City, University of London

MSc in Computer Games Technology

Project Report

2022

Building engagement in a classification data-analysis, citizen science video game

Philip Charles Smith II

Supervisor: Dr. Ross Paterson

January 18th 2023

By submitting this work, I declare that this work is entirely my own except those parts duly identified and referenced in my submission. It complies with any specified word limits and the requirements and regulations detailed in the assessment instructions and any other relevant programme and module documentation. In submitting this work I acknowledge that I have read and understood the regulations and code regarding academic misconduct, including that relating to plagiarism, as specified in the Programme Handbook. I also acknowledge that this work will be subject to a variety of checks for academic misconduct.

Signed:

Philip Smith

Abstract

Gamified citizen science projects like Foldit (2008) and EyeWire (2012) have relied upon prolonged engagement from volunteers, but their participant numbers prove unsatisfactory for the purposes of their large-scale projects. The problem that this project tries to address is the lack of engagement from volunteers in these gamified projects. The aim was to build an engaging citizen science video game based in classification data-analysis. Using the Unity Game Engine, an API developed by Massive Multiplayer Online Science, and a data set provided by another citizen science research group SPIPOLL, the game "Project Fly Catcher" was developed. The game mixes 3D platforming, treasure-hunting, and simple puzzle-solving into its gameplay. It contains 3 levels, one of which being a tutorial level. It was distributed among 18 participants who played through every level or for at least 15 minutes and were then instructed to answer a survey that utilised three established questionnaires in game development: the Game Experience Questionnaire, The Immersive Experience Questionnaire, and the Player Experience Needs Satisfaction model. The results suggested that while the 3D platforming mechanics had much room for improvement, many participants were engaged with the citizen science aspect of the game.

Keywords: gamification, engagement, classification

1. Introduction

1.1. Background

To understand the goals of this project, it is important to understand three key concepts that its research acknowledges.

- ➢ Citizen Science
- ➢ Engagement
- ➢ Gamification

1.1.1. Citizen Science

Citizen science is the practice of employing volunteers from the general public to collect and/or process data in reference to a scientific project (Silvertown, 2009). Over the centuries, scientific research and discovery has been helped a multitude of times by unregistered, unlicensed citizens who worked in the interest of science. 'Scientist' was not even a proper profession until the 19th century (Ben-David, 1972, Silvertown, 2009). Following this instatement, perhaps the earliest recorded instance of an official citizen scientist project post the establishment of the 'professional' scientist was the North American Bird Phenology Program, started by Wells Cooke in 1880 (www.citizenscience.gov., n.d.; www.pwrc.usgs.gov, 2016). By the annals of history, the concept of citizen science has existed for well over a century and is far from a novel or experimental methodology in the scientific community.

Historically, citizen science has been a practice used in fields that fall under the natural sciences. These fields include ornithology (as mentioned before), the study of birds, astronomy, the study of celestial bodies, and entomology, the study of insects.

1.1.2. Engagement

Many people know what it means to be engaged in something, though specifying what factors will facilitate such engagement is a matter that has attracted contesting hypotheses. Numerous theories have attempted to map the nature of human engagement. One such theory is "Self-Determination theory" (SDT), a theory that has been applied to education, sports, and video games (Przybylski et al., 2010; Şengün, 2019; Ryan et. al, 2006). The core of SDT is the notion that people are motivated by two distinguishing motivational factors: intrinsic and extrinsic motivators (Ryan and Deci, 2000). Intrinsic motivation relates to the inherent enjoyment of engaging in an activity, excluding 'separable' or external

outcomes. In essence, the subject receives satisfaction from the participation of said action, not from the resulting outcomes. A subtheory of SDT that further explores intrinsic motivators is Cognitive Evaluation Theory (CET). CET points out two significant needs a person must receive in order to find intrinsic motivation: autonomy and competence (Przybylski et al., 2010; Ryan et. al, 2006). Autonomy refers to a person's free will, their ability to make their own choices in the moment. Competence is a person's level of capability; simply how good one is at a given task. In addition to the needs expressed by CET, further SDT research also highlights a third intrinsic need in the form of 'relatedness', referring to the quality of a person's interactions with other agents during an activity. On the other side of the coin, extrinsic motivation relates explicitly to separable outcomes of an activity. This can come in a variety of forms such as compensation, personal growth, or even the relief of avoiding the consequences of not performing the action.

This all formulates the basic foundation of how SDT views engagement and will be the core of how this report will understand engagement going forward. However, even with a full understanding of SDT and the intrinsic and extrinsic needs it describes, the skills and means to design an activity that would facilitate those needs are not guaranteed. Especially when one must build upon an already existing process that runs the habit of showcasing tedious, consecutive tasks that will bring no intrinsic motivation to the average person. Such a process can come in the form of the scientific labour undergone in citizen science.

1.1.3. Gamification

In an attempt to design a citizen science project that provides intrinsic motivation to its participants, one can turn to the design methodology of gamification.

Gamification is the practice of applying game elements to existing real-world processes (Landers *et. al.*, 2018). Such processes have included education, corporate business, and citizen science. Such an instance of gamified citizen science comes in the form of EyeWire (2012), a web based game played from the official game site run by its developers from Seung Lab at Princeton University. The gameplay of EyeWire (2012) is coded and designed to allow hundreds of thousands of players, non-scientists, to map brain neurons, a task traditionally reserved for the professional scientist. Preceding EyeWire(2012) was the Foldit project (2008), a PC game developed by members of the University of Washington. Foldit's (2008) gameplay tasks players with solving three-dimensional puzzles that translate into protein folding. By solving these puzzles, players help design new proteins that can be used to develop treatments for diseases, design molecules to invent new drugs, and solve protein structures to map molecules (fold.it, n.d.). Finally, a more recent example is Borderlands Science, a free mini-game that is included in every

updated copy of Borderlands 3 (2019) as of April, 2020. Borderlands Science was a joint project conducted by the developers of Borderlands 3, Gearbox Software, along with Massive Multiplayer Online Science (MMOS) and scientists and researchers from McGill University and the Microsetta Initiative at UC San Diego School of Medicine (Gearbox, 2020). The purpose of the project is to aid research into the human gut microbiome, leading to discoveries that can aid in the research of diabetes, obesity, and even cancer. The gameplay is grid-based puzzle solving, intuitively designed to make the task of identifying and decoding the microbes accessible to regular players.

1.2. The Problem

What previous examples showcase is the potential of gamified citizen science, how purposeful game design can make tasks normally reserved for scientists accessible to people who play video games. However, even with gamification, projects like Foldit (2008) and EyeWire (2012) have suffered from a lack of prolonged engagement, as their long-term participant numbers prove unsatisfactory for the purposes of their scientific fields (Waldispühl *et al.*, 2020; Sauermann and Franzoni, 2015).

1.3. Inspiration

The inspiration for this project was Massive Multiplayer Online Science, one of the partners that helped develop Borderlands Science. They are a company whose mission statement is to "connect scientific research and video games as a seamless gaming experience" (Szantner and Revaz, 2014). In their previous projects, their focus was incorporating citizen science elements into pre-existing games, which limited them into making the citizen science part of the games optional and non-intrusive to the pre-established gameplay loop (the cycle of actions repeated continuously over the course of playing a video game). The overall goal of this project was to create a game that has citizen science processes built into its core mechanics while maintaining player engagement.

1.4. Project Aims

The aim of this project was ultimately to build an engaging classification data-analysis, citizen science video game. To clarify the specifics of what this project would produce, each element of this aim was clearly defined from the beginning:

- **Engaging**: To be engaging, the final product must succeed in satisfying the motivational needs specified by SDT.

- **Classification Data-Analysis**: The purpose of the final product will be to perform an analysis on raw data that has already been collected by an outside party. This analysis will be organising each data point into a predefined label or classification.

- **Citizen Science**: The final product should be designed to be accessible to a non-scientist citizen. Users will carry out each of the mentioned analyses, and the results will be shared to the research group that carried out the initial data collection. These user results must be subject to some data quality assurance for the sake of accuracy.

- **Video Game**: The process of the data analysis will be digital and subject to gamification. The final product will take the form of a computer game that will be playable on select operating systems.

1.5. Specifications

In order to ensure the project aim was realised, some initial considerations were made:

- The citizen science element of the game must be a core part of the gameplay loop. It must be essential for the player to engage with the citizen science elements to complete a level in the game.

- The game could not have the data analysis task acting as its only gameplay feature. While the mechanic must be an essential component to the gameplay loop, it was surmised that the classification problem on its own could not deliver the intrinsic motivation needed for the game to be engaging.

1.6. Project Scope

The work plan of the project was set over the course of the several month period between June and December.

1.6.1. Research

Preliminary research was carried out on existing literature describing citizen science and game design elements, as well as their effect on player engagement.

1.6.2. Development

The development process of the project followed a mixture of a flexible and linear project management framework. While specific tasks were completed in a freeform order, only limited by practical task dependency, no interim tests were performed and most design decisions were finalised near the start of development before their respective tasks began. These design decisions consisted mainly of the core mechanics and theme of the game.

It was decided at the conception of this project that the game will be built using the Unity game engine. Acting as software frameworks that house multiple pre-built support programs, game engines are well established tools in video game development that circumvent setting up much of the preliminary programming logic such as physics, graphics, and sound when developing a new game. Utilising a game engine meant that development time did not have to be allocated to building those foundational mechanics, and time could instead be spent incorporating the mechanics essential to achieving the project's goals and specific to the final product. The Unity game engine is open source and widely used in the game developer community, which has allowed for a plethora of resources to be made available to support those that develop in the engine. This includes open source 3D models. Due to the nature of the project's goals, it was decided that utilising these 3D models was necessary to completing the game in the timescale provided, as they further aid in circumventing tasks that would involve creating new graphical assets for the game and take up time better allocated to essential mechanics.

The citizen science aspect of the game was also supported by a third party service. MMOS, in addition to serving as the inspiration of the project, also supplied the foundation for the functionality of the citizen science gameplay elements. A developer portal that MMOS created houses multiple data sets by ongoing research projects. Using their open source SDK (Szanter, 2019) that communicates directly to the database of the developer portal, a project is able to both download citizen science tasks and upload user solutions (Szantner, 2013). It was determined that given the available timescale of the project, it was unrealistic to go through the necessary channels to find another data set not already on the MMOS developer portal and build the necessary software framework to use that data set. Therefore, the MMOS developer portal and its API became essential components to the game.

The data set that was decided on for the game was a data set compiled by a French citizen science project named "Suivi photographique des insectes pollinisateurs" (SPIPOLL), or in English "Photographic monitoring of pollinating insects". The aim of the SPIPOLL project is to study pollination networks and the pollinators that complete them. The data set consisted of citizen-sourced photographic images of hoverflies, a pollinating flying insect.

Figure 1.1: Episyrphus balteatus male (Marmalade Hoverfly) (Syrphidae - Hoverflies) (Oliver, 2021)

Figure 1.2: Marmalade hoverfly (Episyrphus balteatus) female (Sharp, 2014)

The citizen science tasks this data set provides are image classification based. Specifically, users are tasked with determining if the fly in the photograph is a male or female, with options in the event that the solution is not clear. The scale is ordered as:

- Female
- Likely Female
- Can't See
- Likely Male

- Male

It was decided that with the data set finalised, it was appropriate to create a title for the game as a means to aid in building an identity for the game and thus build engagement in players. Following the theme of capturing photos of flies, the working title for the game was “Project Fly Catcher” (referred to as Fly Catcher for the sake of brevity in this report).

1.6.3. Data Collection

To measure the success of the final build of Fly Catcher, both quantitative and qualitative data were collected.

For quantitative data, engagement was measured using the Games Experience Questionnaire (GEQ) (IJsselsteijn et al., 2013), The Player Experience of Need Satisfaction model (PENS) (Immersyve, 2007), and the Immersive Experience Questionnaire (IEQ) (Jennett et al., 2008). The decision to use multiple questionnaires for the data collection was made based on the varying advantages and disadvantages each model has in their effectiveness over the others (Denisova, Nordin, and Cairns, 2016; Johnson *et al*., 2018). These questionnaires were hosted electronically on Google Forms. Google Forms is end-to-end encrypted, so any identifiable information shared in the answers will remain confidential. As for qualitative data, written feedback was collected from a sample of participants.

1.7. Project Changes

A subtle but significant change to the project’s aims and research direction came when further investigation was conducted into engagement theory and its relation to video games. Originally, based on limited starting knowledge of the subject, the project’s understanding and framing of ‘video game engagement’ was based on broad definitions adopted from the establishing papers of the Games Experience Questionnaire (GEQ) (IJsselsteijn et al., 2013) and The Player Experience of Need Satisfaction model (PENS) (Immersyve, 2007). Because of this broader understanding, the original project idea was centred on purposeful game design that could generate player engagement, but did not specify what directions and sought, quantifiable outcomes those design decisions would be expected to fulfil. Additionally, while the project proposal identified a means to quantify engagement, the values represented by the questionnaires were not properly understood.

This limitation was alleviated once Self-Determination Theory was properly explored and understood. Because of the established research and merit the theory had in studying user engagement in video games, SDT became an influential part of the project’s design phase, shaping how and why certain

game elements were implemented (Przybylski et al., 2010; Şengün, 2019; Ryan et. al, 2006). Its sub-theory, Cognitive Evaluation Theory, had a major role, as intrinsic motivators became a focus of the game design process in order to accommodate for the traditionally tedious tasks involved in citizen science.

The original data set that was planned to be the basis of the game was a wasp data set, also from the SPIPOLL project. However, it was discovered early on that the data set did not contain any usable data. With that revelation, it was decided that the game would instead centre on the second data set from SPIPOLL that focused on hoverflies.

1.8. Beneficiaries

With more research being allocated to building engagement in citizen science, the scientific community could benefit greatly. The driving purpose of citizen science is to outsource non-academically intensive but time consuming tasks en masse to regular people. Should the interest in citizen science peak in the general community, more participants will be available to perform these tasks, likely leading to faster results. Furthermore, beyond a person's initial attraction to a research opportunity, this project aims to improve the long-term engagement of participants, maintaining their interest and effort. This can help ongoing projects like Foldit and EyeWire become much more effective as time progresses.

The game development industry will also benefit. The results of this project can show pathways for new opportunities and partnerships not previously opened between mainstream game developers and the scientific community. With citizen science potentially considered its own genre, game publishers can benefit from bringing in a whole new target audience.

1.9. Project Report Structure

The following Section 2 focuses on the critical context. Its purpose is to report on relevant literature, how it contributes to the project topic, and what gaps in its methodology and results can be accommodated by the results of this project. The first topic is citizen science, its data quality, and its relationship with participant engagement. The second topic is game design, the models that are used to measure player engagement, the strategies of gamification, and some of the current examples of gamified citizen science.

Section 3 will cover the methods used in the project regarding both development and data collection. The challenges encountered and solutions found during development within the Unity engine are discussed. Afterwards, the section covers the testing phase of the project and how it was carried out.

The questionnaires used are reintroduced and their function along with the reasoning behind their implementation are discussed as well.

Section 4 is a showcase of the results of the tasks described in Section 3. The game design decisions made and the rationale behind them are discussed. The data collected by the questionnaires are presented through relevant diagrams and figures to illustrate any trends in the participants' responses.

Section 5 is a discussion of the trends presented in the results. The outcomes of the questionnaires will be analysed to determine how well the project aims were realised. This analysis will be partially based on the intended interpretations described by the questionnaires' authors.

Section 6 is the conclusion of the report. A general evaluation is carried out to determine the overall success of the project. The lessons learned throughout the life cycle of the project are highlighted along with areas of potential improvement. Additionally, areas of potential future innovation and research are identified.

---

2. Critical Context

2.1. Citizen Science

2.1.1. The Data Quality of Citizen Science

Citizen science by its nature has significant potential for scientific malpractice. Considering the inherent fact that it is reliant on non-professional individuals to conduct scientific labour, one might doubt how it benefits scientific research. One of the main contributions to that doubt is the concern of data quality.

Due to this concern, the quality of the data produced by citizen science has been studied and critically analysed. It has been found that in some cases, citizen science projects experience the requirement to commit trade-offs between various composite elements of information quality, which include accuracy, completeness, and timeliness (Lukyanenko *et al*., 2020). In order to ensure that participants give accurate accounts of their research, scientists leading the project often employ restrictive regulations on research methods and limit participation to the most educated among the citizen scientists. This leads to a lower output of data (completeness) from the project than if these limitations were not implemented. Observations have also discerned how citizen science projects waver on the balance between discovery and consistency in their results, as striving for consistent methods of research and thought (which comes with the rigid and limiting tasks of citizen science) often conflicts with the scientific goal of discovery (Lukyanenko *et al*., 2016).

With this in mind, it is clear that when designing a citizen science project, one must consider the properties of the data their research methods are expected to produce and whether they are sufficient for the purposes of the project. For this project in particular, it was important to address the trade-offs described and to minimise their impact as much as possible. Accurate classifications from players was a major sub-objective for the project in relation to the game conducting citizen science. However, one of the key aspects of citizen science often cited by enthusiasts is the potential for large quantities of data resulting from the large size of participants (Lukyanenko *et al*., 2020; Shirk *et al*., 2012). With the intention of the final product being a publicly accessible video game, a large group of people have the potential to play it. Therefore in accordance with the standards set by those that advocate for citizen science and to further succeed in the citizen science aspect of the project, the design of Fly Catcher should be as accessible as possible in order to allow more people to contribute. The aim is to minimise the trade-off so the least amount of completeness is lost in service of accuracy.

Regarding the challenges of data quality in citizen science, there have been strategies proposed to combat them. One frequent suggestion is designing projects with the target audience in mind (Danielsen *et al*., 2014; Shirk *et al*., 2012; Bowser *et al.*, 2014). People of different backgrounds and interests develop different skills. Some groups can prove to be specialised in a given task. Danielsen *et al*. observed community members, when given the same tasks as educated field scientists, produced similar results to the scientists (Danielsen *et al*., 2014). The study surmised that this was likely due to the familiarity the participants already had with the research subject and the methods used to complete the related research.

Similarly, Shirk *et al*. argued that accommodating a target audience was key in quality assurance for citizen science (Shirk *et al*., 2012). They suggest that recruiters should selectively choose participants based on interests and skills in relation to the project, and their assessment details that much of the data quality relies on the scientist-participant interaction. While much of what Shirk *et al*. argue falls in line with the solutions suggested by proponents of citizen science quality assurance (Delaney *et al*., 2008; Hunter, Alabri, and van Ingen, 2013), one aspect of their piece may fall somewhat into conflict with the paper by Lukyanenko *et al*.. The latter argues that it is beneficial to reduce the limitations of participation as much as possible for the sake of completeness while maintaining a suitable level of projected accuracy (Lukyanenko *et al*., 2020). Shirk *et al.* does not consider this, though does acknowledge the potential of a citizen science project's scope to reach up to a continental scale. To benefit from the merits of both theories, a balance was proposed for this project.

Shirk *et al*. also discusses a quality assurance method for online image classification, the precise genre of the project's citizen science game. They suggest participant testing, assigning participants with simulated image classification tasks with predetermined solutions (Shirk *et al*., 2012). The purpose of this is to train participants, to teach them in a controlled environment the correct and incorrect approaches to the project's procedures. It also serves to empower the participant as they receive constructive feedback on their performance and can track their progress. This contributes to the extrinsic motivation Fly Catcher needed to achieve the project goal. Coinciding with this modus operandi, the SPIPOLL data set of the MMOS developer portal does include training images for users.

Despite the various preemptive means during development and implementation to combat the risk of quality deficiency, scientists may often utilise a level of quality control in citizen science. Shirk *et al.* suggests only employing citizen scientists with menial tasks while reserving the more analytical tasks to the professional scientists (Shirk *et al*., 2012). While this does again harken back to the point Lukyanenko *et al*. made on the trade-off of consistency and discovery, it was determined that for the scope of this

project, the potential for discovery was not an essential element for the project's aim to be reached. The use of smaller tasks was determined as a necessary component of user engagement, which is discussed further in Section 2.2.2. Shirk *et al*. goes further to explain that as tasks become more complex, the more onsight oversight is required (Shirk *et al*., 2012). With the intention of Fly Catcher having the potential to become widely distributed, it is impractical to issue such complex tasks and expect consistent oversight from a trained professional. And while there is the possibility of developing algorithms to execute statistical pruning or other tools to streamline data, these tasks do not fit within the current project scope.

2.1.2. Participant Motivation in Citizen Science

A study by Rotman *et al.* examined the motivating factors that drove volunteers and scientists to conduct citizen science. They adopted four classifications proposed by Batson *et al*. to describe the motivators experienced by those that perform community involvement or "acting for the common good" (Batson *et al*., 2002).

- ➢ Egoism: The motive to increase one's own welfare.
- ➢ Altruism: The motive to increase the welfare of other individuals.
- ➢ Collectivism: The motive to increase the welfare of a specific group.
- ➢ Principlism: The motive to uphold a moral principle

Rotman *et al*. sampled 142 people (62 identifying as scientists, and 80 identifying as volunteers). They carried out a survey where participants were asked to scale their opinions on varying statements relating to Batson *et al*.'s four motivators using a Likert Scale from 1 to 5, 1 representing "strongly disagree" and 5 representing "strongly agree". While volunteers showcased a relatively consistent average rate in their scores for each motivator, further investigation uncovered a more complicated finding.

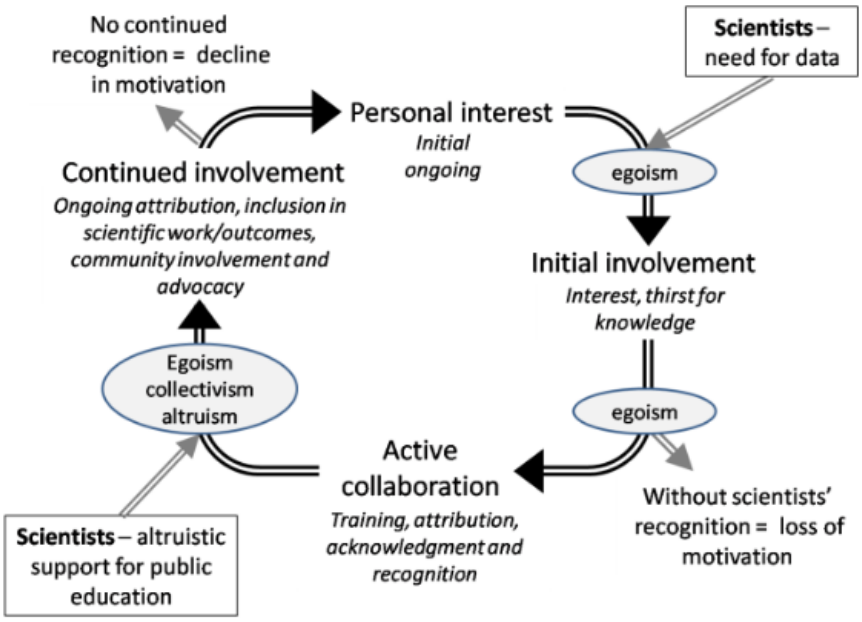


Figure 2.1: A process model of volunteers and scientists involvement in citizen science projects (Rotman *et al.*, 2012)

Following the survey were interviews, where researchers discussed the responses the participants gave. The interviews revealed the fluctuations and changes in dynamics of motivations felt by volunteers throughout the project life cycle. While egoism drove them to seek out the project in the beginning, other factors like helping their community (collectivism) did not emerge until later on (Rotman *et al.*, 2012). This process is represented by Figure 2.1. What these findings showcase is the phenomenon that overtime, the mindsets of citizen science volunteers change, and any ongoing projects must structure their design accordingly. At certain intervals, recognition and feedback is a crutch to participant motivation.

It is a not insignificant fact that Rotman *et al*'s study focuses primarily on **collaborative** citizen science, a subsection of citizen science where participants have more (though still limited) input on the project's design rather than being relegated to only data processing and uncomplicated analysis. This differs from what this project is building, which is **contributory** citizen science, where volunteers have no input on project design. However, the data of the Rotman *et al*. study still proved relevant, as their research reflects upon citizen science and its stakeholders. Understanding volunteers' motives for engaging in an even more demanding version of citizen science contributes to the understanding of volunteers who engage at a lower level, as they both will ultimately perform the same data analysis tasks.

It should also be noted that all of the motivators described are extrinsic motivators, centred around rewards and outcomes. Rotman *et al*. do not focus on intrinsic motivators in their study, likely because without design implementations like gamification, the tasks participants carried out facilitated little to no intrinsic motivation. The study does briefly mention how linking games to research may have the potential to attract and maintain volunteer participation (Rotman *et al.*, 2012). However, this is brief and not the focus of the findings of the study.

While not a key part of the final results of this project, Batson *et al*.'s four motivators and Rotman *et al*.'s citizen science process model did influence how extrinsic motivators were handled during the project's development, as their research illustrates the need of recognition and feedback not only for data quality, but participant motivation as well.

Considering the results of Rotman *et al*.'s research, it is not hard to imagine that maintaining motivation in the volunteers of citizen science has been historically difficult. Delaney *et al*. reported that volunteers in their project failed to complete assigned tasks because they were "tedious" (Delaney *et al*., 2008). Sauermann and Franzoni observed that among seven citizen science projects, they all experienced their largest rates of contributions at launch, followed by a significant decline (Sauermann and Franzoni, 2015). Figure 2.2 illustrates this trend.

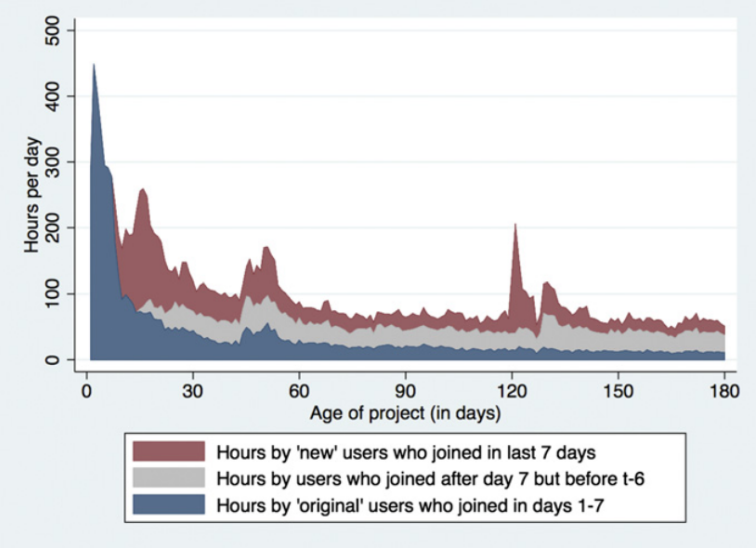


Figure 2.2: A graph illustrating the average rate of hours of effort per day over the course of the first 180 days of the seven projects' life (Sauermann and Franzoni, 2015)

As Figure 2.2 showcases, a majority of the hours offered per day to these projects were from new users (people registered to one of the projects within the last 7 days of the observation date). It was found

that on average only 33% of the daily hours offered to projects were done by original users (people who registered within 7 days of the launch date), who additionally only supply on average 22% of the participant demographic (Sauermann and Franzoni, 2015).

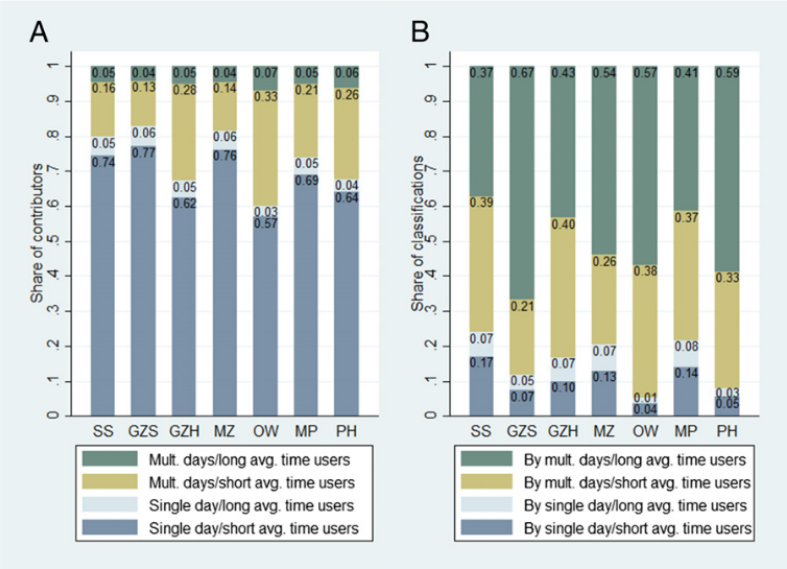


Figure 2.3: (A) Share of four groups of users in each project. The four groups are defined by two dimensions: single-day participation vs. multiple-day participation and short average time spent per active day (below 90th percentile in average time per active day in project) vs. long average time (above 90th percentile). (B) Share of classifications made by each group of users. (Sauermann and Franzoni, 2015)

Sauermann and Franzoni also examined how long participants worked for and whether they returned. Figure 2.3a details among the projects the proportions of people that played for longer or shorter times and those that returned or did not return after their first day. Over the course of 180 days, the study reported that only between 17% and 40% (≈27%) of participants returned after their first day of contributions (Sauermann and Franzoni, 2015). However, according to Figure 2.3b, the contributions by this group of volunteers account for ≈85% of each project's total data output (Sauermann and Franzoni, 2015).

In this data there underlies a general issue with citizen science participant engagement. These projects, as they are, rely heavily on attracting new volunteers on a regular basis to maintain their daily participation hours. Only ≈27% of these new users will engage with the project for more than a single day, but ultimately contribute ≈85% of the total work. After a week has passed, individual participant engagement declines, and new users are required to build up hours in the next interval. This all appears sustainable, but the study introduces other factors. In some projects, users will often become better at the

tasks they perform, increasing not just quality but the quantity that they complete. However, due to the low return rate of participants, projects that would benefit from that phenomena suffer (Sauermann and Franzoni, 2015). The classification tasks that Fly Catcher intends to distribute fall into this category. As players continue playing the game, their skill and knowledge in identifying the sex of hoverflies will improve. Should Fly Catcher be distributed, its user engagement life cycle will more than likely follow the trend described by Sauermann and Franzoni. Its design must account for the potential pitfalls of past projects. The key is finding what motivators researchers have to sustain in order to maintain their existing participants and what mechanisms they must introduce to attract new members. By understanding these motivators along with their audience, researchers can design projects that have a better success sustaining participant engagement.

In another citizen science motivation study, Aristeidou *et al*. reported that among their subjects, a majority fell under the label 'visitor', indicating that they only contributed to the project at most on two different days (Aristeidou *et al*., 2017). Some did not contribute at all, only registering to a project and not participating. The 'visitors' cited feelings of anxiety, lack of time, and frustration with the research tools as reasons for why they did not engage more with their respective projects. To solve this, project design should take into consideration the accessibility of the tasks and the tools used to complete them. The final build of Fly Catcher must not be so challenging that volunteers are discouraged from continuing to play. A common suggestion is structuring small, digestible tasks that lack complexity for citizen scientists (Rotman *et al.*, 2012; Sauermann and Franzoni, 2015). This is a promising strategy to avoid discouraging volunteers and sustaining a healthy participant size.

One study by Serret et. al. included the provider of the data used in Fly Catcher, SPIPOLL (Serret *et al*., 2019). They compared SPIPOLL and the Korean Photographic Survey of Pollinators (K-SPIPOLL), both projects that utilise citizen science to acquire photographs of pollinating insects. Across both projects, the study measured the accuracy of the data provided by volunteers by calculating how many entries followed the regulations of each project. Additionally, engagement of the participants was measured by calculating the frequency in which each contributed a photo. It was determined that SPIPOLL's well integrated community oversight led their participants to produce more accurate data than K-SPIPOLL. However, K-SPIPOLL had a more motivated and engaged following. It was surmised in the study that this was due to K-SPIPOLL's innovation of a phone-app, allowing ease-of-access for their participants to record observations and upload them more frequently (Serret *et al*., 2019). Understanding how SPIPOLL's methodology leads to accuracy and K-SPIPOLL's leads to engagement is valuable. It corroborates the findings of Aristeidou *et al*. that complicated and involved processes in contributory citizen science can lead to lower engagement in volunteers (Aristeidou *et al*., 2017).

2.2. Game Design

2.2.1. Measuring Player Engagement

A study by Johnson *et al*. compared two video game engagement measuring models, GEQ and PENS (Johnson *et al*., 2018). The results were based on the factor structure of each model and how well their structures supported them by representing their respective aspect of the player experience. Johnson *et al*. concluded that the GEQ model was partially supported while the PENS model showcased more support but still faltered in some areas (Johnson *et al*., 2018). Their claim was that both models attempt to measure concepts that overlap, mainly those that fall into the category of 'negativity'. While the study does showcase some biases in its sample demographics (ie. 82% of the participants were in university), it does a good job in evaluating and comparing the faults in the models and will inform how the results of the questionnaires will be interpreted later on.

2.2.2. The Strategies of Gamification

Sauermann and Franzoni discuss that intrinsic motivators are significant to participant motivation in citizen science, and that an avenue to improve intrinsic motivation was gamification (Sauermann and Franzoni, 2015). They do, however, also cite that citizen science projects that do apply gamification follow similar patterns to the projects in their study, with massive dropouts in players soon after launch. The problem with this point, that Sauermann and Franzoni do state, is the lack of research pertaining to gamification.

While there are many studies about gamification, the concept is often generalised by these studies (Sailer et al., 2017). They only consider the inclusion of game elements in a gamified system and don't think about the various factors that drive design decisions in games to map those elements into a system that compliments the attributes of each. The game elements that are born from game design can contribute to player performance (affecting data quality) and, especially significant for this project, player engagement. Matin et al. observed how including and removing a timer, top score, and leaderboard from the UI of a human computing puzzle game affected players (Matin et al., 2020). Human computing is the practice in which humans are tasked with solving problems that are complex for computer logic (Matin et al., 2020). The variables measured were completion time and player performance (aka. the final score). The timer had a positive effect on completion time but a negative effect on player performance. The top score had the opposite effect, improving player performance but worsening completion time. The leaderboard did not have a noticeable effect on its own, but paired with the timer, both UI elements had a larger negative impact on player performance than the solitary timer. Simple changes to the UI had a

noticeable effect on how a player performed in the game. These small changes can have a significant effect on the players of Fly Catcher and should be considered.

Sailer *et al*. examined the effects specific game elements had on player engagement in gamified citizen science, defining engagement based on the framework of SDT (Sailer *et al*., 2017). They observed that rewards, leaderboards, and performance graphs positively affected player's competence need satisfaction, while game avatars, meaningful stories, and teammates (human or AI) positively affected the player's social relatedness need satisfaction. None of the game elements they introduced seem to have any effect on the player's need for autonomy in regards to their freedom of decision, however. While the time to craft a meaningful story and characters was limited under the constraints of the timescale of the project, certain aspects of the elements tied to social relatedness described were incorporated into Fly Catcher. Similarly, the results of the player's competence satisfaction further illustrates the importance of feedback and instilling the sense of accomplishment and progression. Fly Catcher will need similar elements in order to satisfy these player needs.

As stated earlier, designers must also consider their audience. Depending on who a game is targeted for, certain elements may be added or left out. In gamified citizen science, it is important to acknowledge two groups: the gamers and the citizen scientists. While gamers might focus on the game elements like achievements and scores, citizen scientists may prefer the science aspects of the game (Bowser *et al.*, 2014). This difference in focus may lead to further divides in each group's user experience. Either group may have a differing expectation of how the research protocols are taught and carried out. For instance, gamers may prefer more guidance on scientific tasks, while citizen scientists may seek independence (Bowser *et al.*, 2014). And while traditional game systems such as an interactive story and activities designed for entertainment will attract gamers, citizen scientists may dislike what they could see as a persistent interruption to their work (Prestopnik and Crowston, 2012). With this in mind, it was decided to design Fly Catcher in favour of gamers. The reasons for why are discussed further in Section 3.1.1.

2.2.3. Gamified Citizen Science

Currently in the market there is an abundance of citizen science games. Each one carries its own merits, as well as its own lessons.

EyeWire

The gamification of EyeWire (2012) borrows a few elements that have been tested in previous studies to positively affect player engagement. It currently boasts over 250,000 registered volunteers

(Blog, 2012). Players are rewarded points for completing tasks, and have access to leaderboards, performance graphs, and badges (Tinati *et al*., 2016). These elements feed into a player's competence need as well as their extrinsic motivation (Sailer *et al*., 2017; Rotman *et al.*, 2012). Additionally, EyeWire (2012) hosts regular in-game events aiming to re-engage players and encourages a sense of community, cooperation, and competition with its chat service and forums pages. Tinati et al. determined through qualitative analysis that among EyeWire (2012) players, two motivators that were paired together the most often were 'Contribution' and 'Fun', both extrinsic and intrinsic motivators respectively (Tinati *et al*., 2016). Essentially, players felt motivated to contribute in an entertaining way. This is a typical driver for users of gamified systems, and through proper design should apply to Fly Catcher.

However, EyeWire (2012) also finds itself beholden to similar distributions of data contribution as other citizen science projects (Sauermann and Franzoni, 2015). "Highly active" players, defined as those that exhibit activity on the platform (both playing the game and interacting in the chat) consecutively over the course of 30 days, only form 1% of the total player base, but are responsible for contributing over 50% of the total data (Tinati *et al*., 2016). This is a trend Fly Catcher intends to break by designing to accommodate a gamer audience.

Foldit

As of 2020, Foldit (2008) housed 200,000 active players (UW College of Engineering, 2021). Players can either play alone or join groups that solve puzzles collectively. The community environment is rooted in healthy competition, as individuals and groups work to beat existing high scores related to protein structures by designing new structures with improved stability.

It was the efforts of one group, Void Smashers, that led to a breakthrough in the potential design of antiretroviral drugs, including those that can fight HIV (Cooper *et al*., 2010). To elucidate a point made in Section 2.1.1 (Lukyanenko *et al*., 2016), this is due to the leading Foldit (2008) scientists expanding the procedures and protocols of the project to allow the players the opportunity to solve a long-standing problem among protein researchers (Cooper *et al*., 2010). They were able to fulfil the goal of scientific discovery because of the flexibility of the platform and the complex nature of the tasks Foldit (2008) players partake in.

As of now, this is a difficult environment to reproduce in Fly Catcher. The task of classification based on a binary definition of sex is a rigid process and does not leave much room for analysis. This differs from citizen science projects such as Galaxy Zoo (Zooniverse.org., 2020), a galaxy photo classification project that's tasks are composed of multiple levels of classification, referring to various

possible shapes and structures the galaxy could be in. The biological features that differentiate hoverflies by sex are more vivid and require a much less analytical approach. In fact, it's through the more varied and multifactorial classifications of Galaxy Zoo that led volunteers to ask questions on forums and end up leading to the discovery of a new class of astronomical structures. The kinds of discoveries that Galaxy Zoo and Foldit (2008) brought about will be extremely difficult to arouse out of the rigid classification process that SPIPOLL expects out of their dataset. In the scope of the current project, this is not sought out.

---

3. Methods

3.1. Game Design

3.1.1. Target Audience

As stated in section 2.2.2, it was decided that the design of Fly Catcher will be implemented with the notion that should a decision fall to favour gamers or citizen scientists, the decision will be to favour gamers. This choice was made for a couple reasons.

The founding of the company that inspired this project, MMOS, was done to capitalise on the incredible tenacity of the gaming community to commit consistent sessions to entertaining activities (Waldispühl *et al.*, 2020). In the massive multiplayer online role-playing game World of Warcraft (2004), players tend to alternate between 5 days ON (playing the game) and 5 days OFF (not playing the game) periods (Tarng *et al*., 2008). On the ON days, players individually will play on average 3.7 hours per day, with 75% of players playing for at least 1.6 hours on average per day (Tarng *et al*., 2008). There is no denying, the immense popularity of video games and the habit forming behaviour they manifest. This is the untapped potential MMOS, and by extension this project, aims to exploit.

The decision to favour gamers is also in order to avoid falling into the trends made before with previous citizen science projects (Sauermann and Franzoni, 2015; Tinati *et al*., 2016). The intent is that by including and accommodating for a large and engaged audience like gamers, the trends observed in citizen scientists will not override the data outcomes or overshadow the contributions made by gamers. Due to the timescale of this project, the major results of this decision can not be measured.

3.1.2. First Person Platforming

Following the second specification presented in Section 1.5, a separate gameplay feature was conceived that did not involve classification. Because of the inspiration from Borderlands Science, it was decided upon to make this gameplay feature in a first person, 3D world. The intended outcome was by setting the player's perspective to a first person avatar, they would feel more immersed, and thus more engaged in the player character's state.

The platforming decision was personal. As a gamer with experience in playing 3D first person platformers, there is more of an understanding of what features are expected and sought after. To go beyond the standard jumping from one platform to the next, the gameplay incorporates parkour mechanics

that include wall running and jumping, as well as jumping on and sliding on rails. These mechanics were inspired by games like Mirror's Edge (2008) and Prince of Persia (2003).

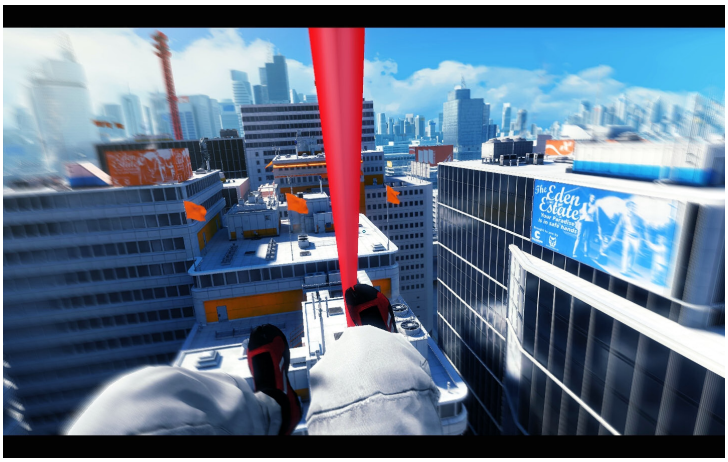


Figure 3.1: The player character in Mirror's Edge (2008) sliding down a rail (LH Yeung, 2009)

Figure 3.2: The player character in Prince of Persia (2003) wall running (Vinchenzo, 2008)

3.1.3. Treasure Hunting, Time Trial

It was determined from the beginning that the objective of Fly Catcher would be taking photos of hoverflies. The player would move from platform to platform looking for flies and aiming a camera to take a photo. Because the player does not know where the flies are initially, it can be described as a "treasure hunting" mechanic.

The decision came that no enemy AI would be implemented into the game, as fighting or avoiding harmful agents did not fit the theme of the project. With that in mind, there needed to be some

form of extrinsic motivator beyond getting every picture in a level in order to supplement the gameplay. Because of the focus on movement, the decision was to implement a timer. Players will be timed on how long it takes for them to photograph all flies in the level. This means in order to get the best times, they must be adept at navigating the game world with the platforming and parkour mechanics. Their best times for each level will be recorded for them to review at any time. This was intended to satisfy both the intrinsic motivator of competence satisfaction and the extrinsic motivator of the accomplishment from beating a previous high score.

3.1.4. The Player Character and The Narrative

While the project's timescale did not allow for a compelling story to be written for Fly Catcher, the game still required some form of narrative. Giving players a narrative grounds them in the game's world and helps build engagement (Thompson, 2020; Sailer *et al*., 2017). Initially, the plan was for the player to be an insect to reflect the data set the game was using (originally a wasp like the species from the original SPIPOLL dataset). The purpose behind this decision was to create a recognisable mascot for players to associate with the game. This was also a very important choice to finalise from the beginning, as the size scale and design of the levels will be vastly different should the player character be a human sized character or a small insect. After some deliberation, the reasoning behind why an anthropomorphised fly would be taking pictures of others of its species to classify them as male or female was leading to become contentious. Therefore, the insect mascot idea was dropped in favour of a character that did not share the insect specimen's species.

Another idea was to make the player character play as another citizen scientist, running around the area taking pictures of flies in hard to reach places. This idea had more merit as it could serve as a fun reference to the citizen scientists that did take the photos used in the data set. However, this had its own issues when it came to the final decision about the narrative.

The ultimate dilemma concerning the narrative was to what extent the citizen science data and its reality would be incorporated. It was a decision of whether the game would risk breaking immersion to inform the player that the game is collecting real world data while explaining the narrative. The alternative would be informing the player outside of gameplay, perhaps as a disclaimer when they start the game. This was seen as less ideal, since the player could disregard the notice because it was not a core part of the gameplay. So the decision was to incorporate it into the narrative, explain to the player what the project is and why it's important in as few and as simple words as possible to avoid disengaging the player.

This is the reason for making the player character a robot. The players can view the game as a means of them ‘driving’ Photobot around a level. In this scenario they aren’t role-playing a character, they are handling a tool. Their sense of immersion can remain intact by acknowledging the gap between the player and their digital avatar, and setting the scope of the game’s narrative outside the virtual world and incorporating the real one.

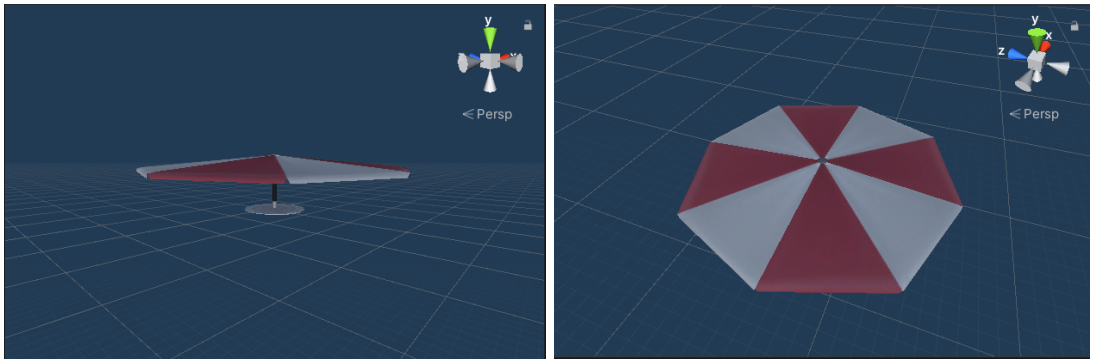
Figure 3.3: Model used for the player character, Photobot (Unity Technologies, 2022)

3.1.5. 3D Level Design

Once the story and setting were finalised, the design stage of the 3D level maps began. Initially, the intent was to build an exaggerated but semi-realistic depiction of the areas in which SPIPOLL photographers would find hoverflies. Research suggests that hoverflies can be found in varying wooded and flowered areas (SANBI, n.d.). Since the areas volunteers would likely frequent were public parks and their personal gardens, the first prototypes of the map design were based on real world park layouts.

Figure 3.4: Map of Brown Road and Lone Wolff parks from the City of St. Peters, Missouri (Brown Road Park, 2020)

Figure 3.4 was planned to be the basis of the design of one of the levels. These levels would consist of objects and obstacles similar to what would normally be found at an urban park (ie. parasoles, benches, small buildings, etc.). Some of these objects would act as interactable game elements that would hinder or enhance the player's movement as they traversed the map looking for flies.



Figures 3.5 and 3.6: Parasol/Umbrella game object that made it into the final build of Fly Catcher (Lowpoly_Master, 2016)

The bounds that would restrict player movement would be the buildings, trees, and fences that would surround the main play arena. Landmarks like gardens and fountains would act as points of

interest, grounding the player in the environment and facilitating their sense of direction. Flies would be located at some of these landmarks.

During the start of its implementation, however, it was observed that the park design did not compliment the 3D platformer gameplay as well as previously expected. The semi-realism of the environment left no easy room for verticality and creativity in the platforms, and traversal had little dependency on the parkour mechanics, one of the major focal points of the gameplay in the 3D platformer section of the game.

Therefore, a complete redesign was implemented, one that, while more fantastical, was designed to still reflect the real natural environments hoverflies can inhabit. The new designs borrowed some aspects of the designs of other games. Instead of an urban park, the level's setting was placed into a wilder, more nature-oriented environment, with tall canopies and wooden platforms. This aesthetic was taken from games like Crash Bandicoot 4 (2020) and Kingdom Hearts Final Mix's "Deep Jungle" level (2002). This new design direction allowed for more flexibility with the platforms and level 'boundaries', as the verticality allowed for more room to place and orientate obstacles and platforms.

Figure 3.7: Promotional image of Crash Bandicoot 4: It's About Time (2020) (Xbox.com, n.d.)

Figure 3.8: Screenshot of a cutscene from the Deep Jungle level in Kingdom Hearts Final Mix (2002) (Every Kingdom Hearts game frame in order, 2020)

3.2. Software Development

3.2.1. Finite State Machine

```
public abstract class FiniteState
{
    protected StateController controller;

    public virtual void Enter(StateController newCtrl)
    {
        controller = newCtrl;
    }

    public virtual void Update()
    {

    }

    public virtual void FixedUpdate()
    {

    }

    public virtual void Exit()
    {

    }
}
```

Figure 3.9: Pseudo Code for Finite State Machine model

A coding model that was determined early on to be implemented in the game was the finite state machine. A finite state machine is a model used by programmers that consists of a limited number of conditional states. These states are mutually exclusive, meaning the machine can only be in one state at a time. They are dependent upon a finite set of inputs and/or conditions that cause the machine to change to a predetermined state.

Each finite state machine has its own unique states and properties. The finite state machine model used in Fly Catcher (Figure 3.9) is based on a template created by inScope Studios (Source: https://youtu.be/VnfD5wGEXFw). This template specifically incorporates a controller class that is meant to coordinate and track which state the machine is in.

```
public class StateController
{
    public FiniteState finiteState;

    // Start is called before the first frame update
    void Start()
    {
        ChangeState(new DefaultState());
    }

    // Update is called once per frame
    void Update()
    {
        finiteState.Update();
    }

    // FixedUpdate is called every fixed frame-rate frame
    private void FixedUpdate()
    {
        finiteState.FixedUpdate();
    }

    // Changes the state of finiteState
    public void ChangeState(FiniteState state)
    {
        if (finiteState != null)
        {
            finiteState.Exit();
        }
        finiteState = state;
        finiteState.Enter(this);
    }
}
```

Figure 3.10: Pseudo Code for StateController

3.2.2. Version Control

During development of the classification mini-game, on September 12th, 2022, the hardware that was being used experienced a malfunction and crashed. After rebooting the system, it was discovered that a not insignificant amount of progress has been lost in the Unity file. After this incident, the project adopted the practice of using GitHub as a version control platform. Unlike some other projects, Unity projects are not immediately configured to work with GitHub, thus some initial set up was required. This was done using the help of a video tutorial and step by step guide:

Video Tutorial: https://www.youtube.com/watch?v=eXujab-p7pQ

Step by Step Guide: https://thoughtbot.com/blog/how-to-git-with-unity

Following these, the project was able to be regularly backed up on cloud storage and progress was easily recorded and monitored.

3.3. Testing Phase

The testing phase was designed to be carried out online, the questionnaires and the game distributed into online communities. Testers were not monitored during their playtesting session and were prompted to read a participation document and sign a consent form through Google Forms before participating. They were then instructed to complete the questionnaires when either 15 minutes had passed since they started playing, or they had played through every level. They were also specifically instructed to play the tutorial first. This was all carried out impersonally, allowing for a wider range of participants to be accepted and tested without the need of oversight.

By the end of the testing phase, 18 testers in total had submitted a completed questionnaire. Initial turnout was less than expected; only 8 testers volunteered through social media. To reach a number of participants that would give an adequate sample size for the scope of this project, it was elected to hire testers through the online game testing platform Game Tester (gametester.gg, n.d.). 10 testers were requested and all were found. Because Game Tester required monetary compensation for their testers, a new consent form and participant information form were drafted to reflect the new circumstances of the now paid volunteers. In addition to signing the NDA supplied by Game Tester, each tester must have agreed to this project's forms before participating as per their contract with Game Tester.

3.3.1. Game Experience Questionnaire (GEQ)

The GEQ (IJsselsteijn et al., 2013) is a questionnaire with the purpose of investigating the thoughts and feelings of a video game player during and after playing a game. It was chosen due to its prominence in the game development community, its general overview of the personal video game experience, and the attributes it measures, specifically Competence and the Positive and Negative effect a game has on the player.

It is comprised of three modules, two of which were used to gauge the experience of players of Fly Catcher:

- The core questionnaire
- The Post-Game Module

Each module gives the participant a series of statements and asks them to rate how much they agree to those statements using a Likert Scale ranging from 0 (Not at all) to 4 (Extremely). Based on prior analysis (Denisova, Nordin, and Cairns, 2016; Johnson *et al*., 2018), one prompt from the core questionnaire was omitted from the test due to its irrelevance to Fly Catcher:

"**3. I was interested in the game's story**"

Because Fly Catcher only has a loose overarching narrative, this statement to the average player would seem irrelevant and out of place (Denisova, Nordin, and Cairns, 2016). Beyond this exclusion, neither module of the questionnaire was altered.

There are a total of 33 statements in the core questionnaire. Each item is attributed to a specific component:

- Competence: Items 2, 10, 15, 17, and 21.
- Sensory and Imaginative Immersion: Items 3, 12, 18, 19, 27, and 30.
- Flow: Items 5, 13, 25, 28, and 31.
- Tension/Annoyance: Items 22, 24, and 29.
- Challenge: Items 11, 23, 26, 32, and 33.
- Negative affect: Items 7, 8, 9, and 16.
- Positive affect: Items 1, 4, 6, 14, and 20.

(IJsselsteijn et al., 2013)

As stated before, the significant components are Competence, and the Positive and Negative effect. However it was decided to include the other questions as well to examine any unexpected trends that might arise. The score for each component is determined by the average of the questions' scores. Therefore the highest score possible for each is 4.

As for the Post-Game module, it contains 17 statements:

- ➢ Positive Experience: Items 1, 5, 7, 8, 12, 16.
- ➢ Negative experience: Items 2, 4, 6, 11, 14, 15.
- ➢ Tiredness: Items 10, 13.
- ➢ Returning to Reality: Items 3, 9, and 17.

(IJsselsteijn et al., 2013)

For this project, the Positive and Negative Experience components function as a means to gauge the player's overall lasting enjoyment of the game and thus represents a set of extrinsic motivators/demotivators.

3.3.2. Immersive Experience Questionnaire

The IEQ (Jennett et al., 2008), as the name suggests, measures the immersion a player experiences while playing a game. With immersion being composition of emotional components that includes presence (Jennett et al., 2008), a concept that also contributes to SDT (Ryan, *et al*., 2006), the questionnaire was a means of thoroughly accounting for any possible component of SDT.

Each item is scaled with a Likert scale of 1 to 7 with varying definitions of what each rating means. The questionnaire has one list of questions that all contribute to a final score that represents the player's immersion level. The scores of questions 6, 8, 9, 10, 18 and 20 are reversed (ie. 1 becomes 7, 6 becomes 2, etc.) With 31 questions, the highest possible immersion rating is 217. In addition to immersion, the questionnaire has a method that breaks down the questions list into separate sub-lists that relate to a specific component of immersion. The relevant one to this project is the list for Control, which relates to the intrinsic motivator of autonomy. The questions of note are 11, 15, 16, and 28, with 10 contributing as a reversed rating.

3.3.3. The Player Experience of Need Satisfaction Model

(**NOTE**: The academic PENS model was provided to this project by Immersyve. Due to a signed NDA, only a limited recollection of the metrics/methodologies of the questionnaire will be provided in the report)

The PENS model (Immersyve, 2007) was created following the definition of engagement proposed by SDT. The purpose of including this model was to measure autonomy and competence, two of the needs specified by SDT. Autonomy was especially important, since it was not explicitly considered in either of the two other questionnaires outside of association with other categories. The competence category was included to support the GEQ Competence category in measuring player competence satisfaction, and to work as a means of comparison during analysis. In addition to these, the category for Intuitive Controls was also measured for the sake of measuring the accessibility of the game for a general audience.

3.3.4. Demographic Questions

In addition to the questionnaires, it was prudent to note some of the pre-existing factors that might contribute to a participant's results. Each participant was asked three multiple choice questions:

- **How long have you been playing video games?**
  - 0-4 years
  - 5-10 years
  - 10+ years
  - Do not wish to share
- **Have you had any interest or experience in Entomology (the study of insects)?**
  - Likert Scale (0 = Not at all, 4 = Extremely)
- **Have you had any interest or experience in Citizen Science?**
  - Likert Scale (0 = Not at all, 4 = Extremely)

The aim was to identify any trends among certain backgrounds and the answers they produced.

3.3.5. Open-Ended Feedback

In addition to the questionnaires, testers had the opportunity to give open-ended feedback on the game. This was an optional portion of the test. This provides the opportunity for a degree of qualitative data to be collected, which will help identify any ideas or sentiments not covered by the questionnaires.

3.3.6. Analysis

All questionnaire models used had details of how to calculate the scores of each category they measured. However, it is left up to the tester as to what is considered a "success". For the purposes of the project, it was determined to follow the typical percentage standard. As such, a score in a category must be above 50% of the maximum score to not be considered a "negative" outcome. From there, a score <60% is considered a "mixed" outcome. Finally, any score >60% is considered a "positive" outcome. This is reversed on categories that measure negativity (ie. Negative Effect and PG Negative Experience).

The open-ended questions were analysed using a predominantly inductive thematic approach; identifying trends and building thematic codes off of those trends to sparse through the responses. An exception to this, because of the aims of the project, were three themes:

- citizen science
- engagement
- classification

The theme of "citizen science" was coded with language that referenced "research", "science", and "contribution". The theme of "engagement" coded language that referenced "fun", "boredom", and "enjoyment". And the theme of "classification" coded language that referenced, "categorization" and "identification".

4. Results

4.1. Final Game

This section of the report will provide an overview of the game flow in the final build of Fly Catcher.

4.1.1. 3D Platforming Mode

At the start of each level, the player begins at a predetermined spot in the 3D game world. They can move around however they want using the platforms and props available to them.

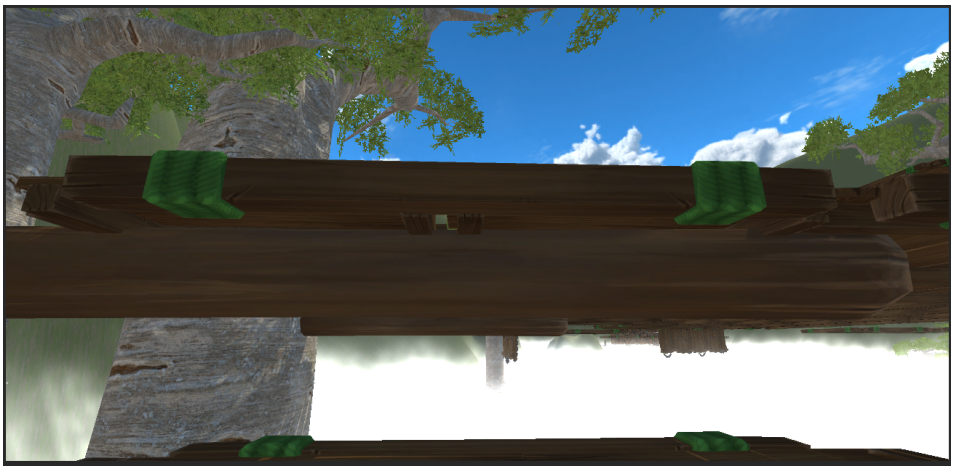


Figure 4.1: The beams with green rope on the sides of most of the platforms can be grabbed and climbed over when the player is close to them.

Figure 4.2: The player can wall-run on walls with chains

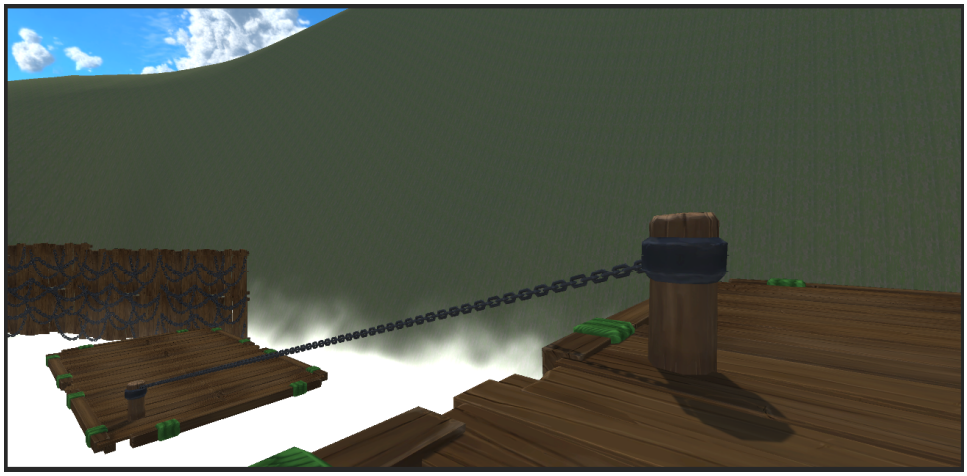


Figure 4.3: The player can jump on and slide along chains to reach otherwise out of reach areas

The player's goal is to explore the environment to find all of the flies in the level and take a picture of them using the in-game camera. There is no fail state in the game, and the 3D platforming portion of the level ends once the player takes a picture of every fly. The player is encouraged to complete the level as fast as possible and their best completion time is recorded.

4.1.2. Photo Analysis Mode

After each platforming level, for every photo taken, the player then has to classify a photo randomly selected from the SPIPOLL dataset. This section directly follows after the 3D platformer phase of the level. A player needs to complete this part of the game in order for their performance in the 3D level to count towards beating their personal best.

However, in order to make the classification process more interesting, another gameplay feature was added. Using a custom shader (Moran, 2016), three different filters of distortion are applied to each fly photo.

Figure 4.4: Distorted fly photo

Each filter is set to a level of intensity at randomised values unknown to the player. Using three separate sliders, the player can diminish these levels of distortion in order to clear the image.

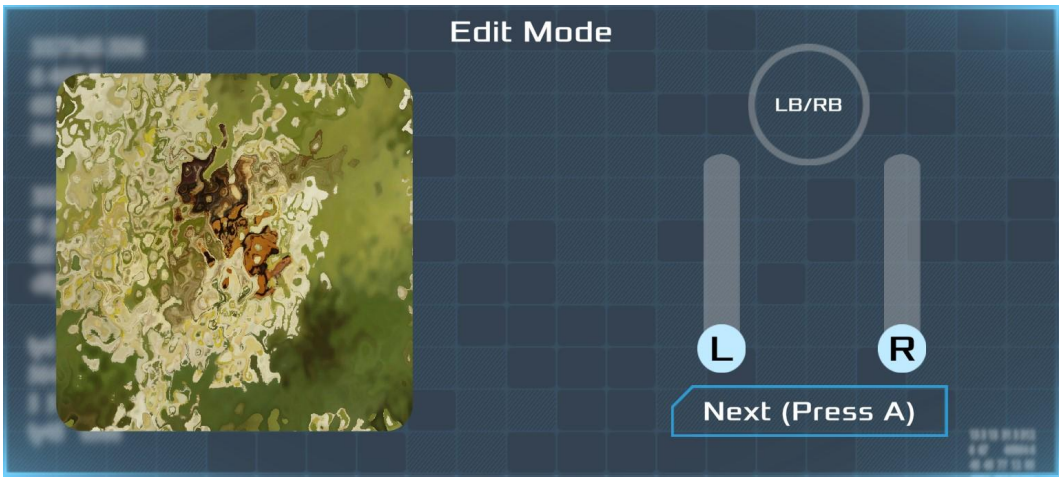


Figure 4.5: Edit mode in the Photo Analysis mini-game (Unity Scene Reference: PhotoAnalysis)

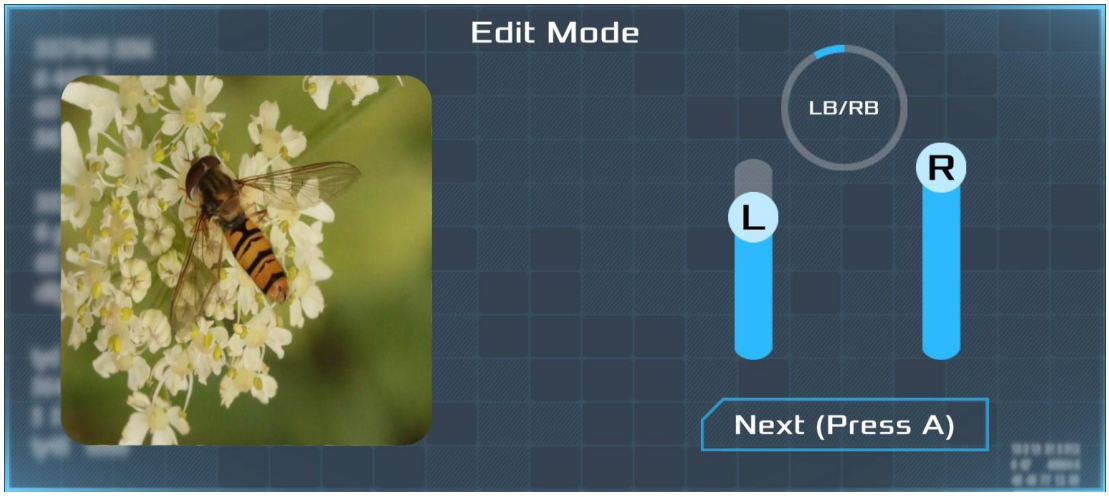


Figure 4.6: Cleared image with slider solution

The player does not need to clear the image completely in order to guess a classification. On the next screen, the player makes a decision on how they want to categorise the sex of the fly based on the options criteria described in Section 1.6.2. This part of the classification is timed.

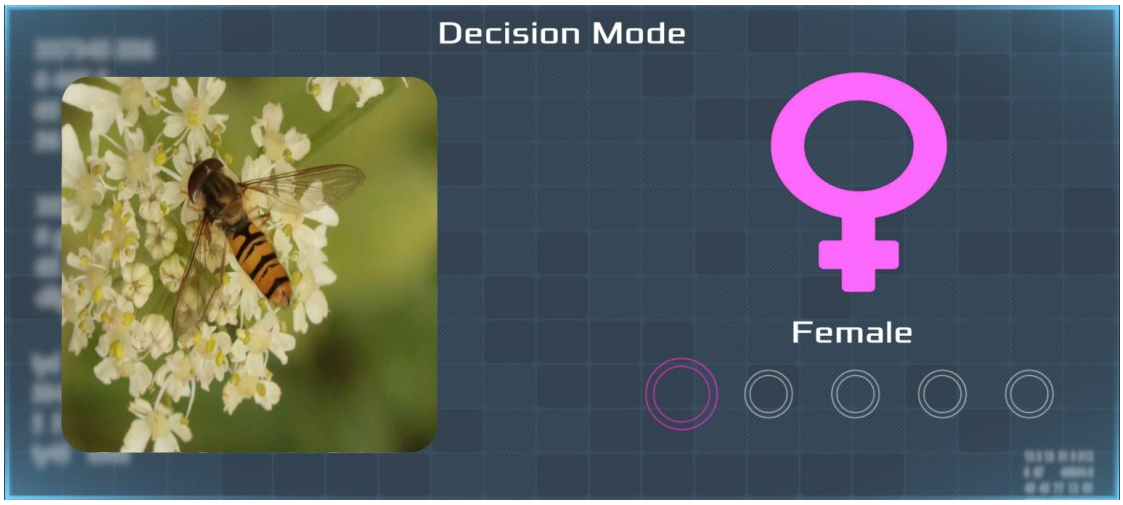


Figure 4.7: Decisions Mode in Photo Analysis. Player determines what sex the hoverfly is and chooses between female, likely female, can't see, likely male, and male.

After confirming the player's decision, Fly Catcher uses the MMOS SDK (Szater, 2019) to send their solution as well as their final decision-making time to the MMOS developer portal. Should the photo be part of the test set and thus have a definitive solution, Fly Catcher will inform the player of whether they guessed the fly's sex correctly. If not, the game only thanks the player for their submission and

continues on. After all photos have been classified, Fly Catcher gives the player their final results including their final time for the 3D platforming.

4.1.3. Game Controls: Gamepad Diagram

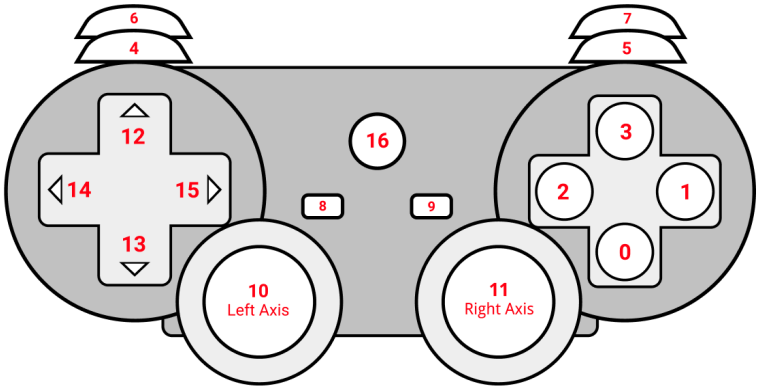


Figure 4.8: Gamepad Diagram (dmahajan980. 2022)

4.1.4. Game Controls: 3D Platforming

Input	Action
Left Axis 10	Move Player Character
Right Axis 11	Move Camera
Button 0	Jump
Button 6	Aim Photo Camera
Button 7	Take Photo
Button 9	Exit to Main Menu

4.1.5. Game Controls: Photo Editing

Input	Action
Left Axis 10	Move Left Slider
Right Axis 11	Move Right Slider
Button 4	Increase Circle Slider
Button 5	Decrease Circle Slider

Button 0	Finish Editing
Button 9	Exit to Main Menu

4.1.6. Game Controls: Photo Classification

Input	Action
Left Axis 10	Change Button Selection
Button 0	Select Button
Button 1	Return to Editing State
Button 3	Open Game Hint
Button 0	Finish Editing
Button 9	Exit to Main Menu

4.1.7. Game Controls: Main Menu

Input	Action
Left Axis 10	Change Button Selection
Button 0	Select Button
Button 1	Return to Previous Screen

4.1.8. Game Controls: Tutorial Text Panel

Input	Action
Button 4	Previous Slide
Button 5	Next Slide

4.1.9. Game Controls: Audio Output

Input	Action
Button 8	Toggle Music

4.1.10. UI Design

The font Fly Catcher uses is Xolonium by Severin Meyer (2019). Using a Unity UI content package "Future UI" from the Unity Asset Store (Unlimited Games, 2017), Fly Catcher was populated with a consistent digital style for the UI. The button boxes, screen border, and the grid filter in the menus all come from Future UI.

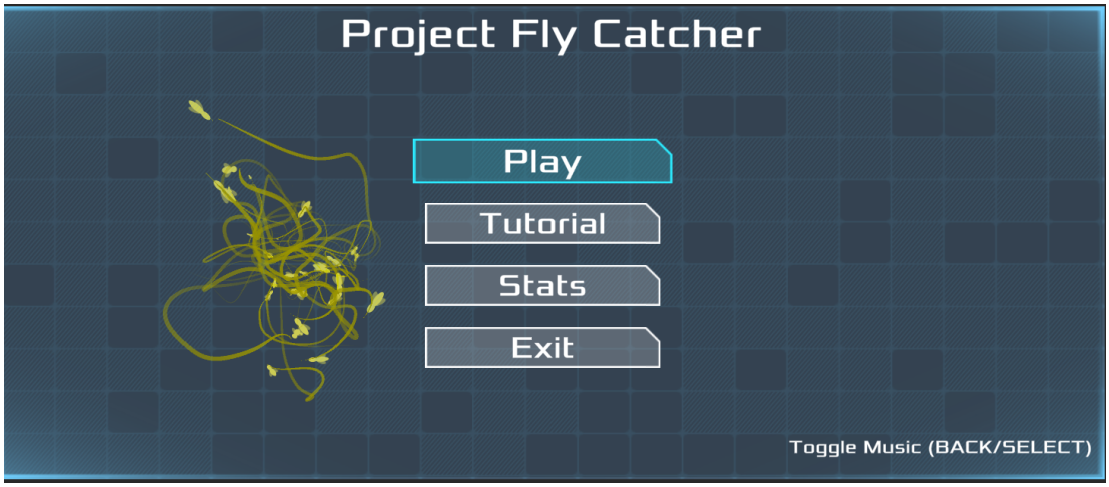


Figure 4.9: The Main Menu screen of Fly Catcher. From here, the player can 1) go to the list of available levels to play the game, 2) start the tutorial to learn or refresh how to play, 3) check their game stats, or 4) exit the game. it also contains a prompt to turn the in-game music track (Coma-Media, 2021) off or on (Unity Editor Scene Reference: MainMenu)

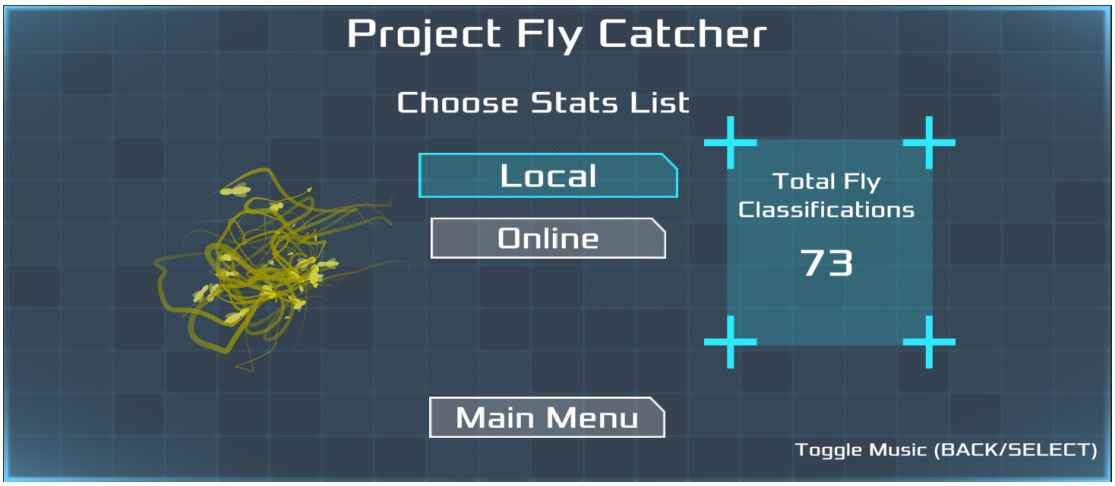


Figure 4.10: This is the Stats screen. The player can choose to check their stats on their local machine or navigate back to the Main Menu. An online database was planned to be in the final build, allowing

players to look at other players' stats. However, the task proved to be too demanding of time and resources. (Unity Editor Scene Reference: MainMenu)

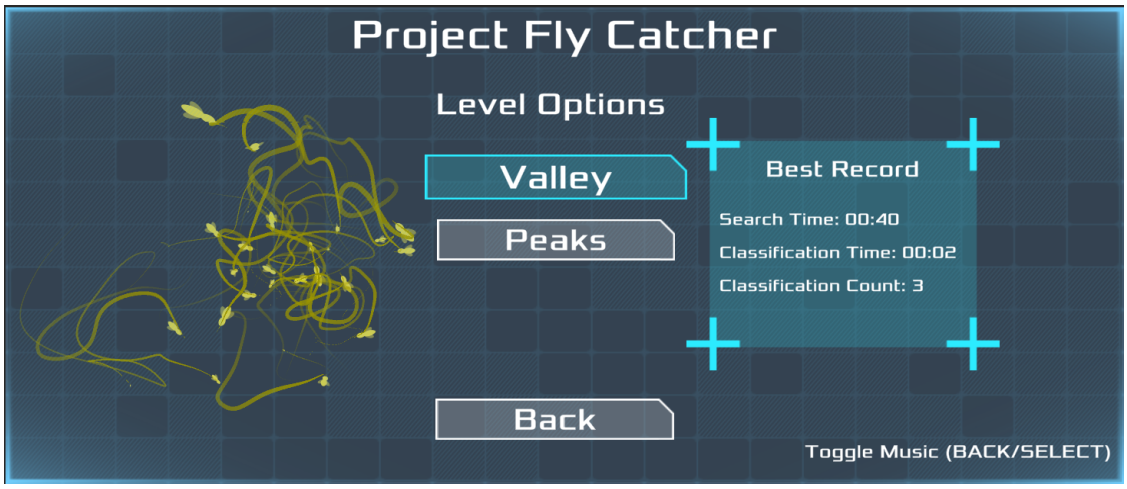


Figure 4.11: This is the Level Stats screen. It shows the best records the player has achieved on that level. The level selection screen has the same buttons and layout, minus the records panel on the side. (Unity Editor Scene Reference: MainMenu)

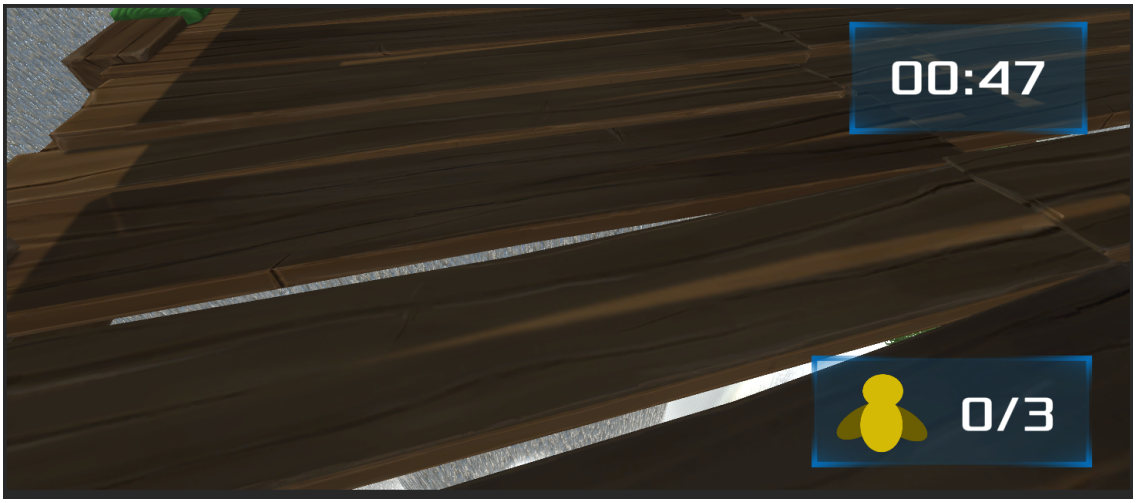


Figure 4.12: 3D platformer UI. Includes the timer on the top right corner and the fly counter on the bottom right.

The fly icon next to the fly counter was an original creation for the project and was made using Microsoft 3D Paint.

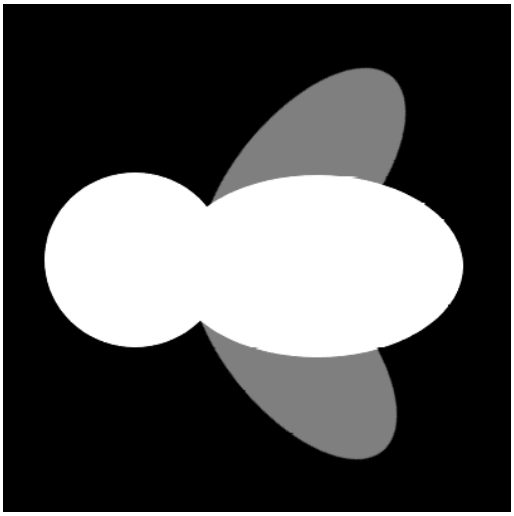


Figure 4.13: Fly icon used in the UI and Fly particle system.

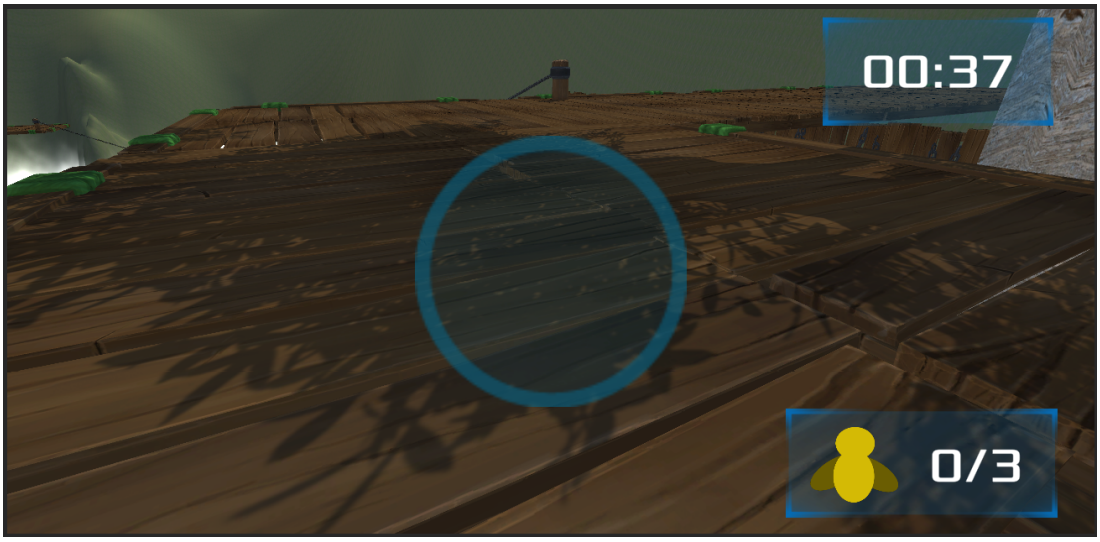
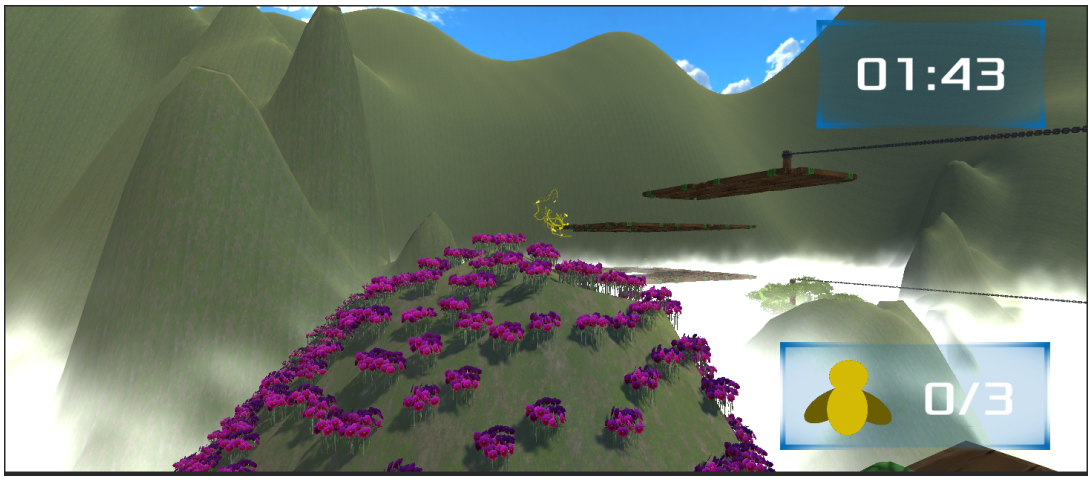
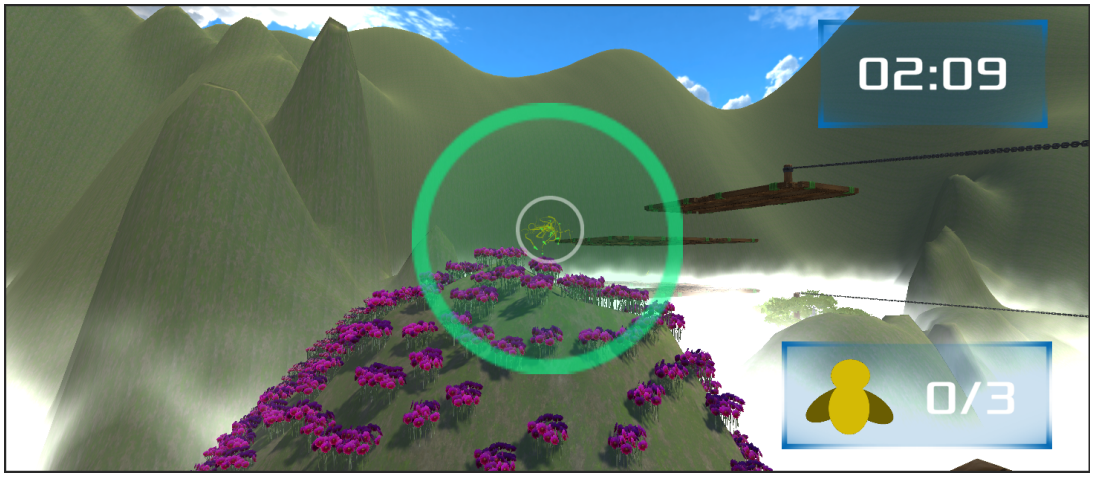


Figure 4.14: Camera Lens UI appears while the player holds down the Aim Camera button





Figures 4.15 and 4.16: When the player aims the camera at flies, if the flies are not obstructed and are in range, the lens and the flies change their colour to green. Also, a second UI element appears that tracks the flies' position in the camera lens. This was implemented to help the player see where the flies are when aiming the camera.

4.2. Key Design Decisions

This section deals with the important design decisions that were made for the final iteration of Fly Catcher.

4.2.1. Multiple Levels

After the foundation of Fly Catcher's level design was finalised, 3 levels were created:

- Tutorial
- Valley
- Peaks

The tutorial level acts as not just a tutorial of the game mechanics, but an introduction to Fly Catcher as a citizen science project. On the bottom left of the screen in this tutorial level, an extra UI element was implemented in the form of a text panel. This panel houses text slides with information regarding the scientific goals of Fly Catcher, the subject matter it is helping research, and the mechanics this level aims to teach. The player can read through each panel freely at their own pace as they explore the level. It is a short, linear level, only meant to teach the player all of the necessary skills and mechanics they need to traverse the more intermediate levels.

Figure 4.17: Top down view of the Tutorial Level in Fly Catcher (Unity Editor Scene Reference: TutorialLevel)

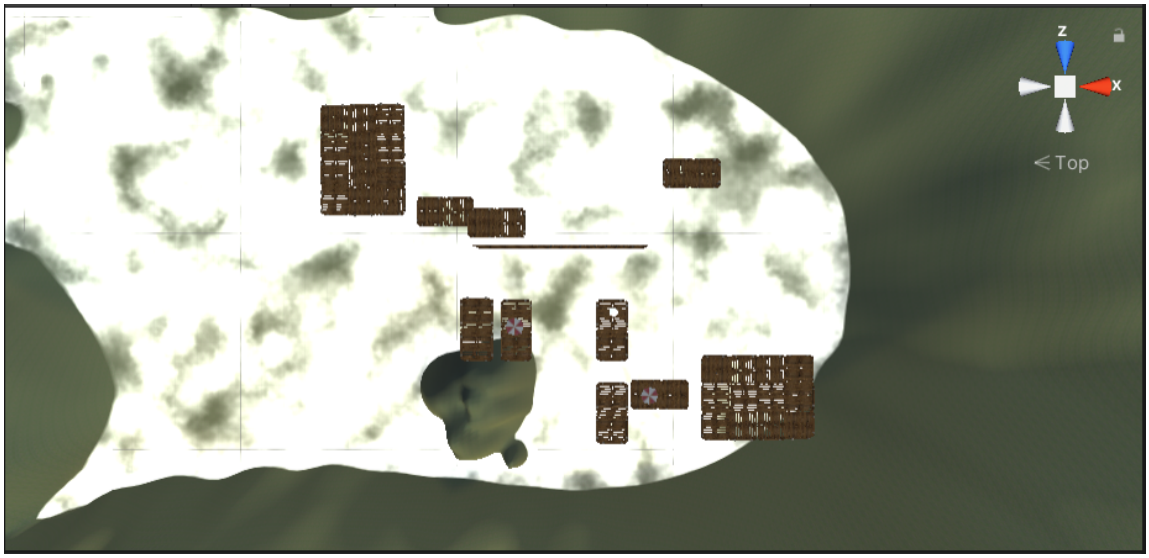


Figure 4.18: Top Down view of the Tutorial Level with fog particle effect activated

Valley and Peaks are the other two levels and act as the main game levels. Their designs are non-linear, as the player is able to choose between multiple paths to complete the levels. By giving players the option to choose how they want to play, the game can facilitate the player's autonomy need satisfaction as well as establish some level of replayability.

Figure 4.19: Top down view of the Valley Level in Fly Catcher (Unity Editor Scene Reference: ValleyLevel)

Figure 4.20: Top Down view of the Valley Level with fog particle effect activated

Figure 4.21: Top down view of the Peak Level in Fly Catcher (Unity Editor Scene Reference: PeakLevel)

Figure 4.22: Top Down view of the Peak Level with fog particle effect activated

4.2.2. Respawn Mechanic

The way in which the levels limited the player character's movement was changed with the departure from the park design. While the park design was implemented, none of the levels had any interactive challenge to the gameplay. The only source of challenge came with the timer, but the only obstacles were static objects that halted the player's momentum, which could possibly prove to be damaging to the player's engagement by hindering their sense of autonomy. This was the wrong type of challenge for what is meant to be an engaging game.

However, it was clear that in order for the player to feel a sense of accomplishment and fulfil the need of competence satisfaction, some level of challenge must be presented. After the switch from the park design to the wild design, it was observed during development that if a player were to fall off a platform, they would need a quick, instantaneous means of returning to the platforms from the ground to not lose momentum. To give the player this but also maintain a sense of challenge, it was decided to implement a respawn mechanic. Now, in the event of the player character falling below the platforms, they would immediately respawn at the starting position of the level to try again. This way the player does not waste time to get back on the platforms but still feel the consequence of their mistake. It was also decided to use fog particle effect to indicate where the boundary was for the player to fall.

This also helped in bounding the player to the level's map. Being on elevated platforms away from the ground means the player cannot easily move their character outside the intended area. However,

should a player find a way to move further than they are expected to, rather than using invisible walls that just stop the player character from moving further, they respawn.

4.2.3. Hoverfly Objects

There was deliberation on whether the flies would be static or moving targets. It was determined that moving targets were an unnecessary increase in difficulty to an already well demanding gameplay loop. Because the fly objects were static, this led to a few more decisions. Firstly, they could not be represented by only one visual object. This would prove too difficult for the player to see and lead to unproductive frustration and disengagement. Therefore, the flies are represented by swarms through the use of Unity's built-in particle system, moving in place in order to stand out visually to the player. Secondly, spawn areas of flies were placed in close proximity to plant game objects. Because Fly Catcher has ties to science and a direct tie to a real scientific project, it was a point of responsibility to properly represent the hoverflies and their roles as pollinators. Thirdly, to increase replayability, flies spawn randomly in preset locations on every new load of a main game level. And fourthly, to help the player locate the fly objects, they emit a buzzing sound (Miklovan, 2021) that's volume is based on the player's proximity to them in 3D space.

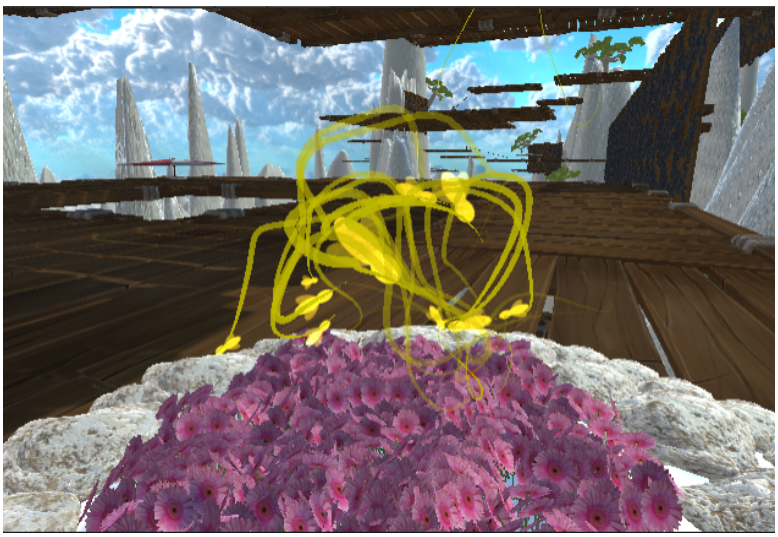


Figure 4.23: Hoverfly particle effect over a bush of flowers (Unity Scene Reference: PeakLevel)

4.3. Code Overview

This section is an overview of the relevant original code that was written for Fly Catcher.

4.3.1. *Monobehaviour*

The class *Monobehaviour* is the base class of many of the classes created for Fly Catcher. The class is synonymous with the Unity Engine, implemented in the engine's core module. It provides the methods *Start* and *Update*, key methods that allow the functionality of the code to run during gameplay. Any script that is meant to be directly attached to a game object must derive from *Monobehaviour*.

4.3.2. Main Menu

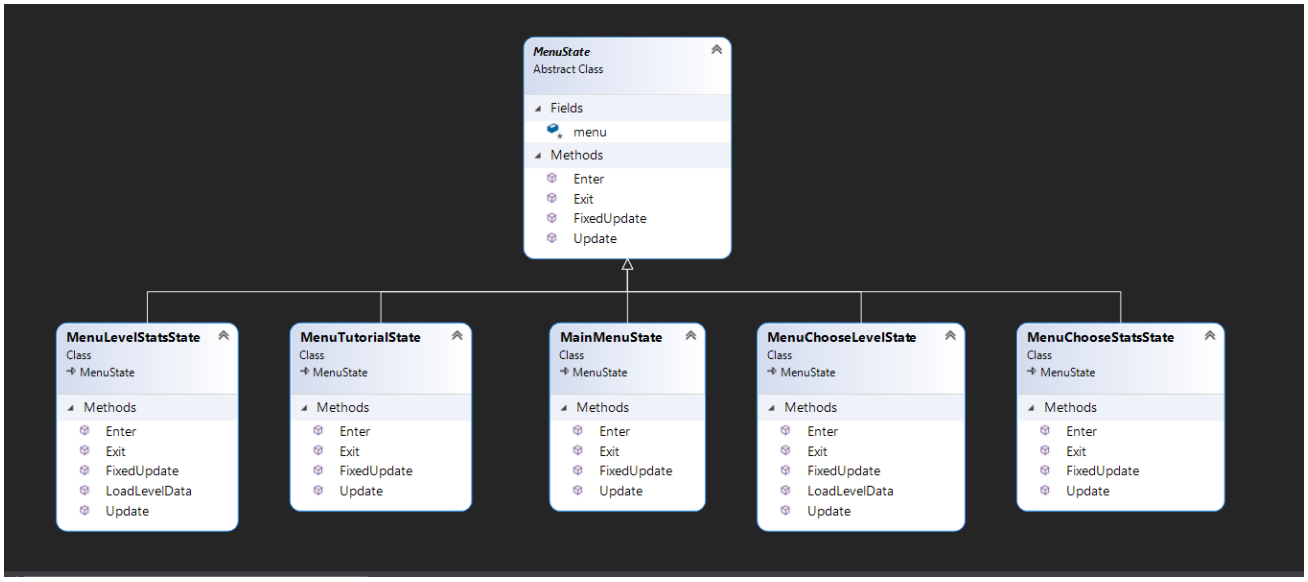


Figure 4.24: *MenuState* Class Hierarchy Class Diagram

The *MenuState* class and its children comprise the finite state machine that governs the Main Menu of the game. The *menu* variable is of the class *MenuController*. *MainMenuState* manages the default state, which is the start screen the player sees upon opening the game (Figure 4.9). *MenuTutorialState* manages the state of the menu when the game prompts the player if they wish to play through the tutorial level before choosing one of the intermediate levels (Valley or Peaks). This prompt only occurs if the game has no data of the player completing the tutorial. *MenuChooseStatsState* manages the Stats screen layout the player sees when they choose the Stats button option (Figure 4.10). *MenuLevelStatsState* manages the screen that showcases the player's records for each level (Figure 4.11).

Finally, *MenuChooseLevelState* manages the level selection screen, and prompts the game to load the level associated with each button.

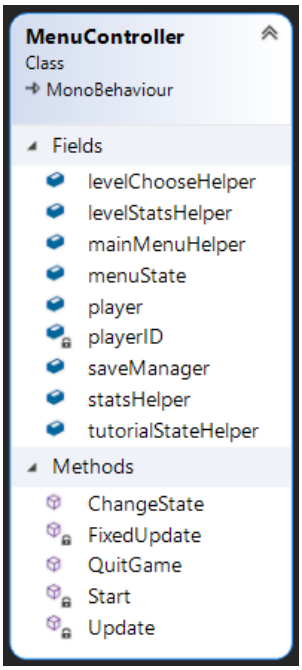


Figure 4.25: *MenuController* Class Diagram

MenuController manages the navigation between each state in the Main Menu's finite state machine, houses helper classes for each menu state as well as serialisation, and handles exiting the game should the player select the "Exit" button. Both its *Update* and *FixedUpdate* methods call the respective methods of *menuState*.

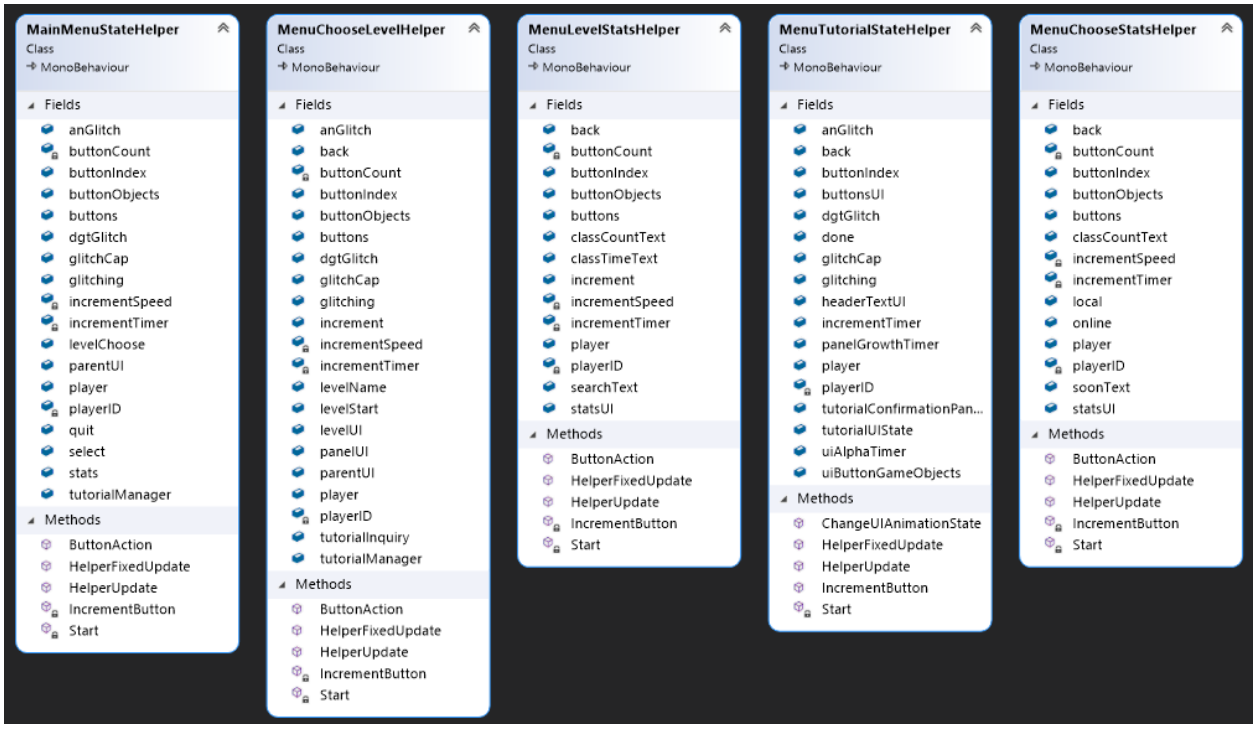


Figure 4.26: Menu State Helper Classes Class Diagram

Each helper class was created to manage the specific actions and responsibilities of their respective menu states. For *MenuTutorialStateHelper*, it houses its own finite state machine management similar to *MenuController*. This finite state machine coordinates the UI animation for the prompt that asks if a player wants to complete the tutorial. Both *MenuChooseStatsHelper* and *MenuLevelStatsHelper* utilise the *MenuController saveManager* to access serialised data of the player's gameplay.

4.3.3. 3D Platforming Mode

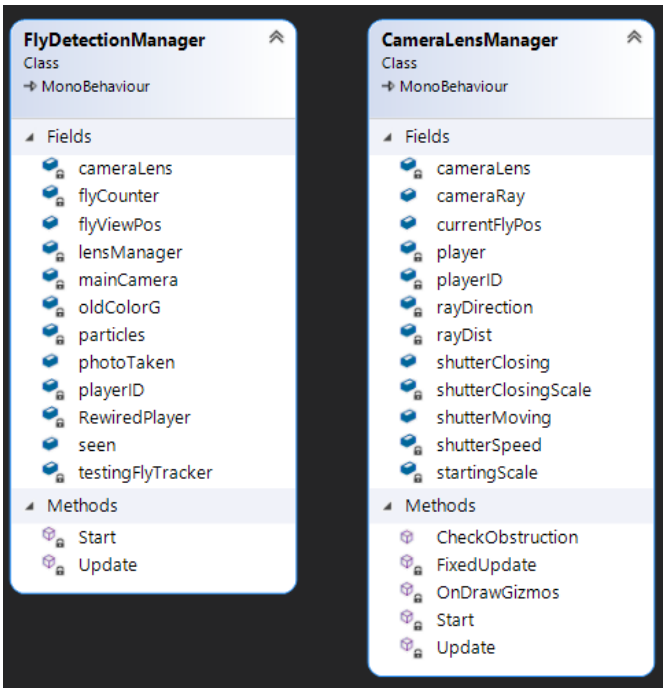


Figure 4.27: *FlyDetectionManager* and *CameraLensManager* Class Diagram

The class *FlyDetectionManager* handles the logic concerning whether the fly object is in frame once the in-game camera is aimed and tracks when the fly object's photo has been taken. *CameraLensManager* handles the in-game camera lens UI and checks whether the view of fly objects that are in range is obstructed. *FlyDetectionManager* uses the *CameraLensManager* method *CheckObstruction* to determine when a valid photo can be taken of a fly object.

For the 3D platforming part of the level, most of the main code used was repurposed from third parties with slight modifications.

- ***PlayerMovement.cs* and *PlayerCollision.cs***: Author: Slug Glove; Source: https://www.youtube.com/watch?v=ZxWfkOhl6bQ&list=PLbT7sIsvd6RUPai-zx8wQ83QP8DG38Y9W&index=26
- ***Rail.cs***: Author: N3K EN; Source: https://www.youtube.com/watch?v=URqjHIz6pts&list=PLbT7sIsvd6RUPai-zx8wQ83QP8DG38Y9W&index=28

4.3.4. Photo Analysis Mode

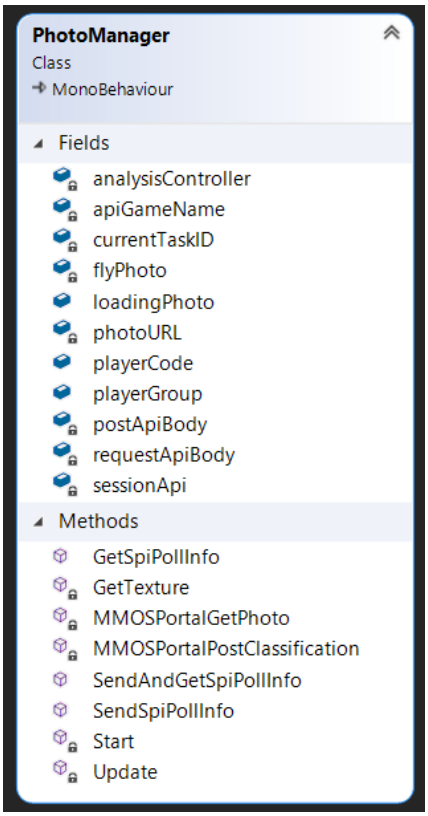


Figure 4.28: *PhotoManager* Class Diagram

PhotoManager is the class that handles and coordinates the communication between Fly Catcher and the MMOS database that houses the hoverfly image data set. It is the only class that directly utilises the MMOS SDK. After receiving the classification task with the image URL (*GetSpiPollInfo*), *PhotoManager* loads the image into the scene (*GetTexture*). Once the player makes a classification, *PhotoManager* sends the necessary information of the classification back to the database (*SendSpiPollInfo*), which in turn responds to the message with a result concerning the player's accuracy.

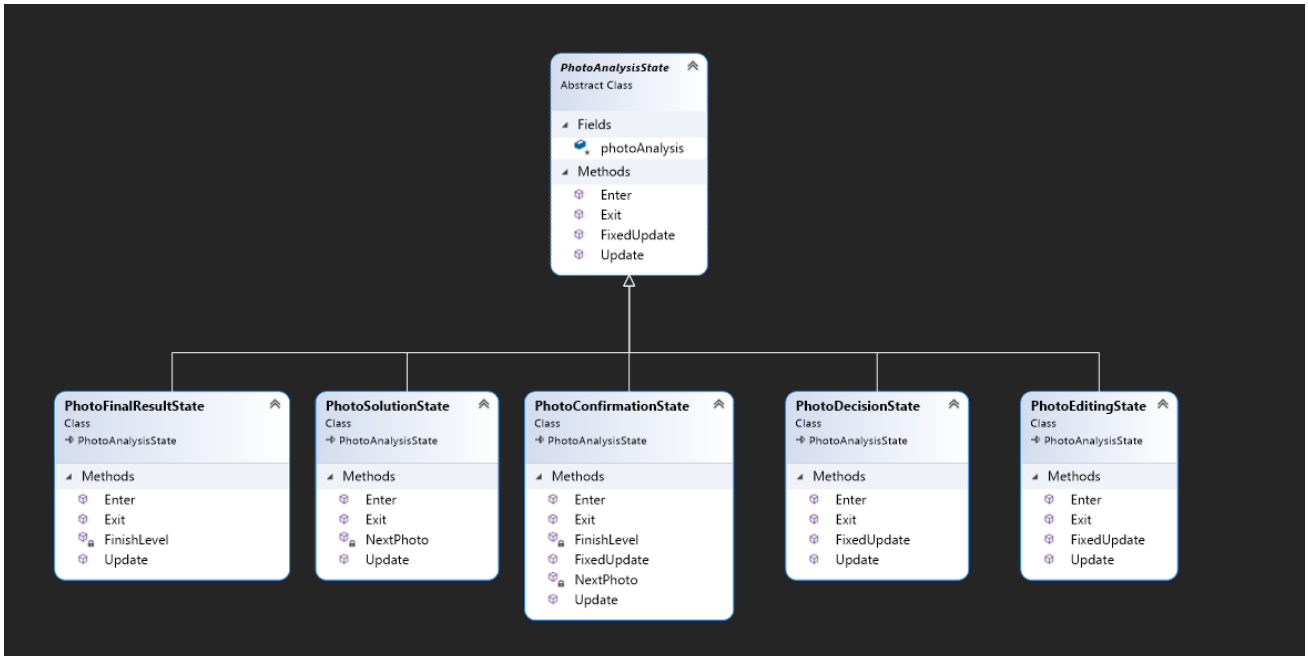


Figure 4.29: *PhotoAnalysisState* Class Hierarchy Class Diagram

The *PhotoAnalysisState* class and its children comprise the finite state machine that governs the Photo Analysis portion of the game's levels. The *photoAnalysis* variable is of the class *PhotoAnalysisController*. *PhotoEditingState* manages the photo editing puzzle at the start of the gameplay section. *PhotoDecisionState* manages the options screen where the player chooses their answer to classify the photo. *PhotoConfirmationState* manages the prompt screen that lets the player confirm their choice. *PhotoSolutionState* manages the solution screen that will either tell the player whether their answer was right or wrong in the event that the photo was part of the test data set, or provide a grateful message to the player for contributing. *PhotoFinalResultState* manages the concluding screen that summarises the player's performance for the entire level, will signal whether the player exceeded the previous best record, and will return the player to the Main Menu screen at the button prompt.

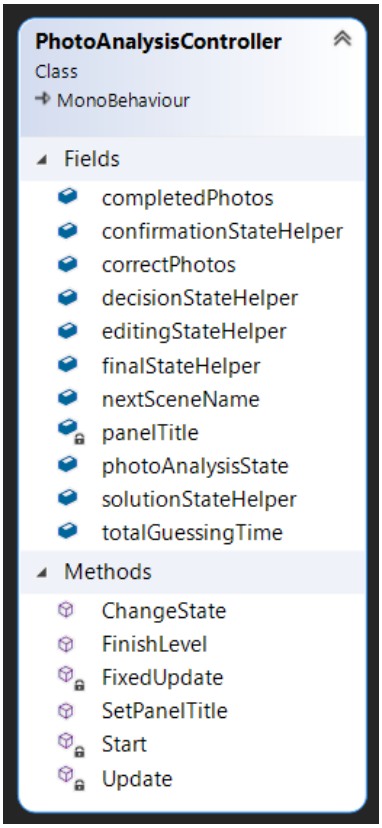


Figure 4.30: *PhotoAnalysisController* Class Diagram

The *PhotoAnalysisController* class manages the navigation between the states of the *PhotoAnalysisState* finite state machine. It houses the helper classes for each respective state class, and it keeps track of the player's progress and performance in the level. *PhotoManager* uses *PhotoAnalysisController* to retrieve the player's solutions for the classification tasks.

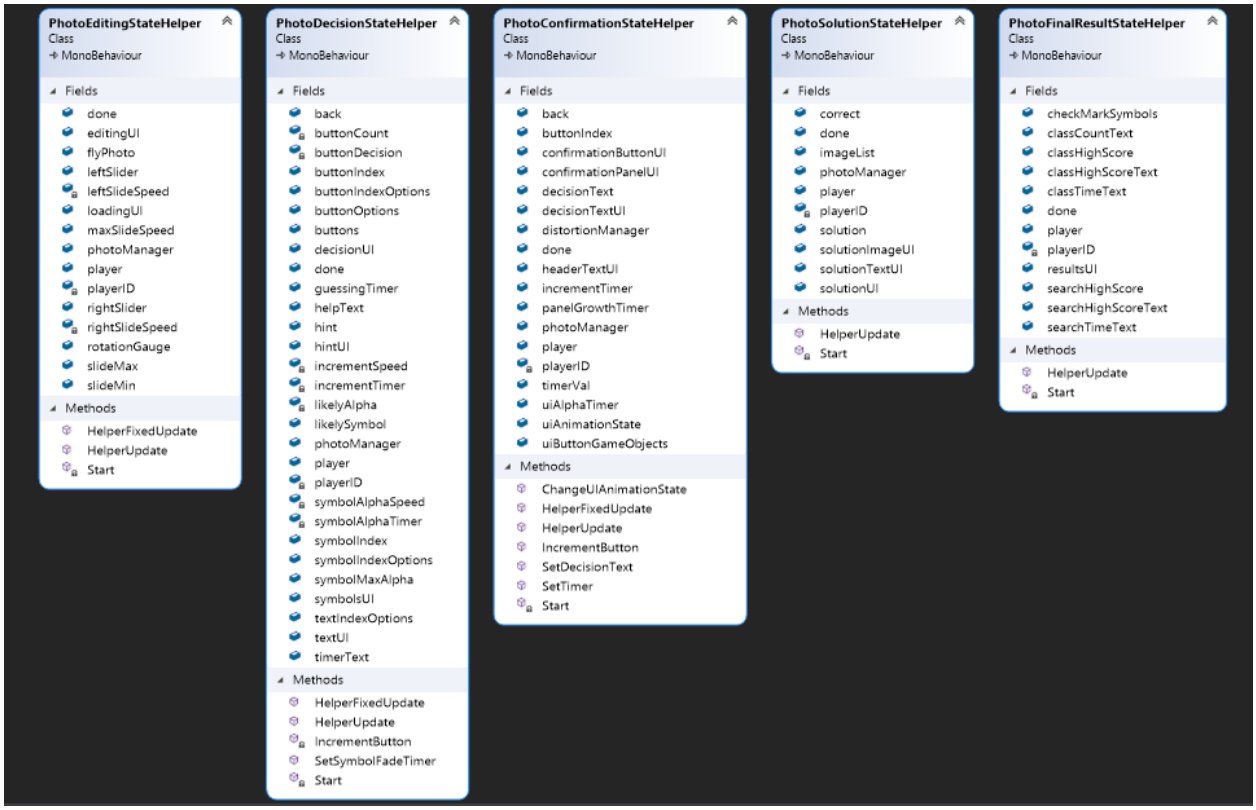


Figure 4.31: Photo Analysis State Helper Classes Class Diagram

Each helper class was created to manage the specific actions and responsibilities of their respective photo analysis states. *PhotoConfirmationStateHelper* in particular must communicate with the *PhotoManager* to send and retrieve the necessary info of the player's classification decision. It also, like *MenuTutorialStateHelper*, houses its own finite state machine management to coordinate the UI animation for the prompt asking the player to confirm their classification.

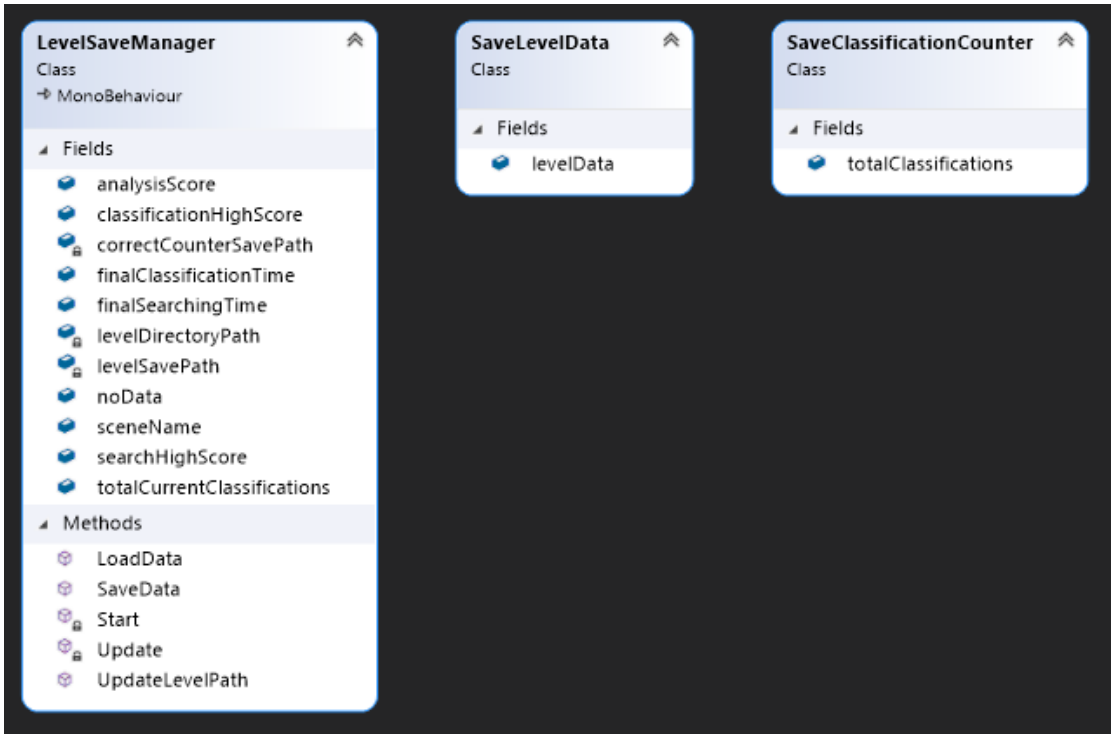


Figure 4.32: Class Diagram for LevelSaveManager and the serialisable classes SaveLevelData and SaveClassificationCounter

LevelSaveManager is the class that handles serialisation for the data that concerns the final results of each level. It uses the serialisable classes *SaveLevelData* and *SaveClassificationCounter*. The class *SaveClasificationCounter* stores an integer that represents the total number of valid classifications the player has made. A classification is valid as long as it is not an incorrect solution to a test data set. *SaveLevelData* is a class that holds a *Dictionary <string, float>* object with the structure of:

- Best Search Time: Best record time of finishing the 3D platforming part of the level
- Best Photo Score: Best score for valid photo classifications in the level
- Best Classification Time: Best record time for completing the valid classifications (Note: This time cannot be bested in a run that does not at least meet the Best Photo Score record)

4.3.5. Full Source Code

To look over the source code and the full Unity project of Fly Catcher, refer to Appendix C.

4.4. Play Testing

This section details the results of the playtesting sessions carried out.

4.4.1. Quantitative Results

After the survey was conducted, the percentage rating of each significant category's average score was calculated.

Categories	Percentage Scores
GEQ Competence	48.33%
GEQ Positive Effect	50.56%
GEQ Negative Effect	32.99%
GEQ PG Positive Experience	31.25%
GEQ PG Negative Experience	14.35%
IEQ Total	55.71%
IEQ Control	62.54%
PENS Autonomy	58.82%
PENS Competence	66.39%
PENS Intuitive Controls	87.11%

Figure 4.33a: Table cataloguing the average percentage scores of each questionnaire category in the Fly Catcher Survey

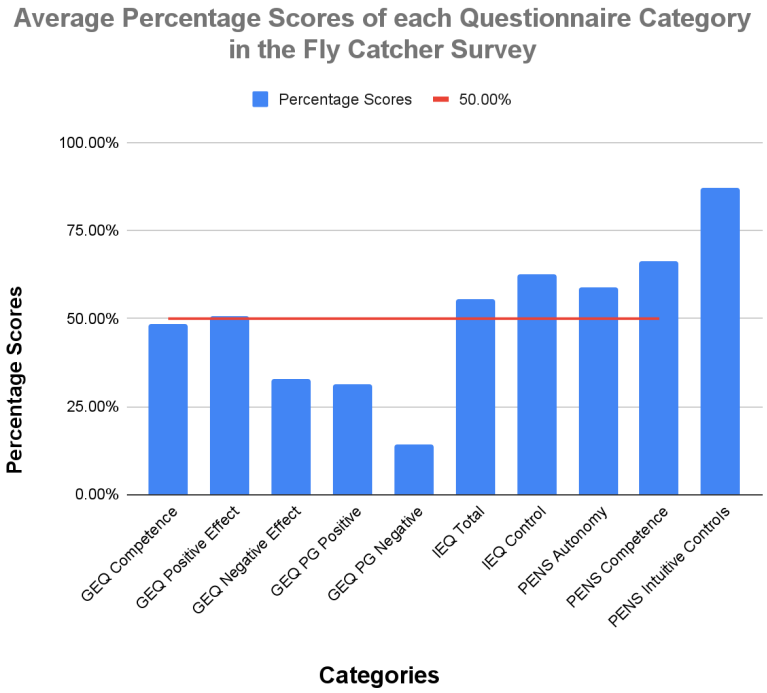


Figure 4.33b: Graphical representation of Figure 4.33a

Most of the positive attributed categories reached the 50% threshold save for GEQ's Competence and Post-Game Positive Experience categories. Both negative attributed categories (GEQ Negative Effect and GEQ Post-Game Experience) remained under 50%.

Concerning the demographic questions, 100% of the participants responded that they have played video games for over 10 years. The other two demographic questions had more varying results.

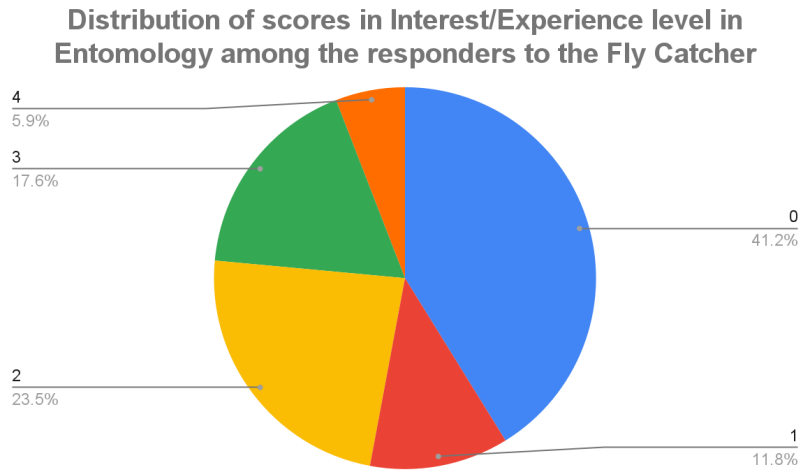


Figure 4.34: Pie chart representation of the demographic distribution among the responders pertaining to their interest or experience level in entomology.

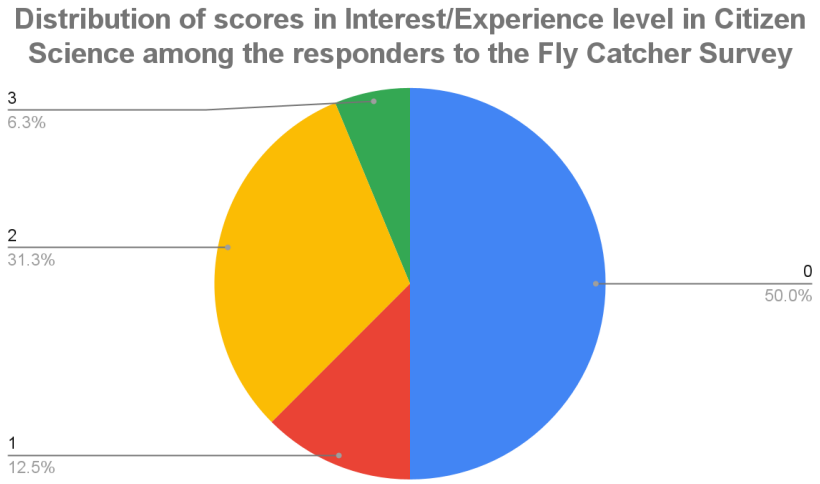


Figure 4.35: Pie chart representation of the demographic distribution among the responders pertaining to their interest or experience level in citizen science.

In both instances, at least 40% of participants had no prior interest or experience in either subjects, with more participants unaware of or have no interest in citizen science (50%). These factors did not appear to affect their other answers to the questionnaires, however, as both interest levels proved to have negligent correlation with any of the significant questionnaire categories.

Subject	Average Correlation
Entomology	-0.092
Citizen Science	-0.229

Figure 4.36: Table of the average correlations of the level of interest/experience in entomology and citizen science with the average scores of each questionnaire category

4.4.2. Qualitative Results

In addition to “citizen science”, “engagement”, and “classification”, inductive analysis of the open-ended responses to the survey produced another series of coded themes.

Theme	Coded Language
navigation	“parkour”, “movement”, “jump”
tutorial	“tutorial level”
controls	“buttons”
sound	“music”, “buzzing”
glitches	“bugs”
graphics	“textures”, “aesthetic”
autonomy	“choice”, “options”
level design	“environment”, “umbrellas”, “chains”, “platforms”, “map”
photo editor	“distort”, “image puzzle”

Figure 4.37: Table of themes and coded phrases that were found using inductive thematic analysis on the open ended feedback of the Fly Catcher survey

Upon reading through the open-ended responses to the survey, it was observed that when words and phrases coded to the themes were mentioned, they did not always carry with them the same emotional sentiment. Some were regarded positively, while others with negativity. Many responders had both praise and criticism that fell under the same theme. So the responses were parsed through and divided into instances of Positive sentiment, and instances of Negative sentiment. In this analysis, a person can only say one statement per sentiment. So if they criticise ‘navigation’ 5 times in their response, it is only counted once. Additionally, should an individual use both positive and negative sentiments for the same theme, both instances are counted once.

Theme	Positive Sentiment	Negative Sentiment
citizen science	5	1
navigation	4	7
tutorial	1	4
engagement	5	2
controls	3	2
sound	2	6
glitches	1	8
classification	2	3
graphics	3	3
autonomy	2	1
level design	2	7
photo editor	1	5

Figure 4.38a: Table showing the frequency of positive and negative sentiments by participants towards coded themes in the Fly Catcher survey

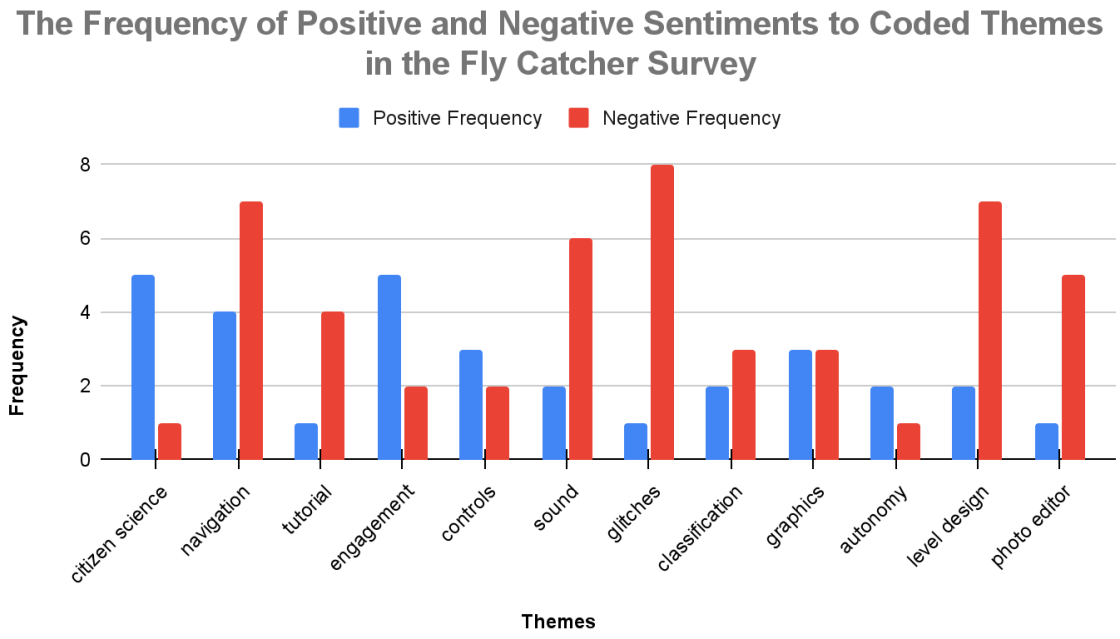


Figure 4.38b: Graphical representation of Figure 4.38a

Some key points from the open-ended responses not covered in the figures:

- ➢ The negativity towards “classification” was not towards the classification mechanic as a concept. Player’s grievances with the mechanic came from the reliability of the mechanic. They cited instances during their playthrough where the game seemed to work differently than what was set up by the game’s instructions.

“*A couple of times, when I wasn't sure about the gender of a hoverfly and I chose "likely male" or "likely female", my submission was deemed wrong; because apparently, I should have chosen the more definite answer "male" or "female". I don't understand why that should happen. {...} Instances like that were quite off-putting and made me frustrated.*” - Game Tester Player (A)

“*When choosing if a fly is Male or Female (likely or not) it seems that most flies within this build were all male regardless of what the tutorial explained and what the picture of flies shows.*” - Game Tester Player (B)

“*Something I did noticed was that when you're classifying the flies there were moments when I was unsure and used the "likely" option. The first time I used it, I said the fly I was classifying was "likely a female" and the game said I was wrong, that the answer was "female"* ” - Game Tester Player (C)

This is an important distinction from having misgivings about the classification task in general, as will be discussed further in Section 5.2.

- ➢ Much of the statements about level design could overlap into navigation. Players found issues with how platforms and other objects were placed in the scene, citing that their placements were not complementary to the game’s movement mechanics.

“*It is quite difficult to jump on umbrellas at the right angle if there is no space behind them, and also difficult to jump off chain walls at the right angle.*” - Game Tester Player (A)

“*Looking for fly clusters to take pictures of would be fine if {...} we didn't have to jump around an overly complicated platform course…*” - Game Tester Player (B)

“*I would suggest research on level designs and movement around first person parkour movement. Mirrors Edge, Ghost Runner, Titan Fall, Apex Legends and possibly Dying Light are good places to start.*” - Game Tester Player (C)

---

5. Discussion

5.1. Quantitative Results

The GEQ Competence category's score was close to reaching above 50%, but ultimately failed. An important fact to note is that overall, the GEQ categories scored the lowest. This could be for a number of reasons. For instance, it could be a fault of the model. Johnson *et al*. did report that the language of the prompts for Positive and Negative effect were redundant among other categories (Johnson *et al*., 2018). Perhaps using the revised structure suggested in their study would yield a result more inline with the other models. It is also very possible that their low score is an indication of the limits of the game. The categories were used by the project to measure extrinsic need satisfaction, the external rewards for doing or completing a task (Ryan and Deci, 2000). While players are given scores and encouraged and praised for beating previous records, they are not given "badges" or any other symbolic reward for the achievement other than simply the acknowledgement of the achievement. Many other games enlist a different practice, distributing rewards based on final scores and other achievements. This is a short-coming of the game and allows opportunity for future improvement to the game's reward mechanics.

The discrepancy between the GEQ Competence category and the PENS Competence category is an awkward one. While it is almost certainly a matter incurred by the structure of the two questionnaires, as that would prove to be the only difference in both cases, what precise features caused this divide are unknown.

A straightforward interpretation of the score for the PENS Intuitive Controls category (the highest scoring category) is that the controls implemented for the game followed market trends and thus players had very little difficulty learning what each button on the controller did. Likely the most influential factor is player experience level. All play testers reported having played video games for over 10 years. They have a high level of experience playing video games and thus would be exposed to a variety of button layouts. This is likely why Intuitive Controls was such a successful category.

The evidence that there was no observation of any significant correlation between previous knowledge or interest of entomology or citizen science and the results of the questionnaires leads to the conclusion that these preliminary factors had little to no effect on player engagement. These results (Figure 4.36) have both positive and negative implications.

It is a benefit that for those that pick up the game with no prior background with citizen science or entomology, they likely won't feel disheartened by their lack of initial understanding of the subject matter

and material. This expands the potential audience of the game, thus making it easier to attract more players.

The potential downside to the results is that both correlations are negative. While their bearing on engagement appeared to be negligible, they still provide evidence of a trend. Should gamers that have prior interest or experience in citizen science or entomology feel less inclined to play this game, this could reduce audience size and potentially alienate a valuable demographic in the target audience who could provide better quantities and quality of data. It would hinder the "citizen science" aspect of the project's aim.

5.2. Qualitative Results

Matching each other in frequency of participant mentions, "navigation" and "level design" were the two second most common themes of criticism in the open-ended responses, preceded only by "glitches". It's clear that the 3D platforming mechanic was a contentious feature of the game. While some did take to the mechanic well, many others experienced frustration with the way the player character moved and how they interacted with the environment around them. The criticism received illustrates a few of the gaps in this project's research. While possibly not within the scope of the current project, understanding and building upon the design decisions behind games like Mirror's Edge (2008) could definitely help in later builds of the game should the platforming mechanic remain in future iterations.

The classification mechanic, while flawed, appeared to be where many players had the most enjoyment from. One possibility is the failings of the more complicated parkour mechanics uplifted the stability of the simple classification puzzle. However, many participants did cite approval for the citizen science aspect of the game. Criticism of the classification mechanic was targeted predominantly at instances where the photo sent was part of the test data set and thus had a definitive answer rather than a 'likely' answer, which players are previously encouraged to use. This instance was not covered in the game's code and can be considered a bug.

Evidently, a lot of the criticism aimed at the citizen science section of the game had nothing to do with citizen science but with the distortion puzzle mechanic. A majority of the criticism cited the simplicity of the puzzle and called for a more complex and involved process. Fewer others stated that it was too difficult or unnecessary. A likely solution to this would be to reexamine the puzzle, perhaps create various image puzzles with different mechanics and solutions but all within the same level of difficulty. This would add more variety and give players that did not enjoy the slider mechanics of the older puzzle a chance to try a new, perhaps more preferable mechanic.

---

6. Project Evaluation

6.1. Project Aims

- **Engaging**: By the standards set by this project, 8 out of the 10 questionnaire categories scored favourably towards the "engagement" piece of the project's aim, reaching above the 50% margin. However, only 3 out of the 10 reached passed the 60% threshold to be considered a "positive" outcome and not "mixed". The qualitative data reflects this, with a lot of criticism aimed at the level design and player movement. Additionally, no concrete evidence of long-term engagement can be determined until a much longer testing period is enacted. While not a negative outcome, and a step in the right direction, Fly Catcher still requires some additional work in the design aspect before it can be considered a true success in this field.

- **Classification Data-Analysis**: Fly Catcher incorporates a photo classification puzzle game into its core gameplay. Players must interact and play through these classifications to successfully finish a level, ensuring that the bare minimum level of player engagement involves completing the classification task.

- **Citizen Science**: Fly Catcher successfully implements the MMOS SDK (Szanter, 2019), interacting with the SPIPOLL hoverfly dataset through the MMOS developer portal. Fly photos are taken directly from the data set and classified by non-scientists while they play Fly Catcher. The results of those classifications are then sent back through MMOS and to SPIPOLL.

- **Video Game**: Fly Catcher is a computer game available on Windows

6.2. Literature Reviewed

More research on the specific game design elements used would have aided in the development and reception of the game, specifically that of the parkour mechanics. As mentioned before, market research focused on games with parkour mechanics such as Mirror's Edge (2008) would have helped in honing the 3D platforming gameplay. The classification mechanic can also be slightly expanded upon, with more variation in the simple puzzle players have to solve before classifying the fly photo.

Concerning the literature and past works that were reviewed, each one contributed in helping lay the foundation of understanding surrounding engagement in citizen science. The original intent, as stated in my initial proposal under Appendix A, was to incorporate interviews into the critical context of the project. Unfortunately due to scheduling issues, this couldn't be done in any substantial way. Further

research under this project idea would benefit from investigating primary sources from within the industry.

6.3. Methods Used

Unity was the right choice for the game engine. Its reliable software and expansive user support from its community aided the project's development immensely. Additionally, because of the engine's versatility in the software it can be applied to, further development can be geared towards other platforms such as mobile devices like iOS and Android.

The exclusion of the "relatedness" motivator from testing was a poor decision in hindsight. While Fly Catcher does not offer any obvious opportunity for players to engage with virtual entities in the game, the instructions of the game are written in a more personalised tone as a means to engage the player. This can be considered a source of relatedness for players. However the questions asked by the questionnaires that fall under the 'relatedness' category were mostly referring to other players or characters in the game world. Perhaps in future studies that use these questionnaires to evaluate Fly Catcher's play sessions, a clarification can be implemented at the beginning of the survey that any questions of that nature should be interpreted as referring to the "narrator" of the instructions.

A weakness in the project's testing method resides in the sampling of participants. As shown in the results of the questionnaire, every participant that completed the test had played video games for over 10 years. While this does coincide with the decision to cater towards gamers in the design aspect, the data still possesses a bias towards that demographic rather than examining a range of people with different levels of gaming experience. Not enough care was placed in advertising the project in communities that are atypical of gamers or that possess shared traits that are not inherent of gamers but still reflect the aims of the project (ie. citizen scientists, entomologists, etc.). The results of these efforts will naturally still be contingent on the interest of the people that witness the advertisement. If further research were to be conducted with this project's aim, the demographic of the sample size must be more varied.

An improvement upon this first iteration of the project would include interim tests. Game development is a process that runs best when under an Agile framework, with many testing phases along the way to its final version. Instead of focusing on building a presentable product before testing, the focus should have been building a mechanic, testing the mechanic against the target audience, determining its flaws based on the test results, and addressing those flaws before moving forward.

6.4. Further Development

As stated earlier, a mobile version of the game is a possibility through the Unity engine. It could prove to be a substantially beneficial endeavour, as it improves the game's accessibility beyond the PC, and thus expands its potential user base. More importantly for the purposes of the project, this can also potentially improve player engagement, as moving to a more readily accessible platform could help motivate players to engage with the game on a more regular basis.

An online feature of the game was planned but never made it to fruition. The player's records and high scores would have been shared to an online database that would rank and display them on a leaderboard for other players to see. This would have contributed to the "relatedness" factor of player motivation. For further development, this idea can be expanded upon. In addition to creating a leaderboard for player scores, a platform for online communication between players can also be developed. This would increase the player's sense of community and thus their sense of relatedness concerning Fly Catcher.

6.5. Concluding Statement

The project overall has been an illuminating experience. It taught many lessons in organisation and helped develop skills and knowledge in game development. It introduced many new techniques and tools in the surveys that can be used for future development in other game projects.

The final result of the project was overall positive, but not by a great amount. The key takeaway is the classification task itself did not impede the players' engagement. The design decisions surrounding the task are what hindered greater success. What the results of the play testing showcased was how citizen science as a concept is not devoid of the allure for a common citizen to engage with. Perhaps what the criticism of the 3D platforming section of the game indicates is that despite the initial claim in the project's specifications that the game's gameplay must include elements that are separate to the classification problem, instead one must look into how to make the classification problem itself more engaging. While not the intended outcome of the project, this is still a conclusion that can prove to have a significant impact on future research: Gamification can build engagement in the citizen science tasks, not by attaching the task to a game process but by further developing and gamifying the task itself.

Work Cited

Aristeidou, M., Scanlon, E. and Sharples, M. (2017). Profiles of engagement in online communities of citizen science participation. *Computers in Human Behavior*, *74*, pp.246-256.

Batson, C.D., Ahmad, N. and Tsang, J.A. (2002). Four motives for community involvement. *Journal of social issues*, *58*(3), pp.429-445.

Ben-David, J. (1972). The profession of science and its powers. *Minerva*, pp.362-383.

Black House. (2017). *Modular Wooden Set*. [online]. Unity Asset Store. Available at: https://assetstore.unity.com/packages/3d/props/modular-wooden-set-80477

Blog. (2012). *About Eyewire, A Game to Map the Brain*. [online]. Available at: https://blog.eyewire.org/about/.

Borderlands 3. (2019). macOS, Stadia, Microsoft Windows, PlayStation 4, Xbox One, Xbox Series X/S, PlayStation 5 [Game]. Gearbox Software: Texas

Bowser, A., Hansen, D., Preece, J., He, Y., Boston, C. and Hammock, J. (2014), February. Gamifying citizen science: a study of two user groups. In *Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing* (pp. 137-140).

Brown Road Park. (2021). [image]. St. Peters Missouri. Available at: https://www.stpetersmo.net/st-peters-parks.aspx.

Cardamone, C., Schawinski, K., Sarzi, M., Bamford, S.P., Bennert, N., Urry, C.M., Lintott, C., Keel, W.C., Parejko, J., Nichol, R.C. and Thomas, D. (2009). Galaxy Zoo Green Peas: Discovery of A Class of Compact Extremely Star-Forming Galaxies. *arXiv preprint arXiv:0907.4155*.

citizenscience.gov. (n.d). *North American Bird Phenology Program | CitizenScience.gov.* [online]. Available at: <https://www.citizenscience.gov/north-american-bird-phenology-program/#> [Accessed 30 Nov. 2022].

Coma-Media. (2021). *Time Technology* [online]. Pixabay. Available at: https://pixabay.com/music/upbeat-time-technology-11257/

Cooper, S., Khatib, F., Treuille, A., Barbero, J., Lee, J., Beenen, M., Leaver-Fay, A., Baker, D. and Popović, Z. (2010). Predicting protein structures with a multiplayer online game. *Nature*, *466*(7307), pp.756-760.

Crash Bandicoot 4: It's About Time. (2020). Xbox One [game]. Activision: California

Danielsen, F., Jensen, P.M., Burgess, N.D., Altamirano, R., Alviola, P.A., Andrianandrasana, H., Brashares, J.S., Burton, A.C., Coronado, I., Corpuz, N. and Enghoff, M. (2014). A multicountry assessment of tropical resource monitoring by local communities. *BioScience*, *64*(3), pp.236-251.

Delaney, D.G., Sperling, C.D., Adams, C.S. and Leung, B. (2008). Marine invasive species: validation of citizen science and implications for national monitoring networks. *Biological Invasions*, *10*(1), pp.117-128.

Denisova, A., Nordin, A.I. and Cairns, P. (2016), October. The convergence of player experience questionnaires. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (pp. 33-37).

dmahajan980. (2022), November. *Gamepad diagram* [image]. GitHub. Available at: https://github.com/dmahajan980/gamepad-prototype-using-infusion

Every Kingdom Hearts game frame in order. (2020). *Kingdom Hearts Final Mix Deep Jungle - frame 4 of 2762* [image]. Facebook. Available at: https://www.facebook.com/EKHFIO/photos/a.106585724484456/119681393174889/?type=3&paipv=0&eav=AfZmTy-QWEaIZjDhbOg7vQx0tMyMr-dj8G1jt_uxLjdjzq3HQE7Os6ESXnLKl9TdtJM&_rdr

EyeWire. (2012). WebGL [game]. Princeton University: Princeton.

Foldit. (2008). PC [game]. University of Washington: Washington.

fold.it. (n.d.). *Foldit*. [online]. Available at: https://fold.it/about_foldit.

gametester.gg. (n.d.). *Game Tester | Make good games great.* [online]. Lionbridge Game Studios. Available at: https://gametester.gg/.

Gearbox. (2020). *Play Borderlands Science, Aid Scientific Research!* [online]. Gearbox Software. Available at:

<https://www.gearboxsoftware.com/2020/04/borderlands-science-is-live-now-play-and-help-scientific-research/> [Accessed 2 Dec. 2022].

Gearbox. (2021). *Gearbox Entertainment Celebrates Anniversary of Borderlands Science Research.* [online]. www.prnewswire.com. Available at: <https://www.prnewswire.com/news-releases/gearbox-entertainment-celebrates-anniversary-of-borderlands-science-research-301293496.html> [Accessed 3 Dec. 2022].

Guavaman Enterprises. (2022). *Rewired*. [software library]. Unity Asset Store. Available at: https://assetstore.unity.com/packages/tools/utilities/rewired-21676

Hunter, J., Alabri, A. and van Ingen, C. (2013). Assessing the quality and trustworthiness of citizen science data. *Concurrency and Computation: Practice and Experience*, *25*(4), pp.454-466.

IJsselsteijn, W.A., De Kort, Y.A. and Poels, K. (2013). The Game Experience Questionnaire.

Immersyve. (2007). *The Player Experience of Need Satisfaction (PENS) An applied model and methodology for understanding key components of the player experience*. [online]. Immersyve, Inc. Available at: <https://immersyve.com/download/pens/?wpdmdl=8267> [Accessed 21 May 2022].

Jennett, C., Cox, A.L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T. and Walton, A. (2008). Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies*, [online]. 66(9), pp.641–661. doi:10.1016/j.ijhcs.2008.04.004.

Johnson, D., Gardner, M.J. and Perry, R. (2018). Validation of two game experience scales: the player experience of need satisfaction (PENS) and game experience questionnaire (GEQ). *International Journal of Human-Computer Studies*, *118*, pp.38-46.

Kingdom Hearts Final Mix. (2002). Playstation 2 [game]. Square: Japan

kirevdokimov. (2022). *Unity-UI-Rounded-Corners*. [online]. GitHub repository, Available at: <https://github.com/kirevdokimov/Unity-UI-Rounded-Corners>

Landers, R.N., Auer, E.M., Collmus, A.B. and Armstrong, M.B. (2018). Gamification science, its history and future: Definitions and a research agenda. *Simulation & Gaming*, *49*(3), pp.315-337.

LH Yeung. (2009). *The player character in Mirror's Edge sliding down a rail* [image]. LH Yeung.net Blog - AniGames. Available at: https://blog.lhyeung.net/2009/03/17/mirrors-edge-pc-version/ [Accessed December 2022]

Lowpoly_Master. (2016). *Umbrella Pack*. [online] Unity Asset Store. Available at: https://assetstore.unity.com/packages/3d/umbrella-pack-74907

Lukyanenko, R., Wiggins, A. and Rosser, H.K. (2020). Citizen science: An information quality research frontier. *Information Systems Frontiers*, *22*(4), pp.961-983.

Lukyanenko, R., Parsons, J. and Wiersma, Y.F. (2016). Emerging problems of data quality in citizen science. *Conservation Biology*, *30*(3), pp.447-449.

Matin, A., Maduro, M., de Leon Pereira, R. and Tremblay-Savard, O. (2020), September. Effect of Timer, Top Score and Leaderboard on Performance and Motivation in a Human Computing Game. In *International Conference on the Foundations of Digital Games* (pp. 1-10).

Miklovan. (2021). *Flies* [online]. Pixabay. Available at: https://pixabay.com/sound-effects/flies-6330/

Mirror's Edge. (2008). Playstation 3 [game]. Electronic Arts: California

Moran, T. (2016). *Shaders 102 - Basics of Image Effects*. [online]. YouTube. Available at: https://youtube.com/watch?v=kpBnIAPtsj8&si=EnSIkaIECMiOmarE

NUMENA. (2021). *Baobab Tree*. [online]. Unity Asset Store. Available at: https://assetstore.unity.com/packages/3d/vegetation/baobab-tree-200281

Oliver, S. (2021). *Episyrphus balteatus male (Marmalade Hoverfly) (Syrphidae - Hoverflies)*. [image]. Flickr. Available at: https://www.flickr.com/photos/126688171@N06/51251856767 [Accessed October 2022].

Prestopnik, N. and Crowston, K. (2012), October. Purposeful gaming & socio-computational systems: a citizen science design case. In *Proceedings of the 17th ACM international conference on supporting group work* (pp. 75-84).

Przybylski, A.K., C. Scott Rigby and Ryan, R.M. (2010). A motivational model of video game engagement. *Review of General Psychology*, [online]. 14(2), pp.154–166. doi:10.1037/a0019440.

pwrc.usgs.gov. (2016). *North American Phenology Program - About.* [online]. Available at: <https://web.archive.org/web/20161226060526/http://www.pwrc.usgs.gov/bpp/about.cfm> [Accessed 30 Nov. 2022].

Rotman, D., Preece, J., Hammock, J., Procita, K., Hansen, D., Parr, C., Lewis, D. and Jacobs, D. (2012). Dynamic changes in motivation in collaborative citizen-science projects. In Proceedings of the ACM 2012 conference on computer supported cooperative work (pp. 217-226).

Ryan, R.M., · C Scott Rigby and Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. Motivation and Emotion, [online]. 30(4). doi:10.1007/s11031-006-9051-8.

Ryan, R.M. and Deci, E.L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), pp.54–67. doi:10.1006/ceps.1999.1020.

Sailer, M., Hense, J.U., Mayr, S.K. and Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in human behavior*, *69*, pp.371-380.

Severin Meyer. (2019). *Xolonium Font* [font]. Available at: https://www.fontspace.com/xolonium-font-f17644

Sauermann, H. and Franzoni, C. (2015). Crowd science user contribution patterns and their implications. *Proceedings of the national academy of sciences*, *112*(3), pp.679-684.

SANBI. (n.d.). *Hover flies*. [online]. Available at: https://www.sanbi.org/animal-of-the-week/hover-flies/.

Şengün, S. (2019). Videogame Engagement: Psychological Frameworks.

Serret, H., Deguines, N., Jang, Y., Lois, G. and Julliard, R. (2019). Data quality and participant engagement in citizen science: comparing two approaches for monitoring pollinators in France and South Korea. *Citizen Science: Theory and Practice*, 4(1), p.22.

Sharp, C. J. (2014). *Marmalade hoverfly (Episyrphus balteatus) female*. [image]. Wikimedia Commons. Available at: https://commons.wikimedia.org/wiki/File:Marmalade_hoverfly_%28Episyrphus_balteatus%29_female.jpg [Accessed October 2022].

Shirk, J.L., Ballard, H.L., Wilderman, C.C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B.V., Krasny, M.E. and Bonney, R. (2012). Public participation in scientific research: a framework for deliberate design. *Ecology and society*, *17*(2).

Silvertown, J. (2009). A new dawn for citizen science. *Trends in ecology & evolution*, *24*(9), pp.467-471.

Sobczyk, B., Dobrowolski, P., Skorko, M., Michalak, J. and Brzezicka, A. (2015). Issues and advances in research methods on video games and cognitive abilities. *Frontiers in Psychology*, *6*, p.1451.

Szantner, A. and Revaz, B. (2014). *MMOS*. [online]. MMOS.ch. Available at: <http://mmos.ch/> [Accessed 21 May 2022].

Szantner, A. (2022). *MMOS SDK - C# edition*. [online]. GitHub repository, Available at: <https://github.com/MassivelyMultiplayerOnlineScience/mmos-sdk-csharp>

Tarng, P.Y., Chen, K.T. and Huang, P. (2008), October. An analysis of WoW players' game hours. In *Proceedings of the 7th ACM SIGCOMM Workshop on Network and System Support for Games* (pp. 47-52).

Thompson, A. (2020). *Importance Of Storytelling in Games | Sliced Bread Animation.* [online]. Sliced Bread Animation. Available at: https://sbanimation.com/the-importance-of-video-game-narrative/.

Tinati, R., Luczak-Roesch, M., Simperl, E. and Hall, W. (2016), May. Because science is awesome: studying participation in a citizen science game. In *Proceedings of the 8th ACM Conference on Web Science* (pp. 45-54).

Unlimited Games. (2017). *Future UI*. [online] Unity Asset Store. Available at: https://assetstore.unity.com/packages/2d/gui/future-ui-55695

Unity Technologies. (2022). *Space Robot Kyle*. [online]. Unity Asset Store. Available at: https://assetstore.unity.com/packages/3d/characters/robots/space-robot-kyle-4696

UW College of Engineering. (2021). *Foldit game engages the public in research*. [online]. Available at: https://www.engr.washington.edu/news/trend/autumn-2010/fold-it-game [Accessed 19 Dec. 2022].

Vinchenzo. (2008). *The player character in Prince of Persia wall running* [image]. Giant Bomb. Available at: https://www.giantbomb.com/wall-run/3015-748/images/

Waldispühl, J., Szantner, A., Knight, R., Caisse, S. and Pitchford, R. (2020). Leveling up citizen science. *Nature Biotechnology*, *38*(10), pp.1124-1126.

Wee, S.C. and Choong, W.W. (2019). Gamification: Predicting the effectiveness of variety game design elements to intrinsically motivate users' energy conservation behaviour. *Journal of environmental management*, *233*, pp.97-106.

World of Warcraft. (2004). PC [Game]. Blizzard Entertainment: California

Xbox.com. (n.d.). *Crash Bandicoot 4: It's About Time | Xbox Promotional Imager*. [image]. Xbox.com. Available at: https://www.xbox.com/en-GB/games/crash-bandicoot-4 [Accessed Dec. 2022].

Zooniverse.org. (2020). *Galaxy Zoo*. [online]. Available at: https://www.zooniverse.org/projects/zookeeper/galaxy-zoo/.

Appendix

Appendix A: Project Proposal

Building an engaging citizen science game through driven game design

---

Introduction

'Citizen Science' is a practice in the scientific community that involves employing volunteers from the general public to collect and/or process data in reference to a scientific project (Silvertown, 2009).

This paper is a proposal for a project that aims to gamify citizen science; to build a citizen science platform through the video game medium. The idea was inspired by the published projects of Massive Multiplayer Online Science (MMOS), a company dedicated to "connect scientific research and video games as a seamless gaming experience" (Szantner and Revaz, 2014). With two of their successful items, Borderlands Science and Project Discovery, MMOS was able to incorporate citizen science activities that functioned as minigames in AAA titles (Borderlands 3 and Eve Online respectively) (Waldispühl *et. al.*, 2020).

This proposal, however, aims to take it a step further. Instead of incorporating citizen science into a pre-existing game, what if citizen science was at the core of the game's design?

The Problem

Citizen science has gone through gamification before, notable examples being Foldit and EyeWire. While those projects are relatively successful, they suffer from a lack of the necessary prolonged engagement from users to accomodate for the scale of their respective scientific fields (Waldispühl *et. al.*, 2020).

Objectives

The project's objectives are as follows:

Aim	**To design and build an engaging video game centered around citizen science**
Research Question	**How can purposeful game design make a video game built around citizen science be engaging?**

The Scope: Deliverables

The project has only two major deliverables:

- A completed game built in the Unity Engine
- The final report

The game should be done well before the final submission of the report since the results of the game testing will need to be analyzed and evaluated as part of it. The game itself will more than likely not be commercially viable upon the project's completion. Instead, the goal will be to incorporate the key functionality and design elements necessary to achieve an engaging experience for the players.

The Scope: The Citizen Science

SpiPoll

The basis of the citizen science part of the game will come in the form of the data from the SpiPoll Wasp dataset. SpiPoll is an abbreviation of 'Suivi photographique des Insectes Pollinisateurs', which in English roughly translates to the 'Photographic Survey of Flower Visitors'. SpiPoll is a citizen science initiative based out of the Natural History Museum of Paris.

The Poliste Wasp

The European Paper Wasp (Or the Poliste Wasp) is the main subject of the SpiPoll dataset in question. The groups of classification the dataset focuses on is whether the wasp has orange antennae, and whether it is a host to parasites.

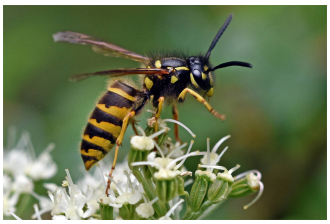


Image 1: 0323 European paper wasp (RealMantis, 2019)

Image 2: A superparasitized Polistes dominulus wasp (Vannini *et. al.*, 2008)

Image 1 showcases a typical Poliste Wasp with no parasites and black antennae. Image 2, in contrast, shows a wasp with orange antennae and the tell tale signs of parasites (ie. raised thorax plates).

The Scope: Measuring Engagement

Because 'engagement' is not an easily quantifiable statistic, the methods of data gathering need to be considered with care. While it's fairly straightforward how engagement can be represented through qualitative data, the same can't be said for quantitative. Therefore, the proposition is to use two officially recognized methods of measuring player engagement in the video game industry. One will be the **Game Experience Questionnaire** (GEQ) (IJsselsteijn *et.*

al., 2013) and the other, the **Player Experience of Need Satisfaction** (PENS) model (Immersyve, 2007).

The Scope: Sample Size

Concerning the quantitative research, the plan is for the game and the surveys to be distributed online. While the game won't be publicly accessible, during the testing phase it will be promoted in online social circles, encouraging potential participants to sign up for playtesting. Additionally, specific groups will be sought out to test the game (more on this in Approaches under Data Collection).

Beneficiaries

An immediate beneficiary will be SpiPoll, as the game will provide a new avenue for processing its Poliste Wasp data. As alluded to before when discussing the problem, the scientific community in general will benefit greatly from more research being allocated to building engagement in citizen science. The game development industry will also benefit, as this can lead to new opportunities and partnerships not previously opened between it and the scientific community, bringing in a whole new target audience.

Critical Context

Citizen Science Engagement

Beyond the context of video games, it is important to consider the efforts made to facilitate engagement in citizen science on its own. One study by Serret *et. al.* (2019) considered this through comparisons between SpiPoll and the Korean Photographic Survey of Pollinators (K-SpiPoll), both projects that utilize citizen science to acquire an abundance of pictures of pollinating insects. To assess the success of the projects, the study measured the accuracy of the data their participants were providing, calculating how many entries adhered to or violated the protocols given by each project's directions, the latter meaning those samples could not helpfully contribute to the project's research. Additionally, engagement of the participants was measured by calculating the frequency in which each contributed a photo.

In the study it was determined that SpiPoll's community tactics led their participants to produce more accurate data than K-SpiPoll. K-SpiPoll, however, had a more motivated and engaged following. It was surmised in the study that this was due to K-SpiPoll's innovation of a phone-app, allowing ease-of-access for their participants to record observations and upload them more frequently.

This study is one I will certainly take into consideration going forward. Not only because it involves SpiPoll, but also because of its relevant findings. It was useful in how it broke down the differing characteristics of the two projects in order to make sense of how it reflected in the data. Understanding how SpiPoll's methodology leads to accuracy and K-SpiPoll's leads to engagement is valuable knowledge. This will help when designing the game. A benefit and a drawback is the data used was pre-existing, meaning the researchers collected the metrics post-recording. While this means that there is a reduced chance of researcher bias from Serret and their colleagues, it also means the data was recorded and provided by the respective projects. Therefore, if there were any mistakes or biases that impacted the data, the researchers of this study would not be privy to how or where this occurred.

One final takeaway is that at one point during the study's closing statements, it encourages the exploration of gamification due to its trend of attracting new participants and sustaining long term engagement. This was based on a study by Tinatia *et. al.* (2016). The study in question examined the success of the citizen science project EyeWire and why participants were motivated to use it. Using thematic coding analysis across the responses, they determined that the desire to contribute in an entertaining way had the most occurence. This follows along with my reasoning of how gamification can further enhance citizen science through engagement.

Measuring Video Game Engagement

One study (Johnson, Gardner, and Perry, 2018) compared the two models, GEQ and PENS, based on how well their structures support the dimensions they claim to measure. They concluded that the GEQ model was largely not supported by its structure while the PENS model showcased more support but still faltered in some areas. Their claim was that both models attempt to measure concepts that overlap, mainly those that fall into the category of 'negativity'.

I take this study with a grain of salt, as by their own admission there were a few caveats to consider with their findings. One is their sample population, which comprises mostly (82%) of university students and should not be considered a near accurate representation of the general population of video gamers. Another comes from their methodology, which entailed asking participants to measure their most recent experience with their favorite game. This may have applied a few biases to their findings. Regardless of these issues, the study does a good job in showcasing some of the faults in the models and what I should consider upon reaching the analysis stage of the project.

Another similar study (Denisova, Nordin, and Cairns, 2016) compared GEQ, PENS, and the Immersive Experience Questionnaire. The study focused on finding correlations between the three models and noting any potential issues. Their methodology involved creating a survey with the questions of all models included. It was then sent out to public online video game forums, asking participants to describe their most recent gaming experience. The results suggested that there was generally a positive correlation between the three models. Furthermore, all three possessed a couple problematic questions that were deemed inappropriate in some areas and vague in others. This study also showcases the faults and benefits of the two models. In addition it provides less room for biases by only asking for the most recent gaming experience rather than the most recent experience with one's favorite game like Johnson, Gardner, and Perry (2018).

Approaches: Methods and Tools for Design, Analysis, and Evaluation

Research: Literature Review

The literature review will be continued using both Google Scholar and City University's online Library database. The subjects researched will consist primarily of the principles of game design, studies analyzing the successes and failures in citizen science projects, and background information on the Poliste wasp.

Research: Interviews

The plan is to conduct interviews with relevant individuals, professionals in both the gaming and scientific industry. The aim will be to gleam first-hand insight into the process of building a citizen science based project/game, as well as building general background

knowledge. This research is supplementary and will not be the core of the context of the final report. Interviewees will not be identified or quoted unless I am given express consent.

Game Development: Design

Finalizing the design of the game will be the most challenging part of the project. The major hurdle of the gamification of citizen science is balancing the game and the science. It requires an intuition of not only game design but also, to an extent, the scientific research being conducted. Unlike the case of MMOS's previous projects, where the challenge lied in pairing a dataset to a pre-existing game (Waldispühl *et. al.*, 2020), this project seeks to build a game based on the dataset. This change in dynamic comes with its benefits but also its difficulties.

The information collected from the literature review and interviews will be invaluable to this phase of the project. All of it will influence the decisions made during this process when it comes to gameplay, themes, and setting.

Game Development: Software

Unity Engine

The game will be built using the Unity Game Engine with the C# programming language. Due to Unity being a widely utilized engine, the community provides a wide variety of support in the form of tutorials and online forums should any issues arise during development. The Unity Asset Store will also prove useful, cutting down on development time that would be allocated to building game world assets. The license rights of the assets will need to be considered should the project's game be published.

MMOS Developer Portal

MMOS not only provided inspiration for the project, but it is also supplying crucial software and data. The MMOS Developer Portal is a host to a collection of datasets, all tailored to be used in citizen science projects. This is where the SpiPoll Wasp dataset is located. For the citizen science aspect of the game, it will utilize the MMOS C# SDK from GitHub to interact with the MMOS API that connects to the developer portal. This leads to another reason for using Unity, as the C# SDK has been built to be incorporated into the Unity Engine and has documentation concerning such an implementation.

Game Development: Hardware

The majority of the project will be conducted using my laptop, a Blade 15 laptop model from Razer (Still The Best 15 inch Gaming Laptop | Razer Blade 15, 2022). It runs a 64-bit operating system with 16GB of RAM. The aim during development will be to ensure that the resulting game can be run on machines with less optimized specs. Additionally, the game will be built for both the Windows and Mac operating systems. This is all for the sake of wider distribution and accessibility, especially during testing.

Data Collection: The Playtesters

Playtesting will be conducted with a number of participants. Each subject, in addition to a consent form, will be given a brief screening form upon entering the project. This form will ask questions with the express purpose of determining four key factors:

- General video game experience
- Interest/experience in Entomology (The Study of Insects)
- Interest/experience in citizen science
- Availability to receive a one-on-one interview.

The first three factors will provide useful metrics for the project moving forward. Participants with video game knowledge and experience may pick up on certain aspects of the game's design not privy to others. Those with pre-existing knowledge of entomology might harbour a unique appreciation for the game's subject matter. And lastly, those with interest or experience in citizen science can indicate whether the game achieves an improved level of engagement in comparison to other, non-gamified citizen science projects. Understanding which portion of players have experience in either field allows for a more in-depth evaluation of the playtesting results.

All playtesters will be informed that at any given point they can opt out of the project with no repercussions, should they so wish.

Data Collection: Quantitative and Qualitative Analysis

In order to determine the success of the final product and measure the engagement of players, a mix of qualitative and quantitative statistics need to be collected.

Quantitative

On the quantitative side, two questionnaires will be distributed to each participant. One will follow the GEQ model (IJsselsteijn *et. al.*, 2013) and the other will follow the PENS model (Immersyve, 2007). The reason behind utilizing both of these models rather than one or the other is due to the drawbacks and benefits both have over each other (Denisova, Nordin, and Cairns, 2016; Johnson, Gardner, and Perry, 2018). These questionnaires will be hosted electronically on Google Forms for the participants' ease of access. Furthermore, Google Forms is end-to-end encrypted, so any identifiable information shared in the answers will remain confidential.

Regarding analysis, the plan currently is to utilize scatter plots. Each of the two axes will represent the scores of the GEQ and PENS models. The points representing each participant will be classified based on the demographic groups their respective participant fits into: Video gamer, Entomology Enthusiast, or Citizen Scientist. Fitting into multiple demographics will be accounted for by using separate graphs to showcase each separate combination of groups that occured in the sample.

Qualitative

As for the qualitative data, interviews will be conducted with select participants. These subjects will be chosen based on the details they filled out in their screening forms. The interview questions will mainly seek to add context to some of the subject's answers in the questionnaires.

Interviews will be recorded to access later for playback and analysis. The plan is for an inductive approach through thematic analysis of the interviewee's answers. The goal will be to find patterns by coding their responses and drawing conclusions through the set of resulting codes once analysis is complete.

Data Evaluation

As stated previously, identifying among the sample size members of the video game, entomology, and citizen science fields of interest will be invaluable information when it comes to evaluating the results. It can help determine the projected success of such a game if placed on the market, as these groups would make up a majority of its target audience. Such results could showcase to game developers the potential in such a partnership and encourage them to invest in similar projects.

The Report

The project report will be the final milestone of the project. However, drafting it will begin once the project begins, adding to the document as the project progresses.

Project Meetings

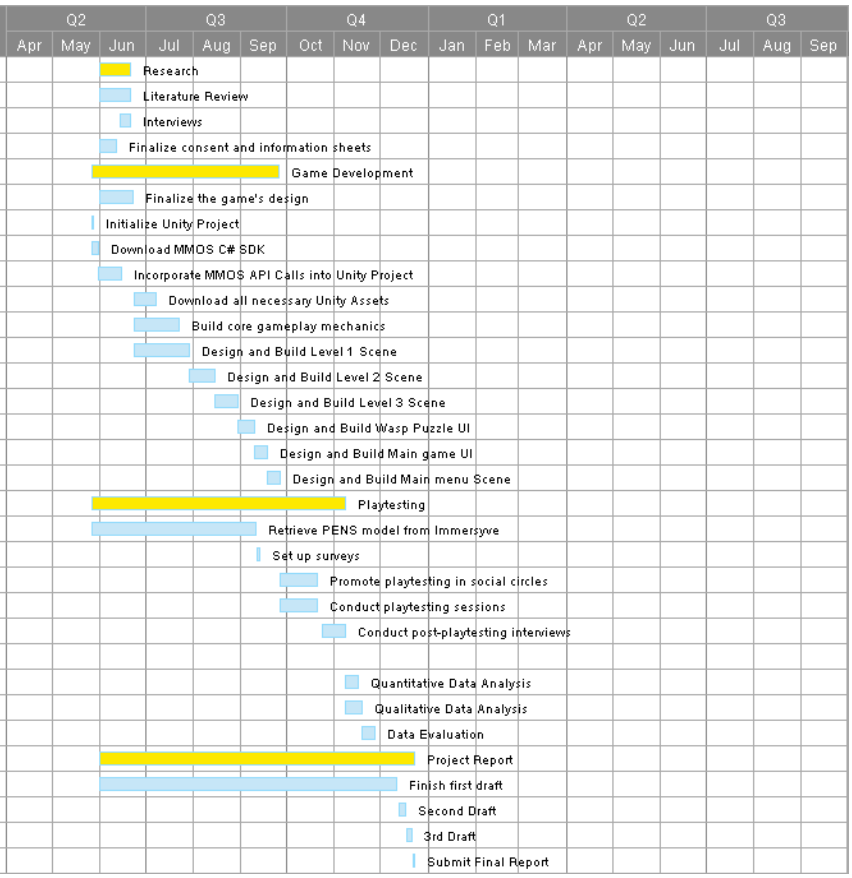
Project meetings with the supervisor will be conducted on a bi-weekly basis.

Ethics and Legal Issues

No vulnerable individuals will be explicitly approached during this project. All participants will sign a consent form upon entering the project. All identifiable information will be stored in Google Forms, an end-to-end encrypted service. No other parties will be privy to the information recorded during data collection save for myself. None of the procedures described violate the Research Ethics and Research Integrity Framework.

Work Plan

	Tasks	Start Date	End Date
1	Research	06/01/22	06/20/22
2	Literature Review	06/01/22	06/20/22
3	Interviews	06/14/22	06/20/22
4	Finalize consent and information sheets	06/01/22	06/11/22
5	Game Development	05/27/22	09/25/22
6	Finalize the game's design	06/01/22	06/22/22
7	Initialize Unity Project	05/27/22	05/27/22
8	Download MMOS C# SDK	05/27/22	05/30/22
9	Incorporate MMOS API Calls into Unity Project	05/31/22	06/14/22
10	Download all necessary Unity Assets	06/23/22	07/06/22
11	Build core gameplay mechanics	06/23/22	07/21/22
12	Design and Build Level 1 Scene	06/23/22	07/28/22
13	Design and Build Level 2 Scene	07/29/22	08/14/22
14	Design and Build Level 3 Scene	08/15/22	08/29/22
15	Design and Build Wasp Puzzle UI	08/30/22	09/09/22
16	Design and Build Main game UI	09/10/22	09/17/22
17	Design and Build Main menu Scene	09/18/22	09/25/22
18	Playtesting	05/27/22	11/07/22
19	Retrieve PENS model from Immersyve	05/27/22	09/10/22
20	Set up surveys	09/11/22	09/12/22
21	Promote playtesting in social circles	09/26/22	10/19/22
22	Conduct playtesting sessions	09/26/22	10/19/22
23	Conduct post-playtesting interviews	10/24/22	11/07/22
24	Data Analysis		
25	Quantitative Data Analysis	11/08/22	11/15/22
26	Qualitative Data Analysis	11/08/22	11/18/22
27	Data Evaluation	11/19/22	11/26/22
28	Project Report	06/01/22	12/22/22
29	Finish first draft	06/01/22	12/10/22
30	Second Draft	12/13/22	12/16/22
31	3rd Draft	12/18/22	12/20/22
32	Submit Final Report	12/22/22	12/22/22



Risk Register

Risk	**Response (Mitigation)**	**Contingency Plan**	**Likelihood (/5)**	**Impact (/5)**	**Threat Level (L * I)**
Unable to acquire PENS questionnaire from Immersyve	Initiate dialog with Immersyve near the beginning of the project to provide enough time to work out any issues	Independently create a mock questionnaire following the Self-Determination Theory similarly to PENS	3	3	9
Loss of game data (ie. hard drive crash, misplaced laptop, etc.)	Create backups using an external hard drive and online version control programs like Git	Recover lost data through backups and rebuild unrecoverable work	3	5	15
Choosing incompatible or broken Unity Assets	Read user reviews before acquiring each asset. Choose assets updated at least within a year to make sure they are compatible with the newest Unity version.	Troubleshoot using Unity online forums. If a solution isn't found within a day of the issue's discovery, uninstall the asset and find a replacement.	4	3	12
No participants want to provide an interview (no qualitative data)	In the bottoms of the questionnaires, provide a space for participants to optionally write out and expand upon any answers given; an opportunity for qualitative data without an interview.	If no qualitative data can be collected, rely solely on the quantitative data and touch upon this in the final report.	4	3	12

Loss of personal motivation/ momentum	Have regular meetings with the project supervisor to stay on track and engaged.	Upon realization, schedule an emergency meeting with the project supervisor to discuss future action.	3	4	12

Works Cited

Denisova, A., Nordin, A.I. and Cairns, P., 2016, October. The convergence of player experience questionnaires. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play* (pp. 33-37).

IJsselsteijn, W.A., De Kort, Y.A. and Poels, K., 2013. The Game Experience Questionnaire.

Immersyve, 2007. *The Player Experience of Need Satisfaction (PENS) An applied model and methodology for understanding key components of the player experience*. [online] Immersyve, Inc. Available at: <https://immersyve.com/download/pens/?wpdmdl=8267> [Accessed 21 May 2022].

Johnson, D., Gardner, M.J. and Perry, R., 2018. Validation of two game experience scales: the player experience of need satisfaction (PENS) and game experience questionnaire (GEQ). *International Journal of Human-Computer Studies*, *118*, pp.38-46.

Razer. 2022. *Still The Best 15 inch Gaming Laptop | Razer Blade 15*. [online] Available at: <https://www.razer.com/gb-en/gaming-laptops/razer-blade?utm_source=google&utm_medium=search-brand&utm_campaign=220118;_RS_SYS_BTM_UK_EGR-Blade-15_TR&gclid=Cj0KCQjwm6KUBhC3ARIsACIwxBiAcE-udeAMIVv0gQaLQyA-e_8UNON_3W37MFqQtXqZTUqoLuNoOowaAq4EEALw_wcB> [Accessed 21 May 2022].

RealMantis (2019). *0323 European paper wasp*. [Online Image] *DeviantArt*. Available at: https://www.deviantart.com/realmantis/art/0323-European-paper-wasp-814261964 [Accessed 22 May 2022].

Serret, H., Deguines, N., Jang, Y., Lois, G. and Julliard, R., 2019. Data quality and participant engagement in citizen science: comparing two approaches for monitoring pollinators in France and South Korea. *Citizen Science: Theory and Practice*, *4*(1), p.22.

Silvertown, J., 2009. A new dawn for citizen science. *Trends in ecology & evolution*, *24*(9), pp.467-471.

Szantner, A. and Revaz, B., 2014. *MMOS*. [online] MMOS.ch. Available at: <http://mmos.ch/> [Accessed 21 May 2022].

Tinatia, R., Luczak-Roescha, M., Simperla, E. and Halla, W., 2016. An Investigation of Player Motivations in Eyewire, a Gamified Citizen Science Project.

Vannini, L., Carapelli, A., Frati, F. and Beani, L., 2008. Non-sibling parasites (Strepsiptera) develop together in the same paper wasp. *Parasitology*, *135*(6), pp.705-713.

Waldispühl, J., Szantner, A., Knight, R., Caisse, S. and Pitchford, R., 2020. Leveling up citizen science. *Nature Biotechnology*, *38*(10), pp.1124-1126.

Research Ethics Review Form

A.1 If you answer YES to any of the questions in this block, you must apply to an appropriate external ethics committee for approval and log this approval as an External Application through Research Ethics Online - https://ethics.city.ac.uk/		*Delete as appropriate*
1.1	Does your research require approval from the National Research Ethics Service (NRES)?	**NO**
1.2	Will you recruit participants who fall under the auspices of the Mental Capacity Act?	**NO**
1.3	Will you recruit any participants who are currently under the auspices of the Criminal Justice System, for example, but not limited to, people on remand, prisoners and those on probation?	**NO**
A.2 If you answer YES to any of the questions in this block, then unless you are applying to an external ethics committee, you must apply for approval from the Senate Research Ethics Committee (SREC) through Research Ethics Online - https://ethics.city.ac.uk/		*Delete as appropriate*
2.1	Does your research involve participants who are unable to give informed consent?	**NO**
2.2	Is there a risk that your research might lead to disclosures from participants concerning their involvement in illegal activities?	**NO**
2.3	Is there a risk that obscene and or illegal material may need to be accessed for your research study (including online content and other material)?	**NO**
2.4	Does your project involve participants disclosing information about special category or sensitive subjects?	**NO**
2.5	Does your research involve you travelling to another country outside of the UK, where the Foreign & Commonwealth Office has issued a travel warning that affects the area in which you will study?	**NO**
2.6	Does your research involve invasive or intrusive procedures?	**NO**
2.7	Does your research involve animals?	**NO**
2.8	Does your research involve the administration of drugs, placebos or other substances to study participants?	**NO**
A.3 If you answer YES to any of the questions in this block, then unless you are applying to an external ethics committee or the SREC, you must apply for approval from the Computer Science		*Delete as appropriate*

Research Ethics Committee (CSREC) through Research Ethics Online - https://ethics.city.ac.uk/ **Depending on the level of risk associated with your application, it may be referred to the Senate Research Ethics Committee.**		
3.1	Does your research involve participants who are under the age of 18?	**NO**
3.2	Does your research involve adults who are vulnerable because of their social, psychological or medical circumstances (vulnerable adults)?	**NO**
3.3	Are participants recruited because they are staff or students of City, University of London?	**NO**
3.4	Does your research involve intentional deception of participants?	**NO**
3.5	Does your research involve participants taking part without their informed consent?	**NO**
3.5	Is the risk posed to participants greater than that in normal working life?	**NO**
3.7	Is the risk posed to you, the researcher(s), greater than that in normal working life?	**NO**
A.4 If you answer YES to the following question and your answers to all other questions in sections A1, A2 and A3 are NO, then your project is deemed to be of MINIMAL RISK. **If this is the case, then you can apply for approval through your supervisor under PROPORTIONATE REVIEW. You do so by completing PART B of this form.** **If you have answered NO to all questions on this form, then your project does not require ethical approval. You should submit and retain this form as evidence of this.**		*Delete as appropriate*
4	Does your project involve human participants or their identifiable personal data?	**YES**

PART B: Ethics Proportionate Review Form

B.1 The following questions must be answered fully. **All grey instructions must be removed.**		*Delete as appropriate*
1.1.	Will you ensure that participants taking part in your project are fully informed about the purpose of the research?	**YES**
1.2	Will you ensure that participants taking part in your project are fully informed about the procedures affecting them or affecting any information collected about them, including information about how the data will be used, to whom it will be disclosed, and how long it will be kept?	**YES**
1.3	When people agree to participate in your project, will it be made clear to them that they may withdraw (i.e. not participate) at any time without any penalty?	**YES**
1.4	Will consent be obtained from the participants in your project? Consent from participants will be necessary if you plan to involve them in your project or if you plan to use identifiable personal data from existing records. "Identifiable personal data" means data relating to a living person who might be identifiable if the record includes their name, username, student id, DNA, fingerprint, address, etc.	**YES**

1.5	Have you made arrangements to ensure that material and/or private information obtained from or about the participating individuals will remain confidential?	**YES**

B.2 If the answer to the following question (B2) is YES, you must provide details		*Delete as appropriate*
2	Will the research be conducted in the participant's home or other non-University location?	**NO**

B.3 Attachments **ALL of the following documents MUST be provided to supervisors if applicable.** **All must be considered prior to final approval by supervisors.** **A written record of final approval must be provided and retained.**	***YES***	***NO***	***Not Applicable***
Details on how safety will be assured in any non-University location, including risk assessment if required (see B2)			X
Details of arrangements to ensure that material and/or private information obtained from or about the participating individuals will remain confidential (see B1.5)			X
Full protocol for any workshops or interviews**			X
Participant information sheet(s)**			X
Consent form(s)**			X
Questionnaire(s)**			X
Topic guide(s) for interviews and focus groups**			X
Permission from external organisations or Head of Department**			X

Appendix B: Original Code

See Additional Files upload *Appendix B Dissertation Original Code.zip*

Access Instructions:

- ➢ Download the zip file
- ➢ Extract contents
- ➢ Open *Dissertation Code Appendix Doc.pdf*

Appendix C: Unity Project GitHub Repository

GitHub Repository link: https://github.com/pjsmith97/Fly_CitizenScience

Appendix D: Open-ended Responses from Survey with Coded Highlights

This is a very interesting game. I love the idea behind it, getting the help of the general public to sort through thousands (possibly millions) of data points. I would like to list here some things I liked and disliked about the game.

I specifically enjoyed these aspects of Project Fly Catcher:

1. The first thing I noticed and liked about the game was the music, and it was still one of my favorite things in the entire game by the end. It's very cool, not too calm and not too chaotic. It's fun and somehow doesn't get tiring or repetitive over time.

2. I loved the scientific aspect of the game, and I was especially intrigued to learn how to differentiate between male and female hoverflies.

3. I quite enjoyed the aesthetics of the Peaks level. The clouds looked beautiful and the peaks gave the impression of being at a great height, which was probably the intention. Also, in this level, I really liked the position of the fly swarm that required us to jump off a Chain Wall and take a picture in mid-air!

Here are a few things I didn't quite enjoy about the game and I feel could use some improvement:

1. The controls, while intuitive, do not work very smoothly. It is quite difficult to jump on umbrellas at the right angle if there is no space behind them, and also difficult to jump off chain walls at the right angle. In the valley level, when I jumped to a wall with a green rope, I did not automatically climb over it and I fell down. In the same level, after I went down a Chain Rail, I just fell off the platform immediately after getting off the rail, as the other end of the rail was very close to the left side of the platform. I have marked this Chain Rail in image #1.

2. A couple of times, when I wasn't sure about the gender of a hoverfly and I chose "likely male" or "likely female", my submission was deemed wrong; because apparently, I should have chosen the more definite answer "male" or "female". I don't understand why that should happen. I thought the point of the game is for people to give their input, not to "win" the game by guessing the correct choice. If there is a blurry image of a male hoverfly and the player guesses that it's likely a male, that should not be counted as a "wrong" submission. Image #2 shows a hoverfly that I guessed was likely female; however, my submission was counted as wrong (the correct answer being female, and not likely female). The attached picture is really as clear as I could get the image to be. Instances like that were quite off-putting and made me frustrated.

3. The tutorial could use some work. I had trouble with both the Chain Wall and the umbrella during the tutorial. The tutorial text mentioned the Chain Rail right after the Chain wall; so at first, I thought that I'm supposed to jump directly to the Chain Rail from the Chain Wall. As for

the umbrella, I could only reach the next platform if I ran to the umbrella and jumped on it. If I tried to bounce on the umbrella a few times to find the right angle, I would not have enough acceleration to reach the next platform. Both of these instances had me stymied for a couple of minutes; which is something that should not happen in a tutorial, in my humble opinion. Therefore, the tutorial text could be somewhat more extensive to include these points.

4. Another thing that could be improved in the tutorial was the name of the controller keys. The controls mentioned in the tutorial are for Xbox controllers, and it would be nice if they were clarified for PS controllers as well. For example, the jump button (A) would be X in a PS controller.

Lastly, I would like to talk about one of my answers in Section 3. I specified that the game felt like a fun activity rather than a task I needed to do. This is true for the time being, as I only played each level once. However, if the levels are always going to be the same, I can imagine that soon it will start getting mind-numbing and will in fact feel like a task. To avoid this issue, I suggest considering random level generation (if it's not in place already).

Overall, I would have preferred much more to just have the part where you try to clear the image and categorize the hoverfly. Looking for fly clusters to take pictures of would be fine if:

1. we didn't have to jump around an overly complicated platform course;
2. we could shoot the photo and immediately start categorizing after each photo, instead of having to snap the total first;

The game itself is still very buggy. The player character kept sliding a bit after I stopped as if the floor was slippery. It made it very difficult to control with precision, especially when landing on the edges of a platform.

During play, the pause button will not pause the timer. Its only purpose is to pop up a prompt to take you to the main screen.

During my play in the Valley map, I glitched while trying to slide along a chain. The animation would loop the same few frames and I could not move in any direction, or even open the pause menu, so I had to force quit the game and start again. I made a video of it occurring, which you'll find attached. (if it doesn't work, you can access it via this link https://drive.google.com/file/d/129HY77chyglhy239ZGEGFaS0r6M1irHd/view?usp=share_link)

No checkpoints meant that I would have to restart de course from the beginning, which was very tiring and frustrating.

I have to say that first-person is not my favourite perspective. I get motion sickness easily and having my character sliding after every move, made the experience more excruciating. It felt like I was trying to control a drunken robot.

What I liked about the game is actually the categorization part. The part that probably matters most in this project. Unfortunately, to get there you need to parkour your way across a contrived set of platforms and complete what seems like the sketched-out prototype of Pokémon Snap. It would have been much more satisfying to have a somewhat open meadow with some vegetation to explore by simply walking around.

Regarding the last two questions, I feel like I need to clarify my answer:
- entomology is very interesting to me, but I have zero experience. I sometimes read bout specific insects when they catch my attention. That's it.
- this is the first time I have heard of Citizen Science. So it's not that I don't find it interesting. I still need to investigate more about it.

Thank you for the opportunity and I hope my answers prove useful. All the best.

The first impact you have with the game is that it's really simple and feels a little empty, also it kinda feels like it had a wrong approach if the main goal of the game is to make the player feel immersed in looking for bees and taking photos of them, then instead of placing the platforms high up in the sky near mountains and with an infinite fall through clouds underneath I think would be much more appropriate and effective to do the same but on ground level, between grass fields and trees. From this point of view, i appreciated the flowery mountains here and there.

In regards to sound design, the background music gave the right feeling and seemed really appropriate with the game's goal.
Sound effects were missing, there aren't for any interaction with the game world beside the bees (which actually was a great indicator in both direction and distance), the first one I would add would be for taking the photos.

From a "mechanical" point of view there were some things I would improve:
- d-pad (controller's arrow keys) doesn't work;
- there isn't a settings page to change keybinds/music volume;
- there aren't checkpoints, falling from a platform results in respawning at the beginning, I would at least make you respawn on the ledge you jumped from;
- when moving the camera tilts in that direction, I would remove this feature as I think it makes the game a little more complicated, it feels weird when shooting photos as the camera instantly flicks back and also I think it could heighten the feeling of simulation sickness some people experience from first person motion (lastly, the bot has legs and feet, so I don't think it's not appropriate);
- sliders are simple to use, the image is distorted "in a direction" and you can easily see the correct point as sliding over that point "flips" the distortion, in my opinion, it's too easy and it feels just like an additional step to do with no gameplay, I would change how this process work, maybe even a puzzle could work;
- the Rb/Lb slider function differently from the other 2 as it's "circular" which at times is annoying, especially when the correct point is close to the "reset";
- instead of auto-vaulting over ledges you are going towards, it seems that those ledges "attract" you if you are looking at them to the point where you can walk on the border of the platform and if you look towards its center you're not going to fall easily. Also looking 90 degrees from a ledge while making contact on its side lets you cling to it;
- wall riding isn't smooth, the game tends to force the camera towards the wall which conflicts with the fact that you get launched (by pressing A) in the direction you are looking;
- pausing doesn't stop the game;
- clinging to the bottom part of a wall with chains lets you wall ride but doesn't launch you, pressing A at that point makes you fall;
- chain rails are somewhat bugged, if you try to take them from the wrong side the interaction is kinda weird, basically, the first time you fall onto them makes you bounce with the same angle of the approach potentially letting you ride all the way up or even "softlocking" the game if the angle of the first interaction happens to be straight down (the best point to test this is on the chain in the valley that's on a platform with an umbrella and close to a flowery mountain);

Also, i think that this game has some aspects that could bring frustration on someone not used to playing videogames and since those seem to be the main target for this game I'll try to highlight those aspects aswell.
New players tend to have a lot of trouble in both remembering which button to press or where that button is and aren't really comfortable in moving the character and its vision at the same time, so they usually have a slow approach to things such as jumping from a ledge to another, and this game punishes that kind of approach.
Ledges are spaced out kinda far away, some jumps asks you to be really precise and with max speed, for a new player that's actually something really difficult to do, and, combined with the absence of checkpoints, this could build up frustration kinda quickly.
Umbrellas ask you to be, again, both precise and approaching at max speed, I would revise the position of close to every platform and umbrella making them closer together both in height and length.
Wall rides and chain rails, even if they ask fast pace reaction, could work as they are right now, but the interactions aren't much intuitive. As previously said jumping on a wall with chains tends to initially lock the camera towards the wall, it would be much easier for the player if the camera would instead look already at the next platform.

- The LERP movement feels refined in simulating Realism and Drag, that said, the tutorial pointing that the ledges where there are ropes are climbale so you can aim for that to recover as opposed to falling from the edge - that is false because I was able to climb up the edge simply by holding forward against a ledge and I was able to climb up regardless of whether there's a rope in front or nearby or not, not sure if that's intended.

- The gamification of photo editing through various shaders in a game engine does make a fun experience for those who don't want to use photo-enhancing software such as Photoshop, meaning they can save disk space and work without installing an additional program - That is provided if the users can upload their own image onto the game and use it as part of the identification process.

- Acceleration and Deceleration on the Wall/Chain would be ideal, as currently, it seems like the player travels at the same speed all the way through, without taking into account of player's prior momentum.

- The photo-editing part is rather primitive, lacking in depth and overall challenge. adding blurriness as a control for the D-Pad Left/Right should simulate the effect of focus from a camera. Other than that, try exploring other photography issues which are commonly dealt with, and implement them for spare buttons the player doesn't use during the identification part. This could be in form of a hard mode difficult option or implemented as is.

- Overall, this game deserves an open-world exploration as opposed to platformer style as exploring bugs and insects feels way more intuitive centralized around a bug-researching town, locating and identifying its local biodiversity in the nearby forests, plains and caves. The current control fits very well in a setting where the player navigates around cliffs and hills, and the game runs well other than a few minor bugs listed at the bottom of this feedback.

- Following on the above issue, the game currently feels boring as it's just a run-and-jump puzzle, aiming to take photos of all the insects in the area via sound hints. The increment in timer means there's a challenge for those who wish to complete the game in the shortest amount of time, and for those who don't, there aren't many incentives. There are multiple ways the game can evolve - it can go into an open-world style exploration with tasks offered by a centralized location. Or it can continue with the current platformer approach, with the main improvement leaning toward Metroidvania, where the platformer is only a part of the game, involving the player exploring locations only done with power-ups in mind, unlocked by discovering a specific set of flies or insects.

Bugs:
- In all instances where you use Chain Link, you can see the character model when looking back despite being in first-person mode.
- There's a massive FPS lag when entering the flower circles, with flies/insects or not, going as low as 2-3 FPS - It only happens when the player starts rendering inside the circle. If the

player's in the circle, and they are not facing the actual flower patch, there is no FPs impact, it's purely when the machine starts rendering the high-quality models inside the circle.
-

So this was actually a very interesting experience! I felt there was some deeper meaning to the game overall, as one aspect of the game very much felt like a chill treasure hunt style game with fun character physics, but also very much had the learning genre covered. And when I finally finished, it very much felt like I was being tested.

To cover some of the general things I wanted to cover, I'm not sure what the final goals of this experience were: am I to think that there will be some further work done with this, or was I just inadvertently part of a psychological study? Thinking about the game as something that will be improved upon and not in a final state, I would like to go over some of the takeaways I had.

Visually speaking, the game I think has some quite beautiful scenery; Lots of crazy peaks and hills, a valley to explore, and some beautiful sky boxes. If I could offer a suggestion, take some more time to add detail to the spires and landscape? To me, it looks very much like a mathematical equation on a graphing calculator. Nothing wrong with that, but from some of the questions I answered, I feel adding some more of those details would enhance the overall beauty and appeal to future players. Similarly, some finer detail trees would also be a welcome sight.

I liked the clever level design, and the openness of it to explore. Reminds me somewhat of a Metroidvania experience, but otherwise the freedom to roam and explore the area was very relaxing. It was open and had challenges scattered throughout.

The audio wasn't too prevalent, as I think I lot of the focus was on a relaxing track and the sound of the flies without extra noise interfering (think footsteps, jump grunts, rustling across grass, chain jingles, etc.). Nonetheless, I do think that some careful sound design here could add to the immersion. Very light footsteps, some ambient animal noises (birds, tree rustling) and another musical track to add variety would be welcoming. I know after a while, my ears tire from listening to the same track over and over, especially anything with drums or percussive instruments. I think it is fine here, and had no problem enjoying the music. But being somebody that thinks variety is the spice of life, some more audio tracks, the better!

The UI was simple, and for the parts where unlocking the image was necessary, I found it easy to pick up and begin manipulating. In fact, all of the controls were pretty tight, and I liked the momentum-based movement of the game. The wall running and chain gliding were all neat additions, and the locking on when in proximity helps to keep the player on track and avoid too much frustration if its missed. But, from my experience, it was hard to miss. And if that's the goal, mission accomplished! All in all, well done, maybe a few graphical improvements to the menus to pretty them up, but otherwise, well designed and simple and easy layout.

The tutorial I think also had the perfect amount of help, and flipping through the help cards was no problem. It introduced the player to the goals as well as how to interact with the environment, and let the player put everything else together. Nice and straight forward.

The mechanics are simple and elegant. Wall runs and chain glides as well as high jumps and that floaty feeling added to the overall empowerment that the PC is given, and encourages you to explore. You really get the sense of vastness and control as you are running across the wall, bouncing up to high platforms, or dropping down on to a chain. The flies are fun to find, too, and the idea that we might be helping research, I like the concept!

As for bugs:
- When wall running or chain gliding, there seems to be some amount of stuttering or camera jumping that takes place while doing these two acts. Sometimes it threw me off when I had to jump off of a wall and there was that strange glitch jump that occurred. I didn't miss a platform or anything, but there were moments my trajectory was off because of it.

Final thoughts, I really like this, and definitely enjoyed the openness of the world and the chill vibe of exploring. Kudos!

I find your game incredibly interesting in the format of how it contributes to the study and what other parts of the given study there are and how they tangle together.
I took part in few case studies in my time at university that combined real life with virtual one and I always found myself curious how much value such simple task as playing a game brings to the general picture.
I never was interested in studying insects, especially since they are kind of a phobia to me, but I will definitely look up the Spipoll study out of curiosity, especially given how important the pollinators are in the nature.

As per the game idea, I think it's a somehow random and surprising connection between parkour platformer and photographing, but it works well in my opinion - highlights what struggles through environment photographers have to go in order to grab a great shot at insects!

The game in itself seems like solid and steady software - no bugs (hehe), issues or crashes to report. Of course, if we'd like to consider the game a market-ready end-product, I believe there's a lot of work ahead, with almost every aspect to be barebones so far.

Textures and graphics are very basic, especially the environment. Only a few separate objects within the world and very low variety to levels and surroundings - If left at the current state, it will bring boredom and game quits due to repetitiveness.

Audio at this moment is just a single looped track - for now I do believe it to be just enough to cover such 30 mins window of playtime, but if in the future you will be aiming to achieve more than this, more tracks and a variety of sound effects will definitely come in handy

Controls and navigation is pretty self-explanatory with no much depth to go into. A basic layout of button that I believe would be a go-to option for most of the devs due to its standardization - every player is used to the same, good old, tried and tested layout that's working well for most of the 1st person genres.

UI and main menu could use some continuous touch up, maybe some theme in the backgrounds to keep it somehow connected. An expansion of menu by an Options window is something that will definitely be necessary, no matter the game's scale and contents - way too many machines and preferences around the world to keep everyone forced with the same settings.

Having tried every level provided in the game, including the tutorial, here are some of the most important thoughts:

-While I tried the game twice (closing and opening it), and there is an option to choose music, for some reason my game had no sounds or music. This continued happening so I thought it was something worth mentioning. I verified that my sounds were in the correct output, and still nothing.

-When moving around the map, there are moments when you're able to double jump, like when you have a close up platform, yet at other times this action doesn't work. I guess this just ads a bit of strategy into the game.

-I don't know if this is a bug or if it was planned but you can jump up the mountains until you eventually "die". It feels awkward that you're allowed to do this but you can't move up the connecting ropes.

-Having said that, if you try going up a rope, it will make the robot look like it glitched until you eventually fall into your doom and disintegrate into the map. When I say it looks glitched, I mean that you are actually able to see part of the robot and a constant back-forth movement which makes it look bugged out instead of normal.

-I understand that the point of the levels is to gather the flies around the map in order to unscramble the photos linked to each. However, the color of the flies on map is sometimes very difficult to see since it blends some of the platforms around the levels. Perhaps making them stand out a bit more with another color like aqua, magenta or bright red could help players locate them faster.

-The map/level design presented was cool and engaging. Platforms aren't really my thing and I felt I had no problems with the ones in this game.

-The graphics are also good. I honestly didn't think much of it at first but as I continued playing, I was able to see the amount of careful thought and planning put into how everything looks.

-Something I did noticed was that when you're classifying the flies there were moments when I was unsure and used the "likely" option. The first time I used it, I said the fly I was classifying was "likely a female" and the game said I was wrong, that the answer was "female". Later on, I used the likely option on a male specimen and that time it accepted it as correct, since it was a male.

-While I'm clearly not part of the community this game is aimed at, I can see how individuals with a love for bugs could enjoy the game. It made me feel like I was butterfly catching for a moment. I know the game consists of catching flies but it would be a great addition if in the future you could capture other insects.

-Finally, the game does what is intended to do, you catch flies and classify them and by doing those, you help science. I admit, it's a nice take on "helping" and volunteering. I imagine it having achievements for fastest run, most correctly identified flies, fastest identifier, etc.

Felt like the whole game was in slow motion and really floaty. It made everything feel like I wasn't exactly in control of my actions, especially when going to jump on the umbrellas and walls.
The headbob effect made me feel REALLY nauseous.
Game starts to stutter when going on top of the flowers.
When going on chains in one direction the robot/character gets stuck on the chain
The bee swarms are hard to see in the game, especially when they're located on the trees. and the bee swarm sound is really loud especially when going nearby.
There was really no way of getting even half clear picture of the hoverflies at the end.
The environment doesn't really make any sense. I think platforms and walls etc should be leaves / vines etc.

Citizen Science is something I have been exposed to and contributed towards on a very small scale. Performing surveys and classifications on insects and various other fields not involving Entomology.

Never, though, have I experienced a fusion of Citizen Science within a gaming realm, so the concept of this is quite interesting. With that said, I do think that it places the devs at a disadvantage, at least with this build in its current state.

If a successful fusion of Citizen Science and gaming is to be obtained, then the primary focus should first be to win over the gamer. The gamer needs to be immersed, and feel powerful during navigation of levels, and must be invested in the rewards. There must be a feeling of progression at the end of a level so that no level feels like a waste of their time.

Currently, movement and navigation is something I would like to see addressed if future builds are on the table. Movement is slow to start, building up momentum, which makes sense realistically. But, considering that Project Fly Catcher is primarily about the classification of flies, it's not important to have that realism applied to movement and navigation within the gaming levels.

The level of movement which the player experiences while jumping is woefully slow. The momentum built up halts to a standstill, which can make it frustrating reaching other platforms. If the player can wall run without the fear of gravity pulling them down, then physics need not apply when jumping from umbrellas. Allow the player much more responsive movement during jumps. This would also serve to make accurate jumps from walls to chains, for instance, providing a more fluid and fun experience and encourage the player to experiment with the risk vs. reward factor.

Other interesting mechanics could be the ability to create portals to reach other platforms, or even some kind of grappling device which can attach to the chains on walls. These could be upgrades which can become available towards the end of each level.

Allow the player to have full speed from the get go and focus on more appealing game mechanics which will allow the player to get closer to YOUR goal. Finding and classifying flies.

Additionally, having some interesting facts about flies strewn around levels could be beneficial and make navigation more rewarding and captivating to the player. Why should we care about flies? What is the difference between fly x and fly y? Interesting stories about flies or the effects they have on the ecosystem.

The picture mechanic is okay, although the need to clear up the image seems pointless and currently serves no purpose other than giving the player something to do. When choosing if a fly is Male or Female (likely or not) it seems that most flies within this build were all male regardless of what the tutorial explained and what the picture of flies shows. The gap between eyes on flies

served no purpose in the classification, as most images which had flies with wide gaps between their eyes were still incorrect when labelled as female or likely female. Within the tutorial and the two main levels, all flies were only correct when selecting male, likely male or unsure.

Moving forward, if Project Fly Catcher is something the devs are passionate about, I would suggest research on level designs and movement around first person parkour movement. Mirrors Edge, Ghost Runner, Titan Fall, Apex Legends and possibly Dying Light are good places to start. Adding additional problem-solving to the mix, one could also look up Portal and Portal 2 as I think the primary mechanic within this game could go nicely with the concept of Project Fly Catcher.

I wish the best of luck to the devs and hope to see another iteration of Project Fly Catcher in the future.

Bugs (no pun intended):

Bug_1_Movement_Chain_Slide_Camera_Clipping_Through_Body

What happens?:

When jumping on a chain, if the player bumps into the wooden stump then lands on the chain, it causes this clipping issue. The camera seems to move out of angle. Player body can be seen. It also creates a loss of speed, leading to the player needing to fall off the chain, resulting in a respawn.

Bug_2_Peaks_Valleys_Mountain_Asset_On_Platform

What happens?:
On this platform, seemingly a piece of the mountain asset can be found here. It's not connected to anything.

Project Fly Catcher was a surprising little game. Initial impressions during the tutorial were a bit rough, but as it progressed and I started to find the interesting navigation options and the graphical details (especially seeing your robot's legs and shadow) it started to grow on me.

My biggest concern was during the tutorial while trying to understand how the wall chain run works. I fell to my death a few times and only during the main level itself I was finally capable of understanding how it really works, from turning around to jumping out with enough care and timing for the landing - perhaps this could be better explained in the hint panel. Apart from that, controls were very intuitive but I sorely lacked some sort of jumping sound effect - probably a minor issue, but it's an indicator that I personally find to connect with the brain in terms of intuitiveness and feedback.

It did feel weird that my robot was capable of climbing those sharp white mountains while looking up, as if it was an exploit that shouldn't be there - it felt like a glitch that made it possible to avoid some of the platforms and just come up with weird and unlikely shortcuts.

In terms of bugs, there wasn't anything in particular but this one where I was trying to use a chain upwards and the game doesn't seem to - obviously - allow this. However, we can still jump onto the chain and the robot glitches, as if going from first-person into a "hollow" third-person, as you can see in the attached screen. I also had a couple of severe but very brief frame drops - 1-2 seconds each time.

I have really enjoyed the categorization of the flies, this was a really fun little puzzle aspect that I'm hoping becomes more complex and extensive. In a purely gaming sense, I'm hoping that the system becomes more in-depth, with additional focus options, but since there's a true real-world purpose for this project, I'm not complaining about the current state - it's fun, intuitive, and it's a nice break from the platform sections.

I was very pleased with my time in Project Fly Catcher. Hopefully some of the graphics will become even better - they are functional but not really stunning - and a series of sound effects will make our navigation even more intuitive and pleasant. Best of luck!

The game was definitely fun, I just unfortunately experienced a lot of lag, so I almost completed each level but the lagginess would not allow me to have full control.

The camera can be a bit disorienting. I feel as though there was a bit too much head bob and camera sway.-Spencer Miller

Hi, I enjoyed the game but felt like stopping playing because it gave me a headache. I generally don't play First Person games and especially when there is a lot of motion in the camera, so I had to stop playing. But I thought it was a great concept, lots of interesting ideas, and a good melding of research and Mirror's Edge style platforming. It could be a brilliant avenue to pursue when it comes to AAA non-violent gaming.

Really like the concept and what has been built thus far.

My feedback would be towards the movement, the momentum builds up a little too slow as the start, so the character doesn't feel fully responsive.

The discrepancy in the distance between a regular ground jump and a jump off of a wall was pretty large, which gave me initial hesitation, briefly asking myself "Can I actually reach that platform?" before jumping off the wall and towards it, my advice would be to make the distance of a jump from a wall to be closer to the regular ground jump's.

On the tutorial side add in something on the first page "you will now walk through / play the tutorial.
2) put the exit menu at the end and make it PS and Xbox friendly with controllers for both (in writing) i.e press A on xbox or X for PS for jump
3) When you die in the game, have check points
4) Turn off the sound when you have taken a picture of the flies and/or add in a 'ding' noise
5) Umbrellas should be closer to the side/barriers to make the jump
6) Add power ups i.e 5 or 10 secs you can float in the sky
7) Remove the holes in the floor?
8) Add in a pause button, same way the "exit" button appears when you press the start/options button
9) Could add different difficulty levels i.e. intermediate, beginner, hard, expert and on the easier levels add arrows to help find the flies and then as the levels advance / players pick hard or expert mode 1 or 0 arrows should be available in the game

I didn't see what the first person parkour mechanics had with photographing flies. Which are not pollinators. Also I was unable to complete the tutorial let alone the levels. The wall run on the tutorial was too difficult and the tutorial prompts were not helpful as you had to skip through them all before playing so forgot what was said when required. Also there was no way of hiding the prompts so that I can play without them in the way.

Appendix E: Game Build executable file

Download link:
https://drive.google.com/file/d/18awKlFgvVDKBSagNakKZwIF-nL16jQBb/view?usp=share_link

---

Devices

-You will need a gamepad (joystick controller) to play the game. Most controllers are supported.

OS Specs:

Operating system version: Windows 7 (SP1+), Windows 10 and Windows 11

CPU: x86, x64 architecture with SSE2 instruction set support.

Graphics API: DX10, DX11, DX12 capable.

Starting the Game

-Download the zip file

-Extract contents

-Navigate to ProjectFlyCatcherWindows folder

-Open the ProjectFlyCatcher.exe file.

Appendix F: CONFIDENTIAL Fly Catcher Survey Results and Analysis

See Confidential Submission upload *CONFIDENTIAL Project Fly Catcher Survey Results and Analysis.xlsx*

NOTE: Sheet1, Cells A1 to CR19 are the fully formatted raw data responses.

Appendix G: CONFIDENTIAL Fly Catcher Survey Google Form pdf

See Confidential Submission upload *FlyCatcherQuestionnaireResponses.pdf*