this.

Through conducting a Bayesian analysis to reveal the most pertinent links in the experiment's results, this methodology was able to identify select major demographic variables which may contribute to engagement, showing that this experiment approach if taken on a larger scale, with deeper analysis of the data, may discover keen insights into the relationships within these demographic variables and how they relate with engagement. The data gathered has indicated tentative links between several major engagement variables between which there is currently no formally accepted conclusive relationship.

The project was able to investigate its research hypothesis, and found tentative results which indicate that in future studies researchers may move away from the Theory of Flow being the primary lens through which we analyse the relationship between game difficulty and player engagement. Player reported levels of engagement were higher on the easy and hard difficulties of the game compared to the medium difficulty, potentially revealing a relationship between the difficulty of a game and how engaged players are with the game. In a larger scale project, results like these could be used to further validate existing literature positing that player's perceived competency levels play a very significant role on player engagement.

This research project has also been somewhat successful in addressing the second research objective of this project, as this experiment approach is able to contribute data towards quantifying difficulty and engagement in digital games. This is important, as there still remains a lack of a precise formal definition of what either 'difficulty' or 'engagement' are in the context of digital games. This study has proposed and validated the ability for the experiment approach to provide insight into key variable relationships, and given a larger scale experiment and deeper analysis, provide a wealth of much needed and sought after knowledge in this area.

This project has successfully addressed knowledge gaps in the areas of difficulty and player engagement in digital games via monitored user trials of a custom designed game. The results of this study have contributed data towards quantifying, identifying and measuring the relationships between select player demographic variables and player engagement. The primary benefit of this experiment approach

is a deeper understanding of how game elements impact player engagement, especially where the difficulty of a game is concerned. Further, this data speaks to the existing approach game developers use when designing games, suggesting a more game difficulty specific focus via the deeper understanding of the impact it has on player engagement.

Bibliography

Alexander, J. T., Sear, J., & Oikonomou, A. (2013). An investigation of the effects of game difficulty on player enjoyment. *Entertainment computing*, *4*(1), 53-62.

Altimira, D., Clarke, J., Lee, G., Billinghurst, M., & Bartneck, C. (2017). Enhancing player engagement through game balancing in digitally augmented physical games. *International Journal of Human-Computer Studies*, *103*, 35-47.

Aponte, M. V., Levieux, G., & Natkin, S. (2011, November). Difficulty in videogames: an experimental validation of a formal definition. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology* (pp. 1-8).

Berseth, G., Haworth, M. B., Kapadia, M., & Faloutsos, P. (2014, November). Characterizing and optimizing game level difficulty. In *Proceedings of the Seventh International Conference on Motion in Games* (pp. 153-160).

Bianchi-Berthouze, N. (2013). Understanding the role of body movement in player engagement. *Human–Computer Interaction*, *28*(1), 40-75.

Boyle, E. A., Connolly, T. M., Hainey, T., & Boyle, J. M. (2012). Engagement in digital entertainment games: A systematic review. *Computers in human behavior*, *28*(3), 771-780.

Brockmyer, J. H., Fox, C. M., Curtiss, K. A., McBroom, E., Burkhart, K. M., & Pidruzny, J. N. (2009). The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. *Journal of Experimental Social Psychology*, *45*(4), 624-634.

Brühlmann, F., & Mekler, E. D. (2018). Surveys in games user research. *Games User Research*, 141-162.

Chanel, G., Rebetez, C., Bétrancourt, M., & Pun, T. (2008, October). Boredom, engagement and anxiety as indicators for adaptation to difficulty in games. In *Proceedings of the 12th international conference on Entertainment and media in the ubiquitous era* (pp. 13-17).

Chen, J. (2007). Flow in games (and everything else). *Communications of the ACM*, *50*(4), 31-34.

Dogtiev, A. (2020). Flappy Bird Revenue – How much did Flappy Bird make?. Retrieved 16 October 2020, from https://www.businessofapps.com/data/flappy-bird-revenue/

Fernandez, T., Godwin, A., Doyle, J., Verdin, D., Boone, H., Kirn, A., ... & Potvin, G. (2016). More comprehensive and inclusive approaches to demographic data collection.

Fischer, J. E., & Benford, S. (2009, April). Inferring player engagement in a pervasive experience. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1903-1906).

Fraser, J., Katchabaw, M., & Mercer, R. E. (2013, November). An Experimental Approach to Identifying Prominent Factors in Video Game Difficulty. In *International Conference on Advances in Computer Entertainment Technology* (pp. 270-283). Springer, Cham.

Fraser, J., Katchabaw, M., & Mercer, R. E. (2014). A methodological approach to identifying and quantifying video game difficulty factors. *Entertainment Computing*, *5*(4), 441-449.

Girouard, A., Solovey, E. T., Hirshfield, L. M., Chauncey, K., Sassaroli, A., Fantini, S., & Jacob, R. J. (2009, August). Distinguishing difficulty levels with non-invasive brain activity measurements. In *IFIP Conference on Human-Computer Interaction* (pp. 440-452). Springer, Berlin, Heidelberg.

Harrigan, K. A., Collins, K., Dixon, M. J., & Fugelsang, J. (2010, May). Addictive gameplay: What casual game designers can learn from slot machine research. In *Proceedings of the international academic conference on the future of game design and technology* (pp. 127-133).

Holt, R., & Mitterer, J. (2000). Examining video game immersion as a flow state. *108th Annual Psychological Association, Washington, DC*.

Hunicke, R. (2005, June). The case for dynamic difficulty adjustment in games. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology* (pp. 429-433).

Jennings-Teats, M., Smith, G., & Wardrip-Fruin, N. (2010, June). Polymorph: dynamic difficulty adjustment through level generation. In *Proceedings of the 2010 Workshop on Procedural Content Generation in Games* (pp. 1-4).

Juul, J. (2009). Fear of failing? the many meanings of difficulty in video games. *The video game theory reader*, *2*(01), 2009.

Khajah, M. M., Roads, B. D., Lindsey, R. V., Liu, Y. E., & Mozer, M. C. (2016, May). Designing engaging games using Bayesian optimization. In *Proceedings of the 2016 CHI conference on human factors in computing systems* (pp. 5571-5582).

Klarkowski, M., Johnson, D., Wyeth, P., McEwan, M., Phillips, C., & Smith, S. (2016, May). Operationalising and evaluating sub-optimal and optimal play experiences through challenge-skill manipulation. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 5583-5594).

Kuang, A. H., & Lextrait, T. S. (2012). Dynamic difficulty adjustment.

Leiker, A. M., Bruzi, A. T., Miller, M. W., Nelson, M., Wegman, R., & Lohse, K. R. (2016). The effects of autonomous difficulty selection on engagement, motivation, and learning in a motion-controlled video game task. *Human movement science*, *49*, 326-335.

Liu, C., Agrawal, P., Sarkar, N., & Chen, S. (2009). Dynamic difficulty adjustment in computer games through real-time anxiety-based affective feedback. *International Journal of Human-Computer Interaction*, *25*(6), 506-529.

Lomas, D., Stamper, J., Muller, R., Patel, K., & Koedinger, K. R. (2012, June). The effects of adaptive sequencing algorithms on player engagement within an online game. In *International conference on intelligent tutoring systems* (pp. 588-590). Springer, Berlin, Heidelberg.

Lomas, J. D., Koedinger, K., Patel, N., Shodhan, S., Poonwala, N., & Forlizzi, J. L. (2017, May). Is difficulty overrated? The effects of choice, novelty and suspense on intrinsic motivation in educational games. In *Proceedings of the 2017 CHI conference on human factors in computing systems* (pp. 1028-1039).

Missura, O., & Gärtner, T. (2009, October). Player modeling for intelligent difficulty adjustment. In *International Conference on Discovery Science* (pp. 197-211). Springer, Berlin, Heidelberg.

Morris, C. (2020). Video Game Demographics - How Many People Play Video Games? - Earnest. Earnest Blog - Money Advice for Young Professionals. Retrieved 25 October 2020, from https://www.earnest.com/blog/the-demographics-of-video-gaming

Mun, J. (2015). "The effect of game playing, goal orientation, and game difficulty level on subsequent creative new product development outcomes: A multi-process account."

Nagle, A., Wolf, P., & Riener, R. (2016). Towards a system of customized video game mechanics based on player personality: Relating the Big Five personality traits with difficulty adaptation in a first-person shooter game. *Entertainment computing*, *13*, 10-24.

Orvis, K. A., Horn, D. B., & Belanich, J. (2008). The roles of task difficulty and prior videogame experience on performance and motivation in instructional videogames. *Computers in Human behavior*, *24*(5), 2415-2433.

Park, S., Sim, H., & Lee, W. (2014). Dynamic game difficulty control by using EEG-based emotion recognition. *Int J Control Autom*, *7*, 267-272.

Pérez, L. J. F., Calla, L. A. R., Valente, L., Montenegro, A. A., & Clua, E. W. G. (2015, November). Dynamic game difficulty balancing in real time using evolutionary fuzzy cognitive maps. In *2015 14th Brazilian Symposium on Computer Games and Digital Entertainment (SBGames)* (pp. 24-32). IEEE.

Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A motivational model of video game engagement. *Review of general psychology*, *14*(2), 154-166.

Qin, H., Rau, P. L. P., & Salvendy, G. (2010). Effects of different scenarios of game difficulty on player immersion. *Interacting with Computers*, *22*(3), 230-239.

Sampayo-Vargas, S., Cope, C. J., He, Z., & Byrne, G. J. (2013). The effectiveness of adaptive difficulty adjustments on students' motivation and learning in an educational computer game. *Computers & Education*, *69*, 452-462.

Sarkar, A., & Cooper, S. (2019, May). Transforming game difficulty curves using function composition. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (pp. 1-7).

Schmierbach, M., Chung, M. Y., Wu, M., & Kim, K. (2014). No one likes to lose. *Journal of Media Psychology*.

Schoenau-Fog, H. (2011, September). The Player Engagement Process-An Exploration of Continuation Desire in Digital Games. In *DiGRA Conference*.

Smeddinck, J. D., Mandryk, R. L., Birk, M. V., Gerling, K. M., Barsilowski, D., & Malaka, R. (2016, May). How to present game difficulty choices? Exploring the impact on player experience. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 5595-5607).

Smith, L. J., King, D. L., Richardson, C., Roane, B. M., & Gradisar, M. (2017). Mechanisms influencing older adolescents' bedtimes during videogaming: the roles of game difficulty and flow. *Sleep medicine*, *39*, 70-76.

Um, S. W., Kim, T. Y., & Choi, J. S. (2007). Dynamic difficulty controlling game system. *IEEE Transactions on Consumer Electronics*, *53*(2), 812-818.

Wehbe, R. R., Mekler, E. D., Schaekermann, M., Lank, E., & Nacke, L. E. (2017, May). Testing incremental difficulty design in platformer games. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 5109-5113).

Yin, H., Luo, L., Cai, W., Ong, Y. S., & Zhong, J. (2015, September). A data-driven approach for online adaptation of game difficulty. In *2015 IEEE conference on computational intelligence and games (CIG)* (pp. 146-153). IEEE.

Yun, C., Trevino, P., Holtkamp, W., & Deng, Z. (2010, July). PADS: enhancing gaming experience using profile-based adaptive difficulty system. In *Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games* (pp. 31-36).

Zheng, X., Aragam, B., Ravikumar, P. K., & Xing, E. P. (2018). DAGs with NO TEARS: Continuous optimization for structure learning. In *Advances in Neural Information Processing Systems* (pp. 9472-9483).

Appendices

Appendix A

User Account Data File Example (de-identified)

hard,male,sevenSessionsWeekly,twoHourSessions,gamingConsole,18-24,highSchool
0000,Y,Y,Y,M,M,M,M,Y,N,N,M,M,Y,Y,Y,N,Y,Y,M
0001,Y,Y,M,N,N,M,N,Y,Y,Y,Y,Y,Y,M,Y,M,M,M,Y
0002,N,Y,Y,N,N,M,Y,N,N,M,N,Y,Y,M,Y,N,N,Y,Y

Appendix B

Gameplay metrics data file ('death log')

2720,0000,3337,119,8/28/2020,13:26:27,easy
2720,0000,7603,255,8/28/2020,13:28:10,easy
2720,0000,5897,90,8/28/2020,13:29:24,easy
2720,0000,3650,490,8/28/2020,13:30:21,easy
2720,0000,5259,304,8/28/2020,13:31:25,easy
2720,0000,4166,735,8/28/2020,13:32:17,easy
2720,0000,5262,255,8/28/2020,13:33:20,easy
2196,0000,894,481,8/28/2020,14:32:22,medium
2196,0000,1560,315,8/28/2020,14:32:45,medium
2196,0000,1813,499,8/28/2020,14:33:11,medium
2196,0000,1951,497,8/28/2020,14:33:41,medium
2196,0000,1804,281,8/28/2020,14:34:7,medium
2196,0000,1813,500,8/28/2020,14:34:32,medium
2196,0000,1810,496,8/28/2020,14:34:58,medium
2196,0000,1783,499,8/28/2020,14:35:25,medium
2196,0000,1812,499,8/28/2020,14:35:50,medium
2196,0000,2214,484,8/28/2020,14:36:20,medium
2196,0000,1783,490,8/28/2020,14:36:49,medium
2196,0000,1788,497,8/28/2020,14:37:16,medium
2196,0000,1811,505,8/28/2020,14:37:43,medium
2196,0000,1811,494,8/28/2020,14:38:9,medium
2196,0000,1812,497,8/28/2020,14:38:35,medium
2196,0000,2329,237,8/28/2020,14:39:7,medium
2196,0000,2222,482,8/28/2020,14:39:37,medium
2196,0000,2326,228,8/28/2020,14:40:8,medium
2196,0000,1813,502,8/28/2020,14:40:35,medium
2196,0000,2214,487,8/28/2020,14:41:15,medium
2196,0000,2346,57,8/28/2020,14:41:47,medium
2196,0000,2196,495,8/28/2020,14:48:33,medium
2196,0000,3260,497,8/28/2020,14:49:16,medium
2196,0000,1412,574,8/28/2020,14:49:38,medium
2196,0000,1959,279,8/28/2020,14:50:8,medium
2634,0000,393,492,8/28/2020,14:52:22,hard
2634,0000,1449,315,8/28/2020,14:52:46,hard
2634,0000,631,496,8/28/2020,14:53:0,hard
2634,0000,1656,150,8/28/2020,14:53:25,hard
2634,0000,634,501,8/28/2020,14:53:39,hard
2634,0000,635,503,8/28/2020,14:53:53,hard
2634,0000,414,499,8/28/2020,14:54:6,hard
2634,0000,2097,435,8/28/2020,14:54:37,hard
2634,0000,1582,120,8/28/2020,14:55:2,hard

Appendix C

Game Demographic Questionnaire

1) How do you describe your gender identity? (Mark all that apply)

[ ] Female	[ ] Male	[ ] Genderqueer	[ ] Gender
[ ] Transgender	[ ] Cisgender	[ ] A gender not listed	_____

2) How often do you play video games?

[ ] 7+ times per week	[ ] 5 times per week	[ ] 3 times per week	[ ] 1 time per week
[ ] Less than once per week	[ ] Never		

3) When you play video games, how long do you typically play for?

[ ] 4+ hours per session	[ ] 3+ hours per session	[ ] 2+ hours per session	[ ] 1+ hour per session
[ ] Less than an hour	[ ] I don't play games		

4) Which device(s) do you typically use to play video games? (Mark all that apply)

[ ] PC / MAC	[ ] Smart Phone	[ ] Handheld Device	[ ] Gaming Console
[ ] Web Browser	[ ] A platform not listed		

5) Which of these age groups do you belong to?

[ ] 18-24	[ ] 25-27	[ ] 28-30
[ ] 31-34	[ ] 35-40	[ ] 41+

6) What is your highest level educational attainment?

[ ] Postgraduate Degree	[ ] Graduate Diploma	[ ] Graduate Certificate	[ ] Bachelor's Degree
[ ] Advanced Diploma	[ ] Certificate III/IV	[ ] Year 12	[ ] Year 11 or below

Appendix D

Game Engagement Questionnaire

Thank you for playing 'Chicken Wings' and helping in this research project! Your participation has been extremely valuable! Before exiting the game please answer this short questionnaire about how you felt while playing Chicken Wings.

Please Note: Skipping this process will render the data collected by the game and your participation in this research unusable, so please make sure to complete this questionnaire before exiting!

I lose track of time
[ ] Yes
[ ] Maybe
[ ] No

Things seem to happen automatically
[ ] Yes
[ ] Maybe
[ ] No

I feel different
[ ] Yes
[ ] Maybe
[ ] No

I feel scared
[ ] Yes
[ ] Maybe
[ ] No

The game feels real
[ ] Yes
[ ] Maybe
[ ] No

If someone talks to me, I don't hear them
[ ] Yes
[ ] Maybe
[ ] No

I get wound up
[ ] Yes
[ ] Maybe
[ ] No

Time seems to kind of stand-still or stop
[ ] Yes
[ ] Maybe
[ ] No

I feel spaced out
[ ] Yes
[ ] Maybe
[ ] No

I don't answer when someone talks to me
[ ] Yes
[ ] Maybe
[ ] No

I can't tell that I'm getting tired
[ ] Yes
[ ] Maybe
[ ] No

Playing seems automatic
[ ] Yes
[ ] Maybe
[ ] No

My thoughts go fast
[ ] Yes
[ ] Maybe
[ ] No

I lose track of where I am
[ ] Yes
[ ] Maybe
[ ] No

I play without thinking about how to play
[ ] Yes
[ ] Maybe
[ ] No

Playing makes me feel calm
[ ] Yes
[ ] Maybe
[ ] No

I play longer than I meant to
[ ] Yes
[ ] Maybe
[ ] No

I really get into the game
[ ] Yes
[ ] Maybe
[ ] No

I feel like I just can't stop playing
[ ] Yes
[ ] Maybe
[ ] No