

The EcoKids and the Paper Pests

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Abstract

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This report details and explains the creation process of the Interactive Media and Game Development, Computer Science, and Professional Writing Major Qualifying Project titled *The EcoKids and the Paper Pests*, shortened in this report to *Paper Pests*. *Paper Pests* is an educational game about invasive species for a middle school audience, designed to teach concepts from a New Zealand invasive species scenario. This report goes into details on the game's background research, all areas of development, playtesting results and iterations, public appearances, potential avenues of future funding and development, and team role postmortems.

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- WPI Game Development Club Showfest
- MassDiGI Game Challenge
- Playcrafting Boston Winter EXPO
- Made in MA
- PAX East
- Boston University Day of the Devs
- Science & Arts Trustees and IMGD Closer Look

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1. Introduction

During the WPI school year of 2014-2015, the team of Pat “Rowan” Roughan, Kiara Vincent, Evan Polekoff, and Sam Kodzis conceptualized, designed, developed, playtested, and publicly showed a game titled *The EcoKids and the Paper Pests*, shortened in this report to *Paper Pests*. The project is an educational game on invasive species for a middle school audience. The educational content is based on a real world event that occurred in New Zealand, which was researched and digitally recreated by the development team.

We approached the design of *Paper Pests* with the goal of teaching middle school-aged players about the dangers of invasive species directly through play. Even if the player never read a word about invasive species, we wanted them to be able to understand some of the hazards based on the mechanics of the game. Additionally, given our young target audience, we tailored our design to be simple and fast-paced, so that all players could immediately pick up the game and understand what was occurring.

When designing the technical component of *Paper Pests*, we placed a strong emphasis on reusable, modular components and object-oriented design that would allow for experimentation and iteration at all points of the project. We focused on strong separation of responsibility, particularly where gameplay and visual aspects of code were concerned. Additionally, we prioritized the ability for our code to robustly handle dynamic situations such as reactive AI and procedural content generation.

Artistically, we wanted to capture the attention of our younger audience with a colorful and inviting art style. The arts-and-crafts look, designed to appear as though a player in our age range had created the assets with creative materials, was chosen to look appealing to players.

Overall, our team’s goal for this project, in addition to its core development, was to get it into the hands of as many players as possible. Through conventions, expos, and contests, we showed attendees the game at various stages of development, using their feedback to improve our final product. We also created and updated a website and Twitter feed to give players access to the game and development updates.

Chapter Two explains the background research and educational basis of *Paper Pests*. Chapter Three goes into detail on the game’s development in all areas, including design, art, and code. Chapter Four is on the playtesting data and resulting game iterations. Chapter Five details the game’s interactions with a public audience through contests, events, and other avenues. Chapter Six analyzes the game’s potential for grant funding and how such funding could be obtained for an educational

game. Chapter Seven goes over each team role's postmortems, outlining what went right and wrong for each, and explaining potential different approaches for the future.

2. Instructional Design

Paper Pests is a game that takes its educational and design basis from real-world research on invasive species. Before we could begin creating the game, we had to do research into case studies involving the introduction of an invasive species to an environment. This provided us not only with artistic content and themes to work with, but also ecological models that created the game's environmental simulation aspect. Using this body of research, we created learning goals before finalizing any gameplay.

2.1 Background Research

Early in the development of *Paper Pests* we researched several species in an attempt to find a memorable scenario that would educate players by subverting their expectations. We chose our environmental setting based on three major goals: we wanted a scenario with an invasive species that did not appear explicitly harmful, where other species were impacted indirectly by competition for food, and where the methods to combat the invasive species could be abstracted in a kid-friendly game.

One of the more strongly considered early species was the stoat, a weasel-like species that was introduced in New Zealand to control rabbits in the 1880s, seen in Figure 1 ("Stoats"). They are a carnivorous species that kills in surplus and has taken a large toll on many New Zealand birds, including yellowheads, kakapo, takahe, and saddlebacks (King, 2006). Traps and poisons are used to keep stoat populations down, and tracking tunnels are used to monitor stoats ("Stoats"). Stoats were a popular early choice, due to their harmless appearance and easily abstracted capture methods, but they were ultimately not chosen since the stoat harms the environment through predation, and we desired a species that would affect the environment in more indirect ways.



Figure 1: The Stoat, originally researched due to their cute appearance and environmental effects.

Another early invasive species candidate was the rabbit, which was released in Australia in 1859, seen in Figure 2 ("Rabbit Problems in Australia"). Rabbits eat and reproduce at a rapid rate, and have caused problems such as soil erosion in Australia. There have been many attempted strategies to eliminate rabbits including hunting, poisoning, destruction of rabbit harbours, and the spread of rabbit diseases ("Rabbit Control", 2012). The variety of methods used to combat rabbits, and the rabbits' widespread indirect environmental damage proved promising early on, and many initial prototypes were completed with rabbits as the invasive species.



Figure 2: Rabbits can grow in population very fast due to quick breeding periods and large birth rates.

Despite these advantages in the rabbit scenario, we ultimately decided it would not be appropriate as the central scenario for our game. In particular, although we wanted a species that wouldn't be normally associated with widespread damage, we had concerns about the use of a common household pet as our target species. Additionally, since the spread of diseases was crucial to containing the rabbit problem, we would have to include that in our game for accuracy, but it proved challenging to abstract the spread of disease in a way that was both entertaining and kid-friendly.

2.2 The New Zealand Case Study

Ultimately, we chose to use the common brushtail possum as our invasive species since it best met our requirements. The possum was introduced to New Zealand from Australia in 1837 in an attempt to create a fur trade industry. The possum quickly adapted to the New Zealand environment, causing challenges for a variety of species due to its highly omnivorous nature and its function as a vector for bovine tuberculosis ("Possums"; Clout, 2007). While the 1980's saw the highest population at 60 million, control measures reduced it to 30 million in 2009, visualized in Figure 3 (New Zealand Pest Agency, 2009).

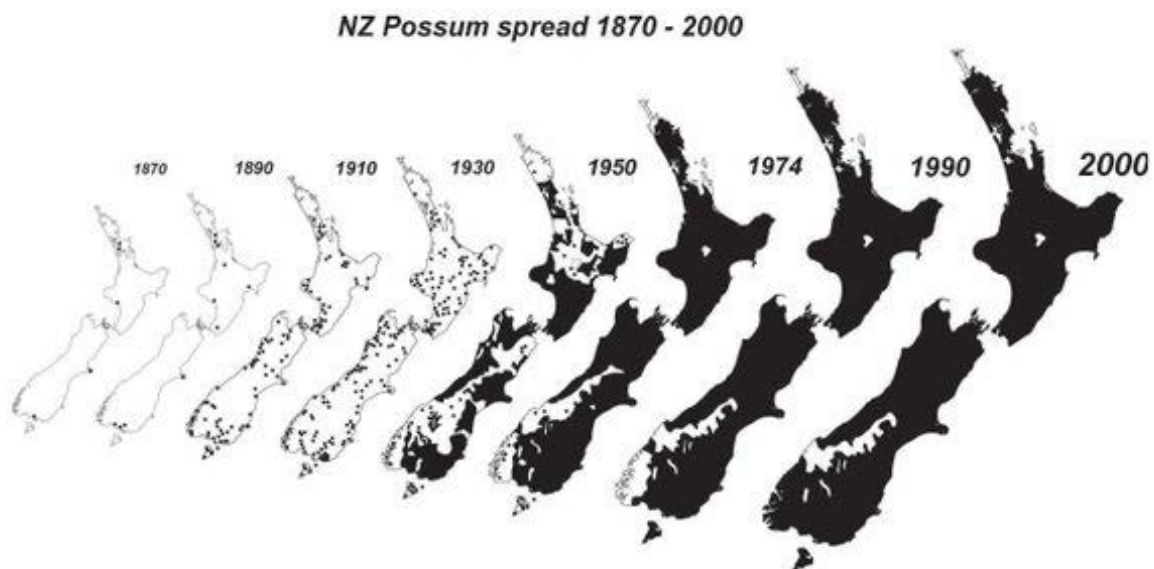


Figure 3: The spread of possums by decade.

The possum's effect on the other animals in the environment is indirect but noticeable. The possum diet is highly adaptable, including several plants, bird eggs, and small snails. In addition to eating from a wide variety of plants, the possum often defoliates the plants from which it eats (Cowan, 2012; Cowan, 2010; "Powelliphanta snail"). This causes problems for other animals that eat from the same plants. The most noticeably affected species, and the herbivore choice for *Paper Pests*, is the kokako, a bird found only on the islands of New Zealand. The possum's destruction of plant food sources, in addition to eating kokako eggs during their long brooding period, placed the kokako on the endangered species list, with 750 pairs left (New Zealand Herald, 2009). The destruction of herbivore food sources, and therefore herbivore populations, then affected the swamp harrier hawk, a natural

New Zealand predator and the carnivore species in *Paper Pests*. These three animals, seen in Figure 4, are the three environmental animals in the game.



Figure 4: The three animals chosen for *Paper Pests*, from left to right: the common brushtail possum, the kokako, and the swamp harrier hawk.

In 1990, New Zealand created the National Possum Control Agency, later renamed to National Pest Control Agency in 2011 to include all other vertebrate pest populations (About NPCA). This organization spreads awareness and creates policy and tools for dealing with invasive pests. Common actions to combat the possum include poisoning, hunting, trapping, and tracking (Clout, 2007).

Given that the possum causes destruction both directly and indirectly, that it doesn't look explicitly harmful, and that possum mitigation techniques are able to be abstracted with relative ease, it made a natural fit for *Paper Pests*. The three animals, plus a plant species, create the New Zealand environment simulation. Players, acting as the EcoKids educated by the National Pest Control Agency, can revegetate defoliated plant life, place possum traps, and capture the possums manually, all actions that occur in real pest control scenarios.

2.3 Ecological Models

We wanted *Paper Pests* to have some grounding in reality, so early in the project we researched different kinds of models that we could use as the basis of our simulation. In particular, given the key role a predator plays in our simulated ecosystem, we looked into the predation model which models the relationship between predators and prey based on the size of the existing populations, the growth rate of the prey, the feeding rate of the predator, the death rate of the predators, and the conversion factor of food to new predators ("Mathematical Models of Population Growth"). Notably, this model, and other mathematical models like it, didn't include space as a factor, which is a key part of *Paper Pests*. Additionally, these models were too abstract and visually unappealing for a game targeted at middle school-aged kids, so we instead looked to Agent-Based

Modeling. This is a form of modeling where individual “agents” represent creatures, and act based on a set of rules and priorities as individual creatures would. By simulating several agents over time, these models can show larger trends over time. The major advantage of these models is that change is visible, not just at the macroscopic scale, but at the individual level, where the player would be interacting with the game (Klugl, 2012).

Another benefit is how widely the complexity of agent-based models can scale. A simple model might have agents flee predators and search for food, using factors such as energy, food intake, terrain slopes, and movement speed to determine survival (Ellers, 2010). On the other end of the spectrum is a complex deer simulation in Florida, which also factored in aging, reproduction, and growth of deer, along with detailed hydrology and vegetation factors (Abbott, 1995). Given that *Paper Pests* was designed to appeal to a young audience new to the concepts of ecology, we aimed to keep the simulation as simple as possible. In addition, we wanted to emphasize more transparent mechanics that the player could clearly observe. As a result, we created a small-scale simulation using only three highly visible mechanics observed from other simulations: hunger, energy, and breeding. All of the animals in *Paper Pests* attempt to eat food and flee predators, before they starve to death. Whenever an animal in *Paper Pests* eats, it gains energy that increases its movement range. Finally, after a certain number of turns, surviving members of each species will produce offspring.

In early tests with this type of modeling, we quickly realized its limits in the context of *Paper Pests*. When we attempted to use eating and breeding rates grounded in real researched numbers, our simulation quickly became very volatile, with natural species regularly going extinct even without the presence of the invasive species. We reasoned that this was a result of the small physical scale of the simulation and the heavy abstraction of elements such as terrain, and other sources of food for the predator. To balance this simulation properly would have taken a large amount of time, and would have introduced a large degree of complexity to the game. Given our inexperienced target audience, we instead opted to focus more on balancing the numbers of our simulation to meet the needs of the game, rather than the other way around.

2.4 Learning Goals

With *Paper Pests* we wanted to teach players basic concepts about invasive species at a high level. We wanted to teach these main ideas to our player:

1. How invasive species can negatively impact an environment
2. Invasive species don't always cause harm in a direct manner
3. Invasive species don't always look like a species that would cause harm

Additionally, by basing the game in the real world, we wanted some players to learn information about an actual invasive species scenario, and some of the types of actions used to combat the species. We wanted this information to be reinforced by the player's actions, as well as by included text in tutorials and journals.

3. Design and Implementation

With *Paper Pests*, we wanted to create an entertaining educational game that would teach middle school-aged players the dangers of invasive species. We wanted the game to immediately welcome and engage players, and teach them about invasive species unobtrusively through play. Additionally, we wanted to create a core structure that was flexible and maintained a high replay value, so that players could keep playing the game and continue to learn and reinforce educational concepts. In this chapter, we will discuss the gameplay vision in more detail, as well as the technical, and artistic choices that were made in order to best achieve our original goals.

3.1 Game Play

The main goal of *Paper Pests* was to educate middle school-aged students about the basic dangers of invasive species in an interactive and engaging manner. We wanted our players to come away with knowledge about how dangerous an invasive species can be, how it may interact with its environment, and to give a few simplified examples of how people combat invasive species.

Paper Pests was designed as a fast-paced turn-based strategy game, where the player would win by carefully planning and using a small set of actions to combat the damage of invasive species. The player begins the game by selecting one of seven tiles on the strategy view shown in Figure 5 and then proceeds to the tactical board, where the bulk of the game occurs. On this board, the player controls two avatars that can move, place traps, capture possums, and revive trees. After eight turns on this board, the player returns to the strategy board, where the board is updated based on the player's actions. The player can then select another tile and continue playing until they stop the possums or the environment is destroyed beyond repair.

3.1.1 Game Flow

Each round of *Paper Pests* begins on the strategy board, which is a collection of seven tiles that represent the health of the environment of New Zealand. On each tile, the relative scale of the different species, as well as the size and condition of the tile's tree, represents the amount of flora and fauna in that region of New Zealand. The strategy board allows the player to plan a long-term strategy in the game without having to deal with a large and potentially overwhelming board. At a glance, the player is able to see which areas of New Zealand have more invasive species, and which ones are in the most critical condition.

From the strategy view, the player selects one of these tiles to proceed to the localized, tactical view of the area, where the player will spend the majority of their time. The tactical board is a randomly-generated hexagon board representing a localized area in New Zealand where flora and fauna are represented by individual pieces which behave autonomously, and the player controls two player avatars, shown in Figure 6.



Figure 5: The strategy view. The arrows indicate increases or decreases in unit counts.

In the tactical view, there are eight turns, each composed of two halves. In the first half of the turn, the player moves their avatars and performs actions to trap possums and restore the environment. In the second half of the turn, the animals in the environment act, attempting to find food and evade predators.



Figure 6: A shot of the tactical board featuring some of the animals and one of the player avatars.

After the end of eight turns, the player is returned to the strategy board, and the surviving flora and fauna of the tactical board are recorded and displayed on the strategy board. At this time, all the other tiles run internal simulations to determine the updated count of each species. The player continues picking tiles on the strategy board until they win or lose the game.

3.1.2 Animals

There are three animals in *Paper Pests*: the Kokako, a natural herbivore in New Zealand, the harrier hawk, a natural predator of the kokako in New Zealand, and the Brushtail Possum, an invasive herbivore that consumes the same food as the kokako. During each turn, individual units of all species have two goals: find food and evade any nearby predators. If any animal fails to evade its predator, or it fails to find food for too many turns, then it dies and is removed from the board. With the exception of the possum, animals in *Paper Pests* are indifferent of the player, as we didn't want to encourage players to micromanage the environment.

Whenever an animal eats food, it removes the piece eaten from the board, and in the case of the herbivores, they replace the original piece with something else, as shown in Figure 7. If a kokako eats a tree, it replaces it with a seedling, which won't be eaten by other kokako, but will grow into a tree between turns on the overarching strategy board. If the possum eats a tree or seedling, the possum replaces it with a dead tree, which cannot regrow into a living tree without being revived by the player.

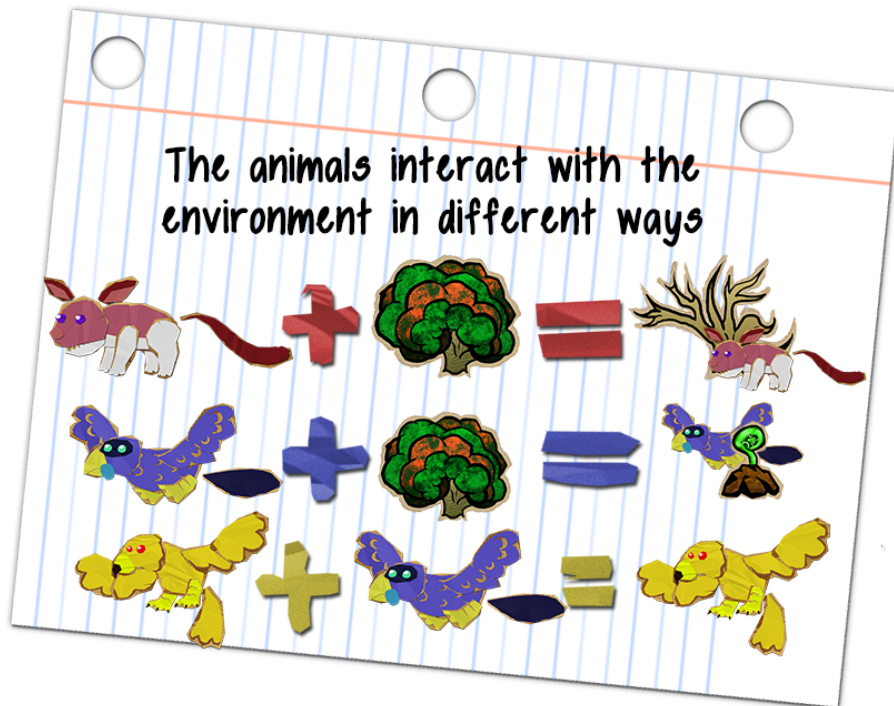


Figure 7: An image from the convention tutorial demonstrating the relationship between pieces on the board.

Additionally, whenever an animal eats food, it regains energy with the amount varying per species. An animal's energy is used to determine its move range; for each unit of energy an animal has, it is able to move an additional unit distance beyond the minimum distance of one. This mechanic is largely used to maintain a balance between the harrier hawk and the kokako, although the player may additionally prevent a possum from eating by steering it away from trees or blocking its path with their avatars until it runs out of energy.

3.1.3 Player Actions

In order to keep the game simple and fast-paced for a younger audience, each of the player's two avatars only has three potential actions. The player may move the avatar, place a trap, or revive a tree. Each avatar has only two action points per turn, and the player must plan their movement and actions carefully to be as efficient as possible in the eight turns they have on the board.

When the player first selects an avatar, the default action is movement. The player can move up to two spaces away, utilizing one action point per unit moved. Although the player's movement is unobstructed by other species, players cannot move through mountains. The only species affected by player movement is the possum; if the player moves onto a space occupied by a possum, that possum is automatically captured.

Each time the tactical board portion of *Paper Pests* begins, the player is given a supply of traps. During their turn, the player can place a trap on an adjacent space, as long as that space is occupied by a living tree and the player has a trap remaining. If there is already a trap on a chosen space, the player recovers the trap instead. Whenever a possum walks over a trapped space, both the possum and the trap are removed.

Finally, if the player is next to a dead tree, they can revive it by planting a seedling in its place. This seedling will grow into a full tree when the player returns to the strategy board, assuming it is not consumed by a possum in the remaining turns. Although the player may revive dead trees at any point in the game, they are encouraged to attempt isolating and capturing the possums first to ensure recovery.

In addition to the three main actions, the player may undo their most recent action as long as their turn has not yet ended. If the player feels they have no more to do on a board, they may end their turn, or fast-forward all of the remaining turns to return to the strategy board at any time.

3.1.4 End Conditions

It is possible for *Paper Pests* to end in one of three ways. The player loses if all of the kokako or harrier die. The player wins if they get rid of all of the possums, or the player survives five turns with a low possum count that varies depending on the difficulty level. This last win condition is important; in real life it is often impossible to eradicate an invasive species entirely, and minimizing the impact is often seen as victory, a fact which we wanted to capture in *Paper Pests*.

When one of the end conditions is reached, the player is ranked from one to three stars based on their performance, seen in Figure 8. This metric is based on the ratio of natural pieces to destructive pieces. Natural pieces include living trees, kokako, and harrier, while destructive pieces include dead

trees and possums. The more the ratio favors natural pieces, the better the star ranking the player receives. Although it is possible to win the game with most of the environment dead, the three star rankings are used as an extra incentive for players to minimize destruction as much as possible.



Figure 8: An end screen for the game indicating that the player successfully removed the possums, but let too much damage occur to the environment.

3.1.5 Levels

From the main menu of *Paper Pests*, the player is able to select from one of six levels. The first three levels are tutorials designed to teach the players the mechanics in a controlled environment, while the last three levels are different difficulties of the main game mode. Initially the player only has access to the first tutorial, but as they complete each tutorial, they unlock the next one, and finally they unlock the three difficulty levels.

The first tutorial level is designed to introduce the player to the native environment and non-hostile actions. In this tutorial the player is taught how to move their characters and how to revive a dead tree. Reviving trees is introduced before any hostile actions to reinforce the idea that the player is not just trying to capture all the possums, but to restore the environment as well. In addition to introducing basic mechanics, this level shows the player how the uninvaded environment should behave.

In the second tutorial, the player is introduced to the invasive possum and how it negatively affects the environment. During this tutorial the player is tasked with removing all the possums from a small board, and is taught how to capture possums and place traps. While the player is learning to manage the possums, they are given their first chance to see how possums eat and destroy trees firsthand.

Finally, in the third tutorial the player is introduced to the strategy board, where they are tasked with keeping the environment stable for three turns. The strategy board is introduced last because it composes the most abstract part of the game, and we wanted the players to have a clear frame-of-reference before encountering it. This tutorial also introduces players to the larger problem of possums spreading to nearby tiles, causing the invasive species problem to multiply.

After completing the tutorials, the player is given access to all three difficulty levels. Each difficulty level uses a randomized board, but on higher difficulties, boards are generated to be more difficult. Additionally, the starting number of possums on the strategy board increases as the difficulty goes up.

3.2 Programming

Two of the four core team members are IMGD/CS double majors, meaning that the project required a significant technical component beyond simply scripting actions in the Unity engine. Since the game is a turn-based strategy game on a grid, the project had a lot of possibilities for interesting technical challenges. The biggest focus on the technical side was to keep the core systems modular so we could swap out large features independently as our design changed. We also wanted to create a dynamic gameplay experience so that the game would be different every time it was played. This section provides more details on these technical goals and how we achieved them in our design.

3.2.1 Object Oriented Design

One crucial lesson that we learned from our years at WPI is how important it is to write clean, understandable code. This is important when working on solo projects in terms of being able to quickly iterate on the core game structures, but is significantly more important on team projects. Both of the programmers on *Paper Pests* were well versed in common design patterns, which was extremely useful in the development of the game. Entire features could be implemented and still be understood without any explanation of how the code worked simply because they adhered to these common patterns.

The main focus of the design on this project was iteration and expandability. We made heavy use of the State Pattern, Strategy Pattern, Observer Pattern and Singleton Pattern from the very start of the project. The benefit of using these patterns is that practically every feature was modular. A new system could be implemented to replace an old one with minimal changes to the calling functions. The perfect example of the success behind this decision is the shape of the tiles on the board. At the very beginning of the project, we wanted to optimize development time by starting on the core of the programming while the paper prototyping phase was still in effect. In order to avoid committing to any specifics in terms of gameplay, we wrote an interface called the IPieceStructure and one called ITileLayout at the core of the entire project. Since all of the classes in the entire project were dependent on these simple constructs, we are able to swap the tiles on the board from hexagons to squares at a moment's notice without breaking any of the dependent classes. By exposing functions in the interface and writing modular classes that implement them, the functionality can be used with confidence from any part of the code as long as the implementing classes make sure the interface's functions return the expected values.

In order to make the game development more object oriented, we decided to do almost all of our programming in native C# classes instead of in scripts attached to Unity GameObjects. While this meant we couldn't simply reference objects by making public member variables and setting them in the Unity Editor, it allowed us a lot more modularity in our class structure. For the first few terms, the game had one single game object that held the GameController script. That one script constructed our entire code base and all of the classes that handled GameObject instantiation. Later in the project, we added more GameObjects for user interface management in Unity 4.6's new UI system and managers for the audio using Fabric.

In order to make general game functionality easier to access in multiple parts of the project without having to pass every important structure as an argument in every function, we used the Singleton pattern to create "managers". The Singleton pattern ensured that only one instance of the object could exist, meaning each manager would maintain its values without fear of being overwritten and without excessive memory use from duplicate variables.

The structure of the game is handled in a state machine. The interactivity in the game changes based on what state the game is currently in. For example, in the PlayerTacticalTurnState, the player can interact with the environment and can use all of the game mechanics. When the state machine enters the AnimateTacticalTurnState, the player can no longer use the core mechanics and the camera follows the animals as they move. This State Pattern allowed us to better categorize the sections of the game and restrict functionality to a specific subset of actions that we want the player to be able to perform based on what state the game is in. The state machine itself was written generically, meaning it could be reused throughout all of the code wherever it was necessary. This

same state machine code was also used in the Tutorial to transition between its stages. For example, if the player was instructed to move to a specific tile, the state would show text indicating what the player is supposed to do and sometimes restrict the player's movement to a specific tile. Once the player moves to that tile, the state would change to the next stage, thus changing the text that is displayed and performing any other setup or cleanup.

3.2.2 Artificial Intelligence

In order to make the artificial intelligence of the animals more easily modifiable and modular, we decided to use behavior trees. Behavior trees allow an entity in the game to make decisions by moving down a tree of behaviors based on the current state of the world. The behaviors are modular, meaning they can be used in multiple trees for multiple pieces. Entire branches of the trees can be swapped out for new behavior if the game designer wants the game to play differently. The behavior trees in this project were implemented with selectors and sequencers, meaning the tree had a lot of flexibility in how the behaviors were traversed.

After working with the behavior of the possum and the kokako, who shared the same behaviors, we ended up simplifying their trees. Since the AI was so simple, we were able to combine a lot of behaviors until eventually there was only one behavior in their trees. Thinking about the decisions they make, they really only need to make one choice. They attempt to go to the nearest tile that has food on it unless an enemy is in the way. There are more calculations for when the animal is about to starve, making it run into danger so it can survive at least one more turn. This extra check was originally a separate behavior, but we noticed that it was all of the exact same calculations since the animal still moved to the closest available tile with food.

3.2.3 Procedural Content Generation

In order to create a higher level of replay value in *Paper Pests*, we chose to use procedurally generated boards. The board generation system was designed to create unique boards in each game, while still providing the designer a high degree of control in the way in which boards were generated. Additionally, the generation system was designed to be highly extensible, such that new constraints could be placed on board generation as we discovered a need for them.

Board generation starts at the `IBoardGenerator` object, which can have its `GenerateBoard` function called on an empty board to populate it. How the board is populated varies based on the type of board generator. For instance, the strategy board's starting populations are determined randomly

within a range dictated by the difficulty level of the game, whereas the tactical board generator uses more detailed constraints to generate more complex boards.

The central element of the tactical board generator is the scenario. Each time a new board is created, the board generator chooses from a variety of scenarios designed to provide a variety of unique gameplay styles. These scenarios are chosen based on a suggested difficulty, whether or not there are enough pieces to create a given scenario, and how recently a scenario has been used to generate a board.

A scenario object contains a set of weighted rules used to constrain the placement of pieces on the board. When attempting to place a piece of a given type, the scenario will evaluate each open space using all rules that apply to that piece type. Each rule has a CalculateDesirability function that examines a potential space on the game board and gives it a value from zero to one, based on how well that space satisfies the rule. All rules for a piece type are evaluated and combined, with rules having weights to give preference to certain constraints when conflicts arise. After evaluating all of the spaces for a given piece, the scenario places the piece at the location with the highest rule value, with ties broken randomly.

For instance, a piece may be constrained by a “maintain exact distance” rule, which will try to keep a piece’s distance to another piece as close to a specific value as possible, and a “maintain minimum density” rule, which ensures that the piece will be placed near a given quantity or greater of a certain piece type. The rule system is also used to ensure that generated boards are traversable by the player, as a “leave a valid path” rule ensures that mountain pieces are not placed in spaces that divide the board.

Additionally, the designer can specify set-pieces in a scenario where more control is desired. A set-piece is a collection of specific pieces and coordinates, which are placed exactly as written. A set-piece can be specified in absolute coordinates, or in local coordinates. When placed in local coordinates, the set-piece can additionally be rotated and offset randomly when placed.

In order to allow for scenarios to be created and iterated faster, a custom file reader and file format were created. These files, an example of which is shown in Figure 9 allow the designer to specify scenario features, and are loaded at runtime. If a scenario file is added to the scenario folder, the file is automatically added to the list of potential scenarios the next time the game is loaded.

```

Frequency: 5
difficulty: 3

Requirements
{
    Invasive Herbivore: 2, 20
}

Unit : Invasive Herbivore
{
    Rule : Maintain Exact Distance {
        Types: Avatar
        Ideal Distance: 3
        Max Distance: 6
        Strength: Medium
    }

    Rule : Maintain Minimum Distance {
        Types: Invasive Herbivore
        Minimum Distance: 3
        Strength: weak
    }
}

Unit : Carnivore - rulesets/generic_harrier_rules
Unit : Herbivore - rulesets/generic_kokako_rules

Unit : Avatar
{
    Rule : Maintain Exact Distance {
        Types: Invasive Herbivore
        Ideal Distance: 3
        Max Distance: 6
        Strength: Medium
    }

    Rule : Maintain Maximum Distance {
        Types: Avatar
        Maximum Distance: 1
        Strength: Strong
    }
}

```

Figure 9: A small scenario file used to specify board generation constraints.

To create a flexible and extensible file reader, C#'s reflection capabilities were utilized to automatically gain class information that could be incorporated into the scenario file format. As a result, if a new rule was added to the game, the file reader would automatically have access to the information required to create that rule, and could immediately read files implementing the new rule without any additional setup.

3.2.4 Animation System

Since most of the code was written in native C# classes that were constructed out of the main GameController script, we had to make an animation system that could be called from any class that could queue an animation to play. The state machine for the game had states that ran calculations to figure out where pieces would move and queue the actions as animations. Then there were states that would animate all of the queued actions to visually show the player what happened that turn.

Each type of action had its own animation class with its own functionality for handling the visual component based on the needs of the animation. For instance, the animation of the cage falling on the possum had three sections: the cage spawned, then it fell onto the possum, before collapsing and fading into the ground. The walking animation had to flip the sprite depending on whether it was walking left or right. Other animations were as simple as sending a Mecanim trigger to the GameObject.

Our animations system had to be flexible so it could handle multiple animation formats. All of the animals were animated using Spine while the players and environment were done in sprite sheets. To unify them all visually, we placed every piece inside of a parent object that held the visual with a Unity animation controller. This allowed each sprite to maintain its own relative size while also allowing the sprites to all be animated in Unity's Mecanim animation system in a uniform way. This is best exemplified in the global pop-up/pop-down animations when any piece is spawned or removed, regardless of whether it was made in Spine or is part of a sprite sheet.

The system itself uses a modular StoredAnimationStructure to handle adding and popping animations. In the finished game, we decided to implement it using a Queue, but that can be swapped out by changing a single line of code. When asked to "PlayAllAnimations", the AnimationManager class asks the StoredAnimationStructure for its next animation and to check the state. If it's set to "Waiting", then the AnimationManager calls that animation's "Initialize()" function. After setting its initial values, the animation sets its state to "Playing". When the AnimationManager gets the next animation from the StoredAnimationStructure and its state is playing, it calls the "Play()" function. In there, an animation sends its triggers, moves the GameObjects, or performs any other necessary action-specific movement. On a per-animation-type basis, some animations may want to allow other animations to start playing at the same time while others may want to block all other animations until it finishes. Some animations set the state to "Finished" immediately, while others watch the Mecanim state to see when they have ended. When the AnimationManager sees an animation that is in the Finished state, it removes it from the StoredAnimationStructure and moves on to the next animation.

The speed of the animations could also be tweaked dynamically. The animations could be sped up or slowed down on a per-animation basis or globally. This was useful in the Fast Forward functionality we added late in the project.

3.2.5 User Interface

Part of the way through the project, Unity released its version 4.6, which contained an entire reworking of the User Interface and GUI system. After winter break, we scrapped the old GUI and moved on to the new system, which was significantly more flexible and easy to use. Since we used native C# classes and interfaces we were able to upgrade to the new UI system with minimum effort.

We created separate canvases, which are Unity's containers for holding UI elements in the game world, for logical separations of UI elements. This way, we could toggle whole sections of the UI on and off when needed. For instance, all of the player action buttons were only toggled on when the game state was at the low-level tactical board, whereas the stats button and pause button were visible at all times. Tapping a button brought up a separate canvas.

Each canvas had its own script attached, which is the one way we used Unity scripting instead of building native C# classes. This allowed us to link UI objects in the game world with the code that set their information. For instance, we would publicly expose text box and button elements so we could set the readable text and animate them based on what was happening in the code of the game.

The main menu was set up a little differently. The table and all of the menus on it were placed in world space. The camera was set to orthographic and was moved around in world space to look at the different menus. The menu system was set up in a state machine, allowing any menu to transition to another with a specific transition function. This function made the camera zoom out and back in with the SmoothDamp function, making a more visually interesting transition between menus. When the camera reached the target position at the end of its transition, a canvas would be toggled on depending on which menu was visible. The canvas had a back button to return to the previous menu and a collection of invisible buttons that were positioned over the buttons on the table. This allowed us to use the built in canvas functionality to make the programming simpler.

3.2.6 Platforms

From the beginning of the project, we knew this was going to be a mobile game, targeting tablets so we could make use of the larger screens to better display our art assets. The IMGD department gave us an iPad to test on, but we still didn't have the iOS developer's license that was needed to build to the device. The department said they would provide us with one, but in C term, we

found out we would no longer be given one. At this point, the team decided to use some of the budget that we won from the MassDiGI Game Challenge to buy the license ourselves.

Development on Android has been smooth throughout the entire project. The department also lent us a Nexus 7 tablet to develop on, which was well suited for testing and demoing at smaller conventions. Using Android, we were able to build directly onto the device from our own computers as opposed to building on iPad, which required a Mac and a license. We could even debug the game with breakpoints on the Android tablet using the Unity Remote app. For the sake of getting the game in front of as wide an audience as possible, we still had to make sure the game worked on iOS and Android at all times.

Despite being designed for touch screens, the game still works well on PC with mouse input. Through playtesting, we realized that the click-and-drag method of moving the camera wasn't as intuitive with a mouse as it was with a touch screen and many players didn't know they could zoom in with the camera. Targeting PC was important in order to reach more players conveniently with easily downloadable builds and the ability to play within a web browser.

3.3. Art Style, Concepting, and Assets

Picking a few words to describe the art style of *The EcoKids and the Paper Pests*, "Arts and Crafts" would summarize perfectly the style we developed for this game. Though we originally looked towards other games for inspiration, we soon left the realm of what had already been created and ventured off into the unknown, drawing ideas from the illustrations found in children's books. If the majority of the game looks like it was cut, colored and glued together by the eager but none too dexterous hands of an exuberant 5th grader, then the artists did their job well. As a team, we wanted to create a visual style that was inviting and eye-catching. To ensure this effect, the artists figured there was no better way than lavishly employing the use of bright colors and cute characters. Though we did not draw specific inspiration from artists, we looked at a number of childrens' illustrated books to gain a better understanding of their art style we were trying to develop. Some of the books used in the initial research include works by Eric Carle, Mo Williems, Ezra Keats and Laura Numeroff, among others. The assets of the game were based on reference images of people, animals, and terrain. The saturation of all assets was increased and all shapes were simplified. In addition to colors, various cloth and paper textures were applied to amplify the hand-crafted look of the game. The following sections detail the creative process, and shows where *Paper Pests* began and how quickly it took shape.

3.3.1 Terrain

The landscapes of New Zealand are sweeping, breathtaking, and extremely varied. There was no difficulty in finding artistic inspiration in the countryside. The challenge came in rendering the natural beauty of the country and fitting it within the more cartoon style of the game. During concept drafting for the environment, the style of *Paper Pests* had yet to be cemented, nor had the location for the game even been confirmed. The team had agreed on the hexagonal grid structure. We knew that the game was targeted towards a younger audience. In addition to lack of a definite location, the artists had strengths in different areas of 2D art. With little to go off of other than the game taking place in a natural environment, the art team developed preliminary and generic art assets. Figure 10 shows a more stylized, cartoon-like style. These were the only parameters the team had to work with. After some time spent creating concept art for the game, the images shown in Figure 10 were the first drafts of terrain, and terrain items.

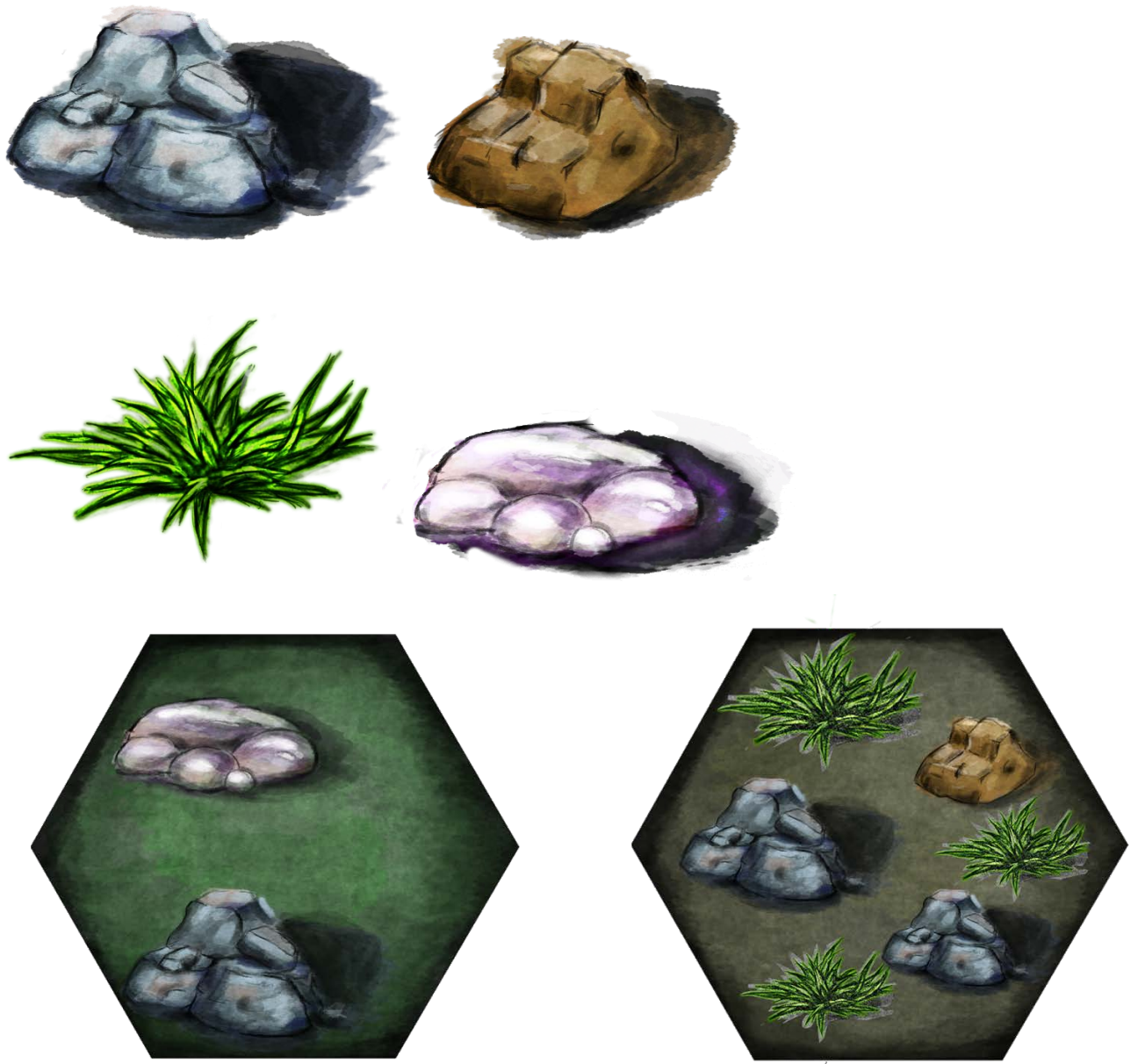


Figure 10: Watercolor-style conceptual terrain assets.

As illustrated, this iteration of tiles is viewed from a strictly top/down birds eye view. The items positioned on the tiles are drawn in perspective. In conjunction with lighting, the space is given minimal depth. The question soon arose how a player would move through this environment. In addition to this query, there was the problem of the two conflicting art styles. Already there was divergence, with one

set of early assets leaning towards a rough watercolor feel and the other a crisp, clean vector art style, seen in Figure 11.

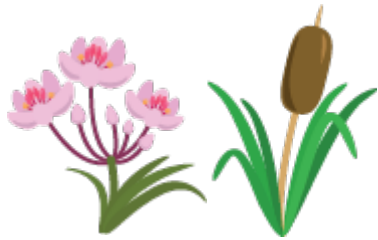


Figure 11: Vector-style conceptual terrain assets.

The next iteration of tiles focused on depth. Height was a factor the team experimented with. The subject was heavily discussed early during development, since the height would add a decisive challenge and interesting navigation obstacle. Naturally occurring terrain puzzles were a desire from the beginning, and height seemed to be a natural way to insert this dynamic. Figure 12 and Figure 13 show early examples of the board using height. The art style at this point was not yet solidified, nor had the geographic location been pinpointed. At this time, the team was aware of the increasing possibility of the game being stationed in New Zealand.

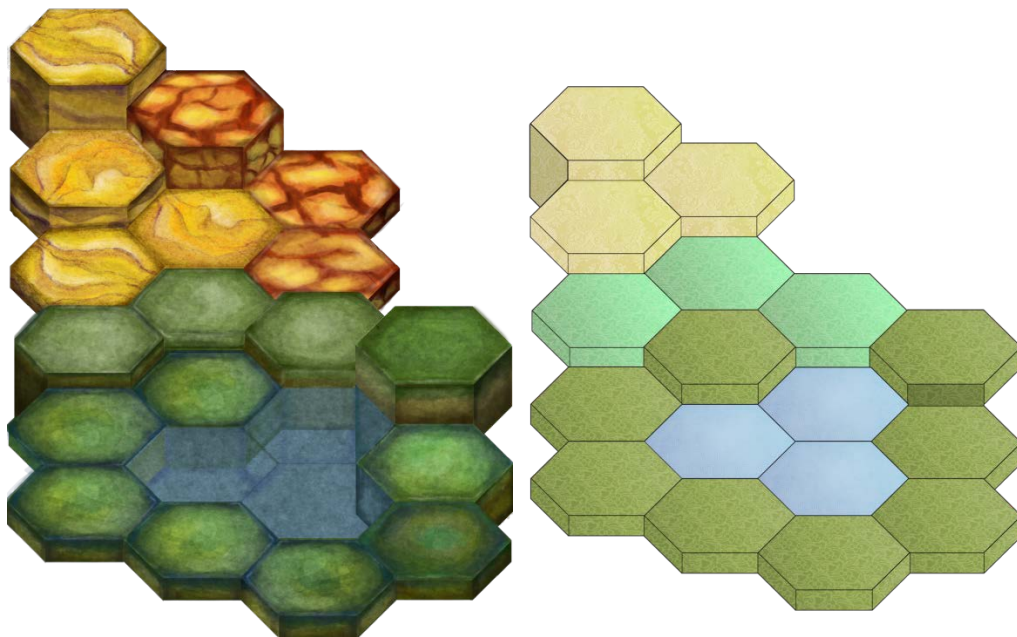


Figure 12: A watercolor landscape (left) and a patterned landscape (right).

In the terrain shown in Figure 12, the player would navigate through the game space in a three-dimensional space. A player could not move to a tile with a height differential greater than one. Water tiles existed at this stage as well, and would pose random obstructions throughout the map that players would have to navigate around. Both tile sets have a variety of “types” such as wetlands, grasslands, desert, and volcano. Because New Zealand had all these biome types, the artists thought it might be fun incorporating those somehow into the game. Scope however quickly pared the land type exclusively to lightly forested grassland. Eventually the idea of height was discarded, as it went against the new desires for gameplay. Water, both stagnant pools and terrain bisecting running rivers, was the next design choice to be removed.

Reaching somewhat of a block on visualization, the artists went with a different approach and switched from 2D rendering to 3D rendering, hoping that modeling the terrain in 3D space might allow for a better representation for the artists so they could create something more interesting than the previous designs.



Figure 13: A 3D test of the terrain.

The results of modeling the hex grids in 3D space can be seen in Figure 13. A number of old elements were re-added that had previously been rejected in the 2D design. At this stage of development, the setting for *Paper Pests* had been confirmed. In Figure 13, the precursor to the finished game’s camera angle is displayed, and elements such as trees, gorges, and mountains were tested. Of these terrain choices, mountains were the only obstacle that was kept. Though the various terrain obstacles allow for the possibility for very dynamic maps, due to time constraints they were not

put into the finished product. After much testing, a final, simple tile prefab was constructed and painted, seen in Figure 14.

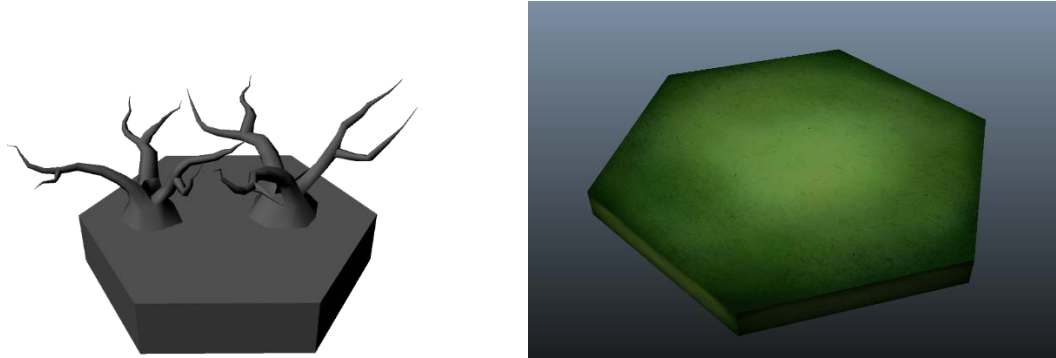


Figure 14: 3D tile tests.

3.3.2 Flora

With the setting confirmed, the animal species selected, and the tileset roughly sketched out and generated, it was finally time to return to the challenge of creating fauna. Due to our species choices of the possum, harrier hawk, and kokako, we were now constrained to plant species that fed these animals. The Kokako, an omnivore that eats seeds, fruit, bugs, and shrub fronds, was the driving force for fauna generation (BirdLife International). For choosing what plant species to use, we looked at plants that were consumed by both the Kokako and possum populations. Two trees fell into this category. They are the *metrosideros robusta* and the *dacrycarpus dacrydioides* (Powlesland). The *metrosideros robusta*, known more commonly as the northern rata, is distinctly known for its scarlet flowers that blossom when in season. Though the tree is not a food source particularly popular with kokako, this species of tree has been greatly harmed by the browsing patterns of the invasive possum. Possums eat the leaves, shoots, buds and flowers, greatly harming the tree. The second tree type was based off of a common New Zealand tree, once a heavily integrated part of the Maori way of life. The indigenous peoples of New Zealand used the tree *dacrycarpus dacrydioides*, or more commonly, kahikatea in Maori, for a variety of uses. Countless species of New Zealand birds eat the berries of this tree. The kahikatea was an extremely important part of the New Zealand ecosystem (Knight). As it stands now, the regrowth of the massive kahikatea forests is unlikely to happen. Though it is less widespread, we chose this tree because of its significance in the culture of New Zealand, in addition to the fact that it relies on birds to spread its seeds. The beginning stages of tree design followed by the final designs are shown in Figure 15. As is displayed in the images, over time, the artistic style of the game solidified into the kids' arts and crafts style present in the final game.



Figure 15: The reference photos (left) and final foliage art assets (right).

3.3.3 Character Design

The process of designing characters was originally designated to Rowan. At the suggestion of the art advisor, the character designs were changed from abstract people to two members of the *Paper Pest* team. At this stage of development, Kiara took over the task of character design while Rowan began focusing on the game's UI.

As the characters were now based on existing characters, this removed much of the design process out of the equation. To capture the uniqueness of the teammates, Kiara took images of herself and Rowan, and she tried to reduce the portraits to their strongest recognizable features. Color scheme and clothing were now based on existing models. Character One, based off of Rowan, did not go through many changes. His attire was based off of clothing he often wore in daily life. Character Two, based off of Kiara, was also based on her most favored attire: hoodies and comfortable pants. Character Two's color scheme had to be edited, because the original green clothing blended too well with the green of the terrain. Discovering that purple continued to stand out very strongly against the terrain, purple became the Player Character color.

Once concepts for the characters were developed, it was necessary to decide how to animate them. Photoshop seemed like the obvious choice. Photoshop allowed for strong artistic control, and the spritesheets of the characters were simple to implement. In the beginning, using frame animation was sufficient. As the game progressed, more complex animations were added, and generating sprite sheets from animations dozens of frames long proved to be extremely tedious and error prone. Although the results were strong and integrated well into the game, another approach would be used if the process could be done over again. Starting from the same base file for each character, then in that same Photoshop document animating all actions would eliminate the problem of files changing sizes and resolutions. This was the largest problem and often what lagged the production of animation assets.

We believe the final product works perfectly with the game and the art style of the protagonists' meshes cleanly with every other piece in the game. Figure 16 and Figure 17 show the progression of the game's protagonists. As illustrated in Figure 16 and Figure 17, the character progression for Character One included the most redesigns. Once the team agreed upon a style, the other redesign was quickly implemented.



Figure 16: The Kiara character art evolution.



Figure 17: The Rowan character art evolution.

3.3.4 Animal Design

The animals that appear in *The EcoKids and the Paper Pests* are taken directly from the New Zealand environment. In order to fit with the paper craft stylized look of the game, the animals were simplified into key elements, including shape and color, in order to fit into the game world and still read as their species. All animals were created from crumpled construction paper which provides the color of the animals placed over a cardboard texture. This creates borders around each of the animal's pieces. These pieces move, but they do not deform, when the animal is animated.

In order to reach this style, the animals went through a long series of concept designs. Analyzing and playing with styles and inspirations from a wide variety of artists and illustrations led to three vectorized animal outlines dubbed 'float style' by the artists due to the floating body parts (Fisher, Laberis). These vectorized animals looked very computerized and digital, which did not match previous terrain experimentations that had a watercolor style. Following the watercolor lead, the animals were redesigned with a paper texture, and their outlines were made jittery and non-uniform to give the look

of roughly cut and torn paper, seen in Figure 18. This look stuck, and the animals of *Paper Pests* are now cardboard and construction paper cutouts.

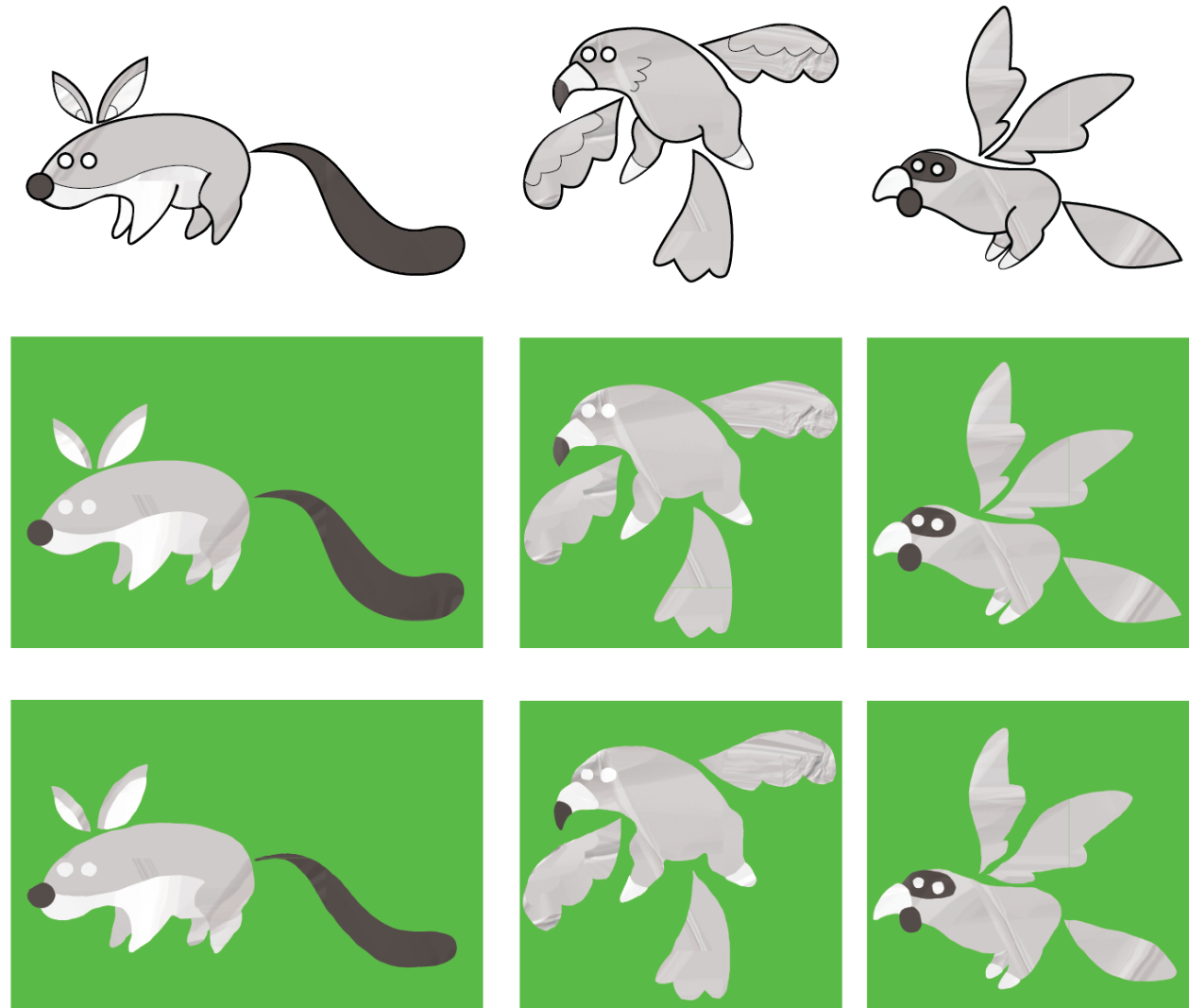


Figure 18: An early concept image which shows the transition from the clean vector experimentation to rougher papercraft.

The common brushtail possum is the main antagonist of the game. Elements of the design of the character were based on this role. The possum character has a mainly red color scheme which does not match the real-world possum but instead emphasizes its enemy role. Red is often used to signify danger, especially in video games. Having only the possum be red visually signals that it is the main threat of the game. The possum's bottom jaw is lined with sharp teeth which are only visible when the possum opens its mouth. Having this line of teeth on an otherwise cute animal visually shows

that while the possum is to many people, cute, it is still a threat to the safety of plants and other animals. A comparison between the real world animal and *Paper Pests* character can be seen in Figure 19.



Figure 19: The real-world possum (left) and the possum character (right).

The kokako is the gentle herbivore of the environment. Both the kokako character and the real-world kokako have a blue color scheme, though the kokako character is saturated to make it stand out more than the real-world kokako's dulled gray blues. The kokako's distinct mask and wattles are visible on both the real-world and character kokako, visually relating the two. The character also has a yellow beak and feet, rather than gray, in order to read as an avian creature from a distance and break up the dark color scheme. The kokako character's body and wings have feather shapes cut out of them, revealing the cardboard backing, to give texture to the large and otherwise flat pieces. It also has a dulled beak and clawless feet, representing its herbivore and non-threatening nature. A comparison between the real world animal and *Paper Pests* character can be seen in Figure 20.



Figure 20: The real-world kokako (left) and the kokako character (right).

The harrier hawk is a predator and kills the kokako, but still is an important part of the natural ecosystem. The harrier character and the real-world harrier shown in Figure 21 both are gold and brown, which is emphasized on the harrier character. The character's pieces are outlined with brown on the tips of its feathers, which matches the real-world harrier's feathers. Unlike the kokako character, the harrier character's foot pieces have jagged lines cut out of them and also show visible claws, making it visually more threatening than the herbivore kokako. It also has red eyes, a signifier of danger, to show that it is also a threat, but not as severe a threat as the completely red possum character. The character's beak is also sharp and darkened at the end. These are traits that are also seen on the real-world carnivorous harrier. A comparison between the real world animal and *Paper Pests* character can be seen in Figure 21.



Figure 21: The real-world harrier (left) and the harrier character (right).

The three animals are all animated in Spine by Esoteric Software. In Spine, 2D pieces are mapped to a skeleton and moved through joints in a similar way to 3D rigging and animation. With this method, the 2D pieces that make up the characters do not deform. This proved perfect for the arts and crafts style of the animals, since each piece would be a single unmoving unit of construction paper on cardboard. The animal behaviors were animated by watching and simplifying the behaviors of the real world animals. The largest example of this are the three animal movements. The possum walks in a quadruped walk cycle; the harrier takes off, flies, and lands; and the kokako bounces from tile to tile. These three movement behaviors mimic how the animal moves in reality.

3.3.5 User Interface Design

The user interface (UI) of the game follows the arts and crafts theme, using paper, tape, and other creative tools to create the game's world and the player's ability to interact with it. In general, all assets consist of either lined, grid, or construction paper; pencil, marker, or crayon words and images; sewing buttons; bottle caps; cardboard; sticky notes; and tape. These tools are combined in various ways to build the entire UI.

The creative theme of the UI is emphasized through the main menu of the game, seen in Figure 22. The four main menu screens, which are title screen, level select, journal, and credits, are all papers or journals placed on a singular wooden table image. Each area is covered in scraps of paper, scissors, tape, and other creative tools that could be used to make all the crafts seen in the game. The camera only focuses on a fourth of the screen at a time and pans between them when switched, revealing the scraps and tools across the table. Showing the menu in this manner not only adds flow between the screens that the player goes through before gameplay, but it also emphasizes the game world being an arts and crafts project.



Figure 22: The entire Main Menu background image, from top right to bottom left: title screen, level select, journal, and credits. The journal and interactive buttons are not shown.

The Title screen is the first screen the player sees in the game, shown in Figure 23. This screen serves as the gateway to all other aspects of the game. The game's logo is visible, and beneath the logo is a drawn two-frame animation of the characters and animals of the game. On the right-hand side of the screen are the three main buttons, Play, Journal, and Credits, as well as the Settings button in the lower right hand corner. Each button is visually matched with a sticker showing what the button says, giving the player reinforcement of the button's functionality.



Figure 23: The Title screen, which leads to all other aspects of the game.

The Settings screen, shown in Figure 24, can be accessed from both the main menu and the pause menu through the same bottle cap asset. There are two sliders for Music and Sound Effects volume, with one side being muted and the other being maximum volume. A crossed out music note and a possum with an ellipsis speech bubble are on one side of each slider, visually representing muted music and no sound, respectively. On the other side are a group of music notes with lines around them and a possum with a spiky exclamation point speech bubble, representing high volume of sound. There is also an Erase Data option, which pulls up a dialog asking the player if they're certain they want to erase all the game's save data. A sad Kokako doodle is on the main image, and the "Yes" button shows an angry possum while the "No" shows a happy harrier. These images visually show that deleting data will reset all the progress the player has made, returning the ecosystem to being infested by possums without the EcoKids.

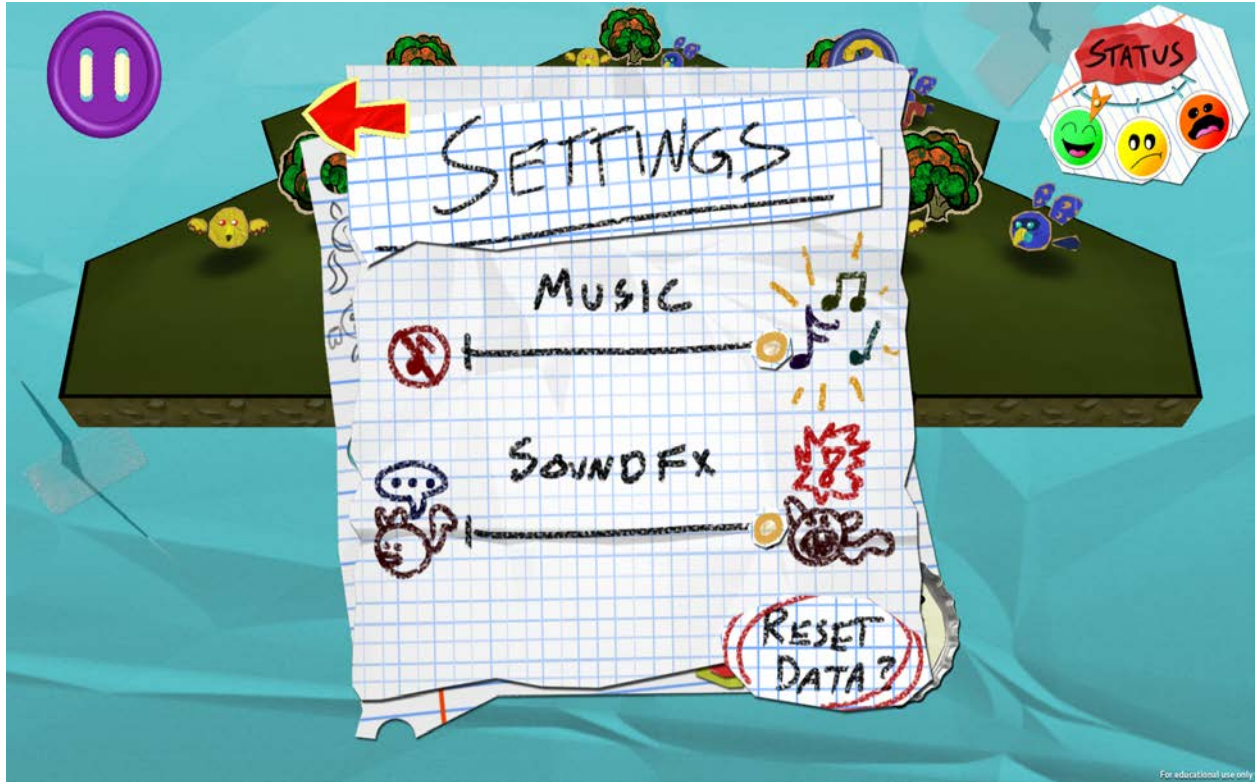


Figure 24: The Settings screen, which can be accessed both on the main menu and in game.

The Level Select, shown in Figure 25, is the menu separating the player from gameplay, and it has multiple elements to show the player's gameplay options. The first three tile spaces are the Tutorial levels which have a direct progression element. The three branching off the Tutorial tiles are the main gameplay levels with three difficulties. The difficulties represent how long the possums have been left to multiply and wreak havoc on the ecosystem with the green being easiest and the red being hardest. The number of possums and color of the tiles both visually depict the threat level of the possums in the three scenarios. Selecting any of these tiles gives a description of the level in the text box, allowing the player to make sure they are selecting the intended tile. Double clicking launches the level.

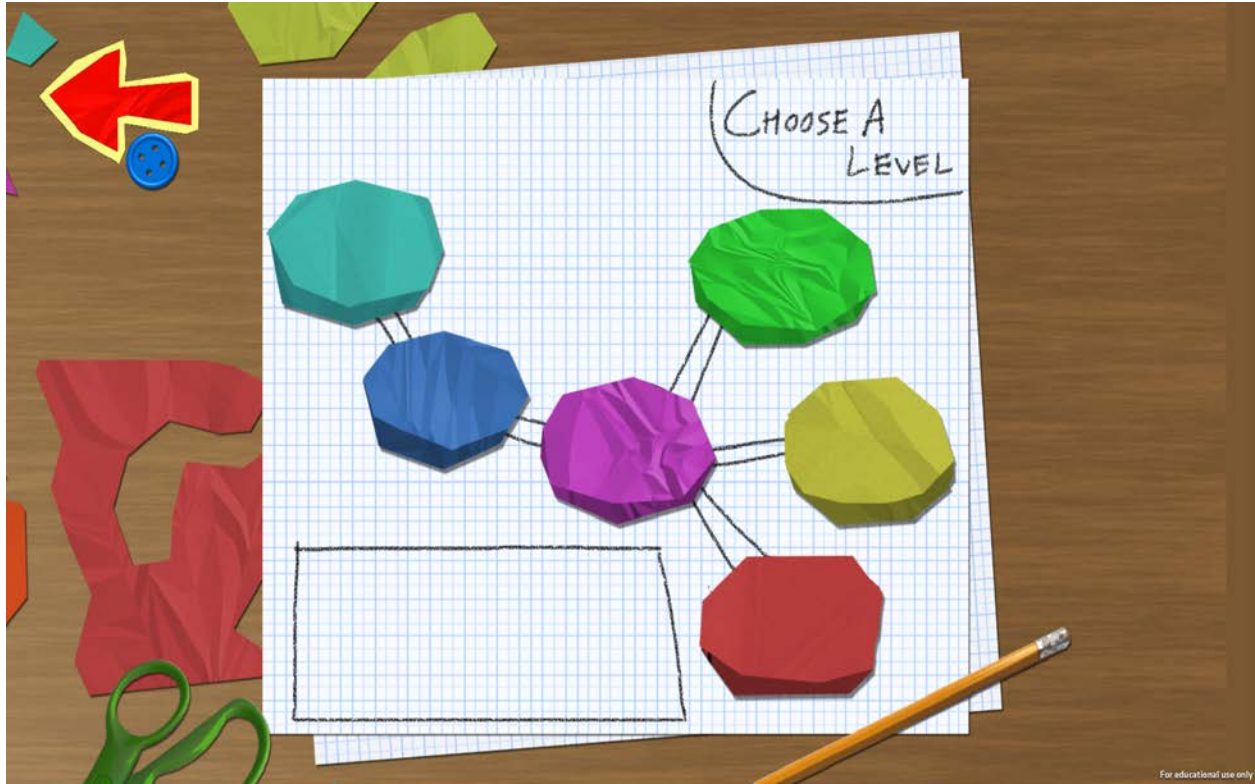


Figure 25: The Level Select screen, showing the progression and difficulty scale of the game.

The Journal is an educational tool for the player, connecting the animals and events in the game to their real world counterparts. Entries are organized by sticky notes with the in-game assets placed on them, as shown in Figure 26. Selecting a sticky note leads to a full entry on the subject. The entries are each a single page of information and have real-world images outlined in white and taped onto the adjacent page. This page flow means that the player first sees and recognizes the game assets, then immediately sees the pictures that those assets are based on, allowing the player to quickly recognize the connection between the two. The short entries give a quick summary of the topic, enough to have a very basic understanding of what it discusses, and also gives enough information for interested players to learn more through external means.



Figure 26: The front page of the Journal (left) and the Kokako entry (right).

The Credits screen gives credit to all those who have worked on the game. Images of the team in the EcoKids style are shown next to the name and role of each member, and a series of stickers lists the special thanks recipients, as shown in Figure 27. The player has no interactions with this page, as it is purely informative on the development for the game.

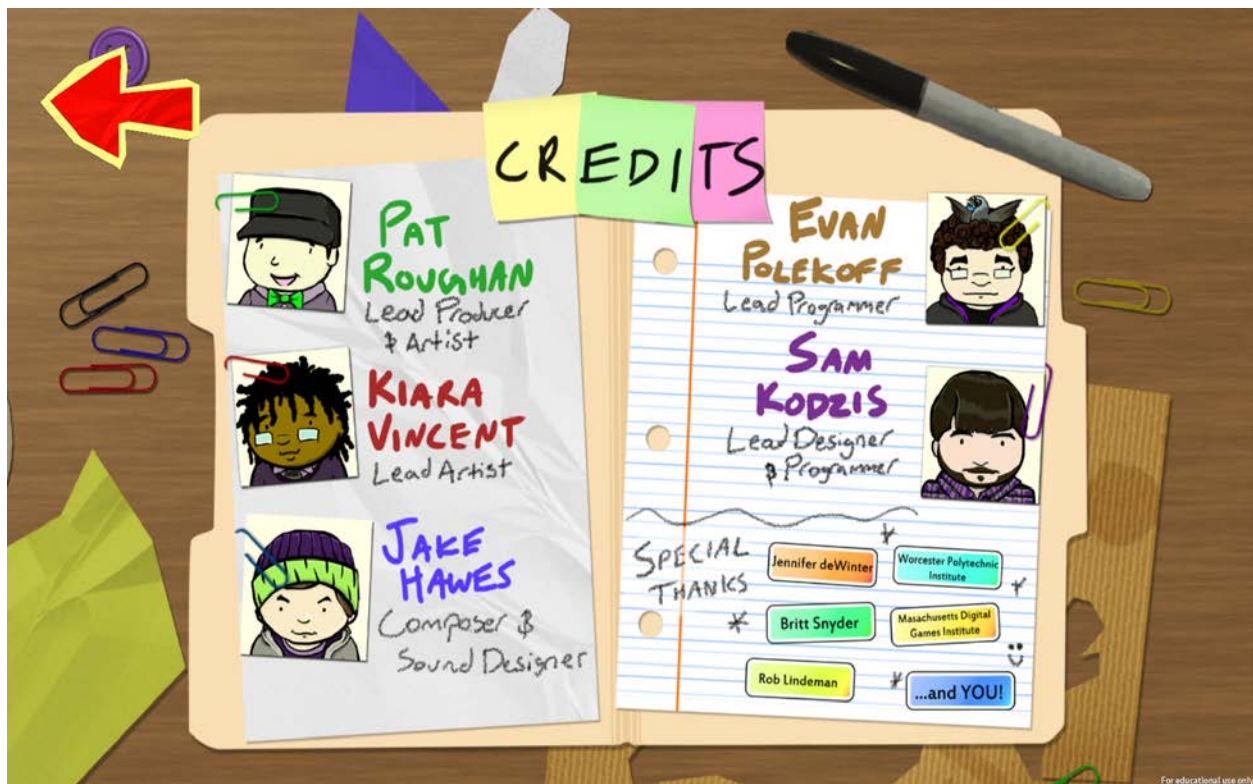


Figure 27: The Credits screen is a simple but necessary screen in order to give credit to the development team.

The loading screens of the game shown in Figure 28 functionally prevent any hanging or black screens, and some visually depict the actions that the environment takes. The first screen depicts a kokako protecting its eggs from the possums, which implies that possums will go after the eggs of the kokako, an important mechanic to understand during gameplay in order to ensure the kokako population survives. The second shows four harrier hawks surrounding a sad kokako, reminding the player that while both birds need to survive to keep the ecosystem balanced, the harriers are predators and will eat the herbivore kokako to survive. The latter two, showing possums chasing kokako and the kokako cheering about a trapped possum, are more comedic than the other two screens.

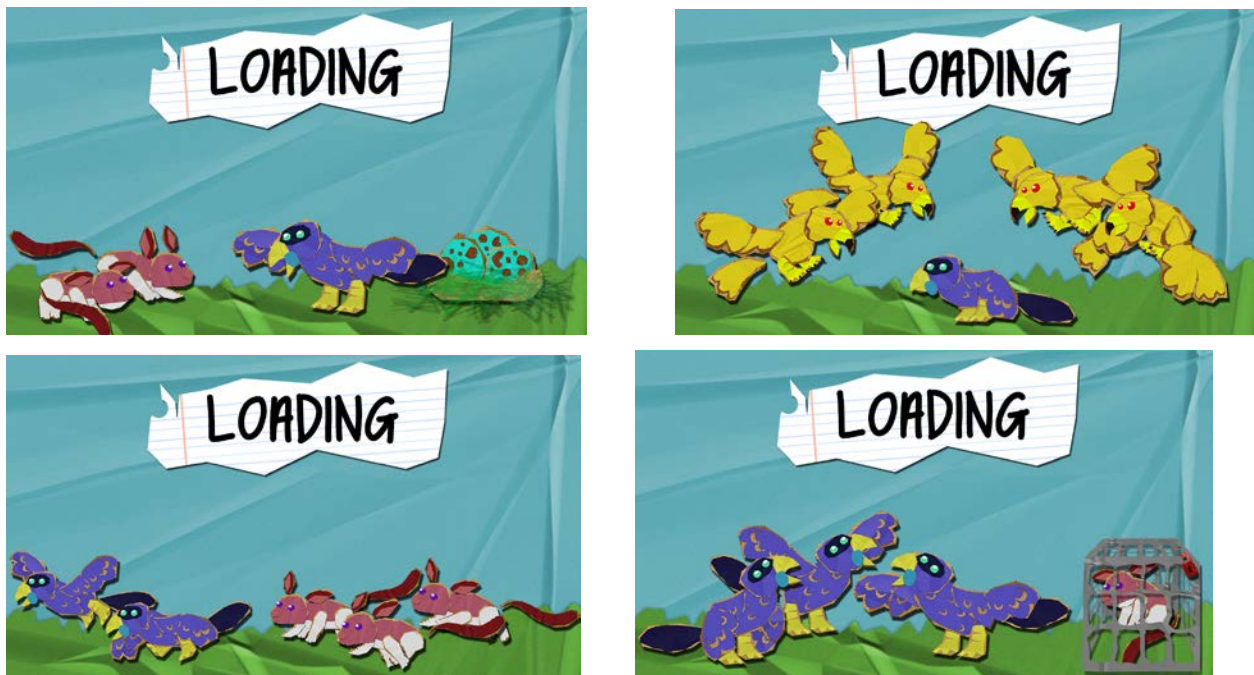


Figure 28: The four loading screens, showing the animals on a simple environment background.

The Strategy Map is the first gameplay map that the player encounters. This map shows the environment at large. Each tile of the map represents an area that the player can enter, and the icons on top of them are the population scales of the animals and plants in that area. When these populations change, the icons change size alongside a green arrow or a red arrow, visually showing the changes of population in the different areas. Selecting a tile on the Strategy Map visually zooms into that map area and fades into the Tactical Map, where the player performs actions. Attempting to select an area without possums prompts a confirmation screen, which asks if the player is sure they want to enter that area since there may not be anything to do.



Figure 29: The Strategy Map, depicting the populations of the world at large.

When the player selects a tile on the Strategy Map, shown in Figure 29, they are taken into the Tactical board, shown in Figure 30, which represents that segment of the ecosystem. The map itself is made up of tiles, which are areas that players and animals can move on, and units, which consist of plants, animals, and the player characters. Upon entry, all the units on the tiles pop up visually, akin to the action of pop-up children's books, allowing the player to get a quick understanding of where various unit types are located. Selecting a player or animal highlights their move range by creating a glow effect on the tiles, showing how many tiles any unit can move at any time. When a unit leaves the map, it falls down in the same manner of the pop-up book action that it took when it entered.



Figure 30: The Tactical Map, where gameplay takes place.

Both the Strategy and Tactical maps have the Status image in the upper right hand corner. This image is both a visual indicator of progress and the button for more information. The image itself has three smiley face stickers: a green happy one, a yellow uncertain one, and a red panicked one. A paper arrow points at one of these faces at a time, depending on how the environment is balanced. If it is doing well and threats are minimal the arrow points to the green face, and when the possums are wreaking havoc it points to the red. This lets the player to get a quick visual on how they're doing with their current gameplay style, allowing them to change their strategy if they see that their current methods are doing nothing or worsening the indicator.

Selecting the image opens the Status screen shown in Figure 31, giving a tabular understanding of the environment's status at a glance. There is a list of the numbers for each unit either as a whole or in the current area, depending on whether the screen is selected in the Overworld or Strategy maps, respectively. The numbers are divided into two segments: the Good, which are units that belong in the environment, and the Bad, which are problem units. Each unit name has a sticker depiction of the game asset it relates to, connecting the names and numbers to the images the player interacts with. Next to the numbers is a Notes box, which gives the player hints on possible modes of action to deal with what they're currently facing.



Figure 31: The Stats screen, which gives players the status of the game’s environment at a glance.

The pause button and menu’s functions were designed to be easy to understand from their visuals. The pause button is a literal button with two strings tied on it, creating the recognizable two-lined pause symbol that many players can recognize at a glance. Selecting this button pulls up the pause menu shown in Figure 32, which has five options to select. Three of the buttons, Resume, Restart, and Quit, all have symbols on them to visually show what each button does, which are to resume the game, restart the game, and quit the game and return to the main menu, respectively. The fourth button, the Settings button, is a bottle cap in the lower right hand corner. The final button is the Tutorial question mark button, which allows the player to review the basic mechanics and workings of the game without having to return to the main gameplay tutorial. In addition to the literal functions of the menu through the buttons, the main menu also provides additional information about the game world and mechanics. The paper that makes up the menu has pencil drawings around it, depicting a possum killing a tree, an equation showing possums and live trees creating dead ones, and a harrier chasing a kokako. These are all actions that the ecosystem takes in the game, and these visuals add another degree of reinforcement for understanding these concepts.

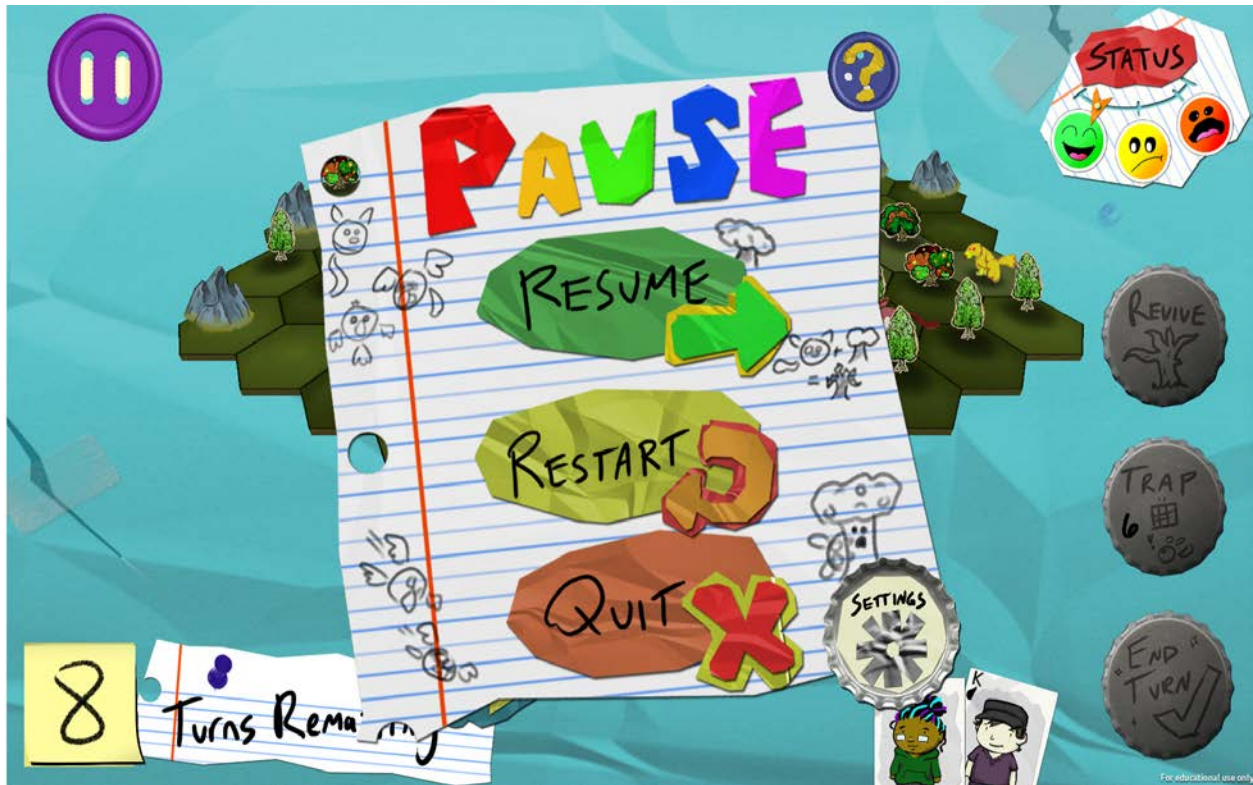


Figure 32: The pause button, top right, and menu, showing the functional buttons and gameplay-representational drawings.

In the Tactical Map, players can control the EcoKids through a selection of actions, which are shown on screen. The action buttons, shown in Figure 33, are double-sided bottle caps with paper images on the interior of the cap and worn marker drawings on the exterior. When an action is impossible to do, the worn exterior is shown, effectively greying out the action due to the cap's color scheme, which is designed to indicate that the action is not possible. When the action can be performed, the cap flips over to the colorful paper side. The animation is meant to catch the eye of the player due to movement, and the distinction between gray and color is meant to tell the player that the button's state has changed.



Figure 33: The two sides of the bottle caps, showing the difference between the inactive and active visual display.

The Tactical Map is limited to eight turns, where the number of remaining turns is displayed on the lower left hand of the screen, as shown in Figure 34. An unchanging “Turns Remaining” paper, which is pinned to the screen, is next to a pile of numbered sticky notes. The topmost sticky visually falls off at the end of every turn, revealing the next number. The numbers three, two, and one progressively get written in brighter red pencil, with the final being a bright red with the words “Last Turn!” to emphasize that the player will soon return to the Strategy Map. Also next to the paper is a Fast-Forward paper icon. Selecting this icon pops up a dialog which asks if the player wishes to Fast-Forward, which skips all remaining player turns and returns to the Strategy Map. Green and red sticky notes represent yes and no, respectively, giving a color indication of their role alongside the words written on them.



Figure 34: The Turns Remaining marker, lower left, and the Fast-Forward dialog.

The Final Report screen, shown in Figure 35, appears once the player has captured almost all or all possums or a species on the map goes extinct. On it, there is a final star ranking, an image showing the player a visual of the environment, and notes explaining the state of the environment and how the player’s actions affected those outcomes. Examples of the images showing the environmental outcomes can be seen in Figure 36. The screen also has buttons to return to the Main Menu or to play the game again.



Figure 35: The full final report screen, showing a 3 star ranking.

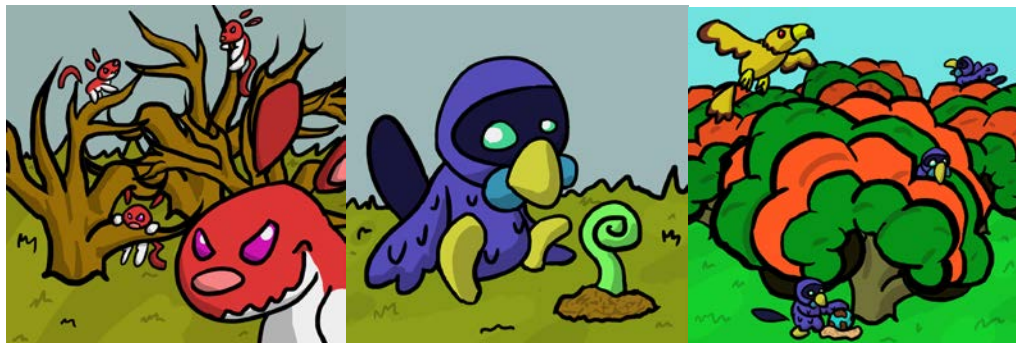


Figure 36: The three final images, depicting the environment in different states of damage.

3.3.6 Audio Design

The primary goal of the audio in *Paper Pests* is to provide feedback for player actions. There are various sound effects for all the different actions the player can take, as well as several of the important animal animations. Auditory feedback is associated with setting traps, reviving plants, and capturing possums.

The sounds themselves are designed to be simple and playful; traps are spread out with a wooden click, bottle cap interface buttons emit a short metallic shuffling when pressed, and so on. Many sounds, like the footsteps, were recorded with actual paper to support the overall arts and crafts aesthetic.

The background music during gameplay was composed to be calm and unobtrusive, in order to let any relevant gameplay sounds cut through the mix. The instrumentation supports a jungle theme, with an exotic flute and marimba taking the lead.

On the technical side, all audio is done through Fabric, a Unity plugin which allows more intricate control of any audio playback than the default tools. This allows the programmer to create in-game triggers, which are linked to audio events made by the sound designer. This lets the sound designer work independently utilizing core functionality (volume, pan, etc.) without having to consult the programmer. By using this plugin, we were able to save a significant amount of time by allowing audio design to continue independent of programming.

4. Playtesting and Iteration

From conception, *Paper Pests* was created with the intention of entertaining as well as educating players about the dangers of invasive species. Before coding any part of the game, a series of paper and digital prototypes was created to test design and gameplay concepts.

In addition to testing for information retention, we concluded that this game could not be deemed an “educational children’s game” if children did not enjoy or understand the game. To test both educational impact and the success of the game as an entertaining piece of interactive media, we devised a brief series of surveys for playtesters to complete during the game’s development.

4.1 Paper Prototyping

During multiple weeks of the initial design phase of *Paper Pests*, we created many paper prototypes. These prototypes are rough approximations of game mechanics using physical-world materials such as cardboard and paper, and were used to test and iterate over core mechanics rapidly without the need to create significant amounts of code or art.

Due to the time-consuming nature of setting up, running, and cleaning up paper prototypes, many preliminary tests were run individually on Excel spreadsheets, shown in Figure 37, using color coded cells with numbers to represent tiles and units. After running through a round of the game, we wrote observations about the design as well as potential changes, and we recorded information such as the length of the game session and the number of each creature to rebalance the next prototype. Although balance was adjusted between tests, the goals of these prototypes were not to perfectly balance the game, but to gauge the viability of certain mechanics and additionally, and to observe potential difficulties in balancing these mechanics.

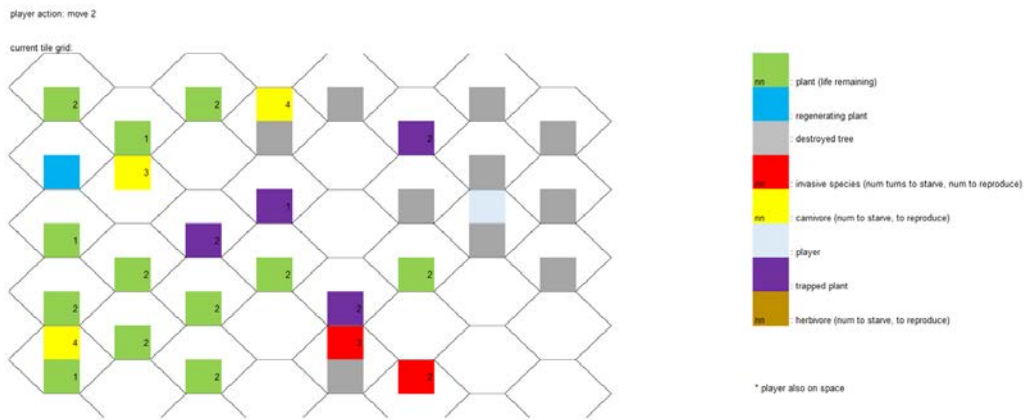


Figure 37: An Excel sheet based prototype with colors representing pieces, and numbers representing health.

More promising results were brought to the entire group to test and refine in more detail using physical cardboard and paper, as shown in Figure 38. One group member would play the game while another would simulate the game world and the animal behavior in lieu of a computer. The tests that performed best formed the framework of the first technically implemented versions of the game.



Figure 38: An early paper prototype, testing gameplay on a small board.

Paper prototypes paved the way for many changes in the game design of *Paper Pests*. Initial versions of the game were played in an omnipresent “god mode” perspective and involved placing fences to block invasive species on a large grid. As a result of early testing, avatars were added to add the extra challenge of character placement, fencing was removed and replaced with replanting trees, and the grid was made smaller, and split into a more manageable world map and local map.

4.2 Playtesting Surveys

Creating the surveys for playtesting during development was itself a process. The game is intended for audiences aged 10-14, as this is the age range when students in the standard US school system learn about biology and rudimentary ecology. To gather data on whether players retained information from our game, we created a pair of surveys, seen in Appendix C. Though identical, one survey was administered before playing *Paper Pests* while the second was followed up immediately after play. The big ideas we wanted players to take away after play was the concept of an invasive species and how they affect different types of environment. There are a number of benefits and hindrances to this system of checking for understanding. The largest struggle was picking questions that were both accessible to the youngest players, in both word choice and concept, and indicative of the information we were hoping to gather. It was easy to form questions, but making sure these questions asked for the information we actually desired took a number of iterations. It was quickly apparent from our first playtest session that question phrasing was crucial if we wanted to gather any sort of useful information at all.

The third survey, in Appendix C-3, was one designed to gather information on the game itself; mechanics, interface design, music choice, and whether the game was fun. The language for this survey was originally geared more towards those who already had some experience with playing video games, rather than the general populace. We worked to fix this as well, so even players not familiar with gaming would be able to provide valuable feedback.

Some shortcomings with testing included early difficulty with questions, participants losing interest in completing surveys, and time constraints leaving post tests uncompleted. Simply through surveying player populations, we identified weaknesses in our surveys and improved them as needed.

In order to reach our target demographic, we identified local educational institutions that had access to subjects within our specified age range. We reached out to these locations, detailing our position as local college students needing testers for our senior thesis. Working out logistics, we were

able to set up times with various institutions for local visits. Each playtesting session was different, yet we gained valuable information from each. Below are the institutions we visited and a brief synopsis of the procedures we followed and how the session went.

4.3 Worcester Arts Magnet School

Worcester Arts Magnet School is a local public school that quickly responded to our call for play testers. It is a K-8 Middle school located on 315 Nicholas Ave.

4.3.1 Planning

Contact for Worcester Arts Magnet School began with an email. The school principal's response was both fast and enthusiastic. After working with Safe Homes, we thought we had an understanding of how playtesting would go, so we of course promised to bring our own devices for playtesting. The date was set, but due to the setbacks of one of the two team members making the session, the start time for the Magnet school was delayed by an hour.

4.3.2 Playtesting

As the students took the tests, it became quickly apparent that the revamped pre/post test questions were still too wordy. The questions were strong in that they were phrased to capture the information our team was interested in gathering. The questions were weak in that they were lengthy and the vocabulary was a bit difficult for the average 4th grader. There were a few students who helped answer the questions of their peers in regards to what the questions meant, but for the majority of the time, team members would help students to understand the wordy questions. It was somewhat busy when multiple students had varying questions, depending on whether they were still taking the survey or had started the game demo.

One thing we had not planned for was students taking the majority of the time to complete the pretest. There were a few students who barely had time to play the game, let alone complete the post and playtesting surveys. A decent number of students moved on from the posttest to the playtest survey without guidance, and this strongly improved the flow of the session. Despite its few setbacks, the Worcester Arts Magnet School provided the majority of our playtesting information for this project.

4.4 YWCA: Wawecus Campus

The Young Women's Christian Association of Central MA is part of one of the oldest and largest multicultural women's organizations in the world. The goal of the YWCA is to eliminate racism and empower women worldwide. The YWCA offers a broad selection of services, including health and wellness classes, afterschool care, assistance with domestic violence, resources for young parents, and for women in need of short term housing.

4.4.1 Planning

We reached out to the YWCA because of its afterschool services. The response from the YWCA afterschool coordinator, like all responses, was quick and showed interest. Due to the restrictions of the YWCA office, the program coordinator however could not install the game to review the content beforehand. Due to this, two members visited the YWCA headquarters in downtown MA to do a personal demo. We showed the director the game as well as the questions that went with playtesting. After setting up playtesting times with her, we were ready to venture to two different locations. Due to scheduling errors, we were able to only test one out of the two locations with the YWCA.

4.4.2 Playtesting

After meeting with the program coordinator of that location, 5 students were pulled from the main group. There were benefits of this small group, mainly being that we were able to help them quickly when questions arose. The largest negative of the small group was that once one student became distracted with the survey process, the distraction spread and soon no one was interested in finishing the surveys. As a result we had half the group do pre-test and post tests and the other half complete the playtesting survey. Having more devices or being more strict with the playtesters about finishing the tests would have helped avoid this issue.

4.5 Playtesting Results and Analysis

By visiting these locations; Safe Homes, the Worcester Arts Magnet School and YWCA: Wawecus, we were able to gather some preliminary data. Though our sample size was low (averaging around 40 students tested), we were able to gain a glimpse of what students within our age demographic already understood about invasive species and the damage they cause to their environment. We learned that at least short term wise, players of the game feel more comfortable with

the concept of invasive species after playing, and are able to more clearly articulate why introducing non-native species to an environment can be potentially devastating. This is demonstrated by the more concise language used in the post test survey as opposed to the simpler language used in the pre-test.

Other than gaining insight about the educational aspect of our game, through the playtest survey, we learned a bit of information on how the game was received by players in general. A common trend amongst players was the initial learning curve. The players would not read the tutorial, and would then have many questions on how to play the game. After a more in depth demonstration on how to work the game, players quickly learned to recognize objectives and devise ways to obtain them. The playtest survey supported the observation that players did not closely follow the tutorial pages, but that they eventually did understand what to do in the game.

Areas of Improvement

From the beginning of *Paper Pests*, the idea of playtesting hovered in the backs of our minds. Yet as we doggedly worked on actualizing our new vision, testing the game with players within our designated demographic kept getting pushed to the side. This was the mentality until D-Term. We had a mostly completed, relatively polished game that played on all devices we wanted. Game bugs were minimal, or known and documented. The game had been tested at a number of shows and conventions. We knew the game worked well as a game, but we had no data at all to support the claim that *The EcoKids and the Paper Pests* was an *educational* game or that it was even fun.

Rather than punting this qualifier, we rushed to figure a way to get *Paper Pests* into the hands of youth it was devised for. The process of gathering a list of Worcester educational and after school institutions and then reaching out to each of them did not take long, and though the number of responses was low, those who did respond did so enthusiastically. If this whole project had to be repeated, we would have reached out to these organizations earlier in the development process, and built a sort of relationship with each location. In addition to contacting schools earlier and setting up more playtesting dates, we would have created stronger surveys. As they stand, the pre and post test do gather some useful information. Yet the questions could use some re-working, as it was quickly apparent that younger students had difficulties comprehending the wordy questions. Overall playtesting was beneficial to us, and helped give us some useful pointers on where we could improve our game. However, playtesting happening so late in development meant that comments on design could not be implemented into the game.

5. Interactions with the Public

Over the course of *Paper Pests*' development, the game has been shown at multiple game exhibitions and competitions. Each of these showings brought new opportunities to the game and team, from playtesting to getting public attention. Overall, presenting the game at several events not only gave us valuable playtesting data, but it also taught us how to pitch our game to a potential audience, something that many developers forget is a critical skill in game development, especially in the indie scene. A game without players, however great, isn't being played. By bringing *Paper Pests* to multiple conventions, we were able to improve the game and get the attention of players and people already in the game development industry.

5.1 WPI Game Development Club Showfest

The first time we ever showed the game to players was at the Game Development Club's B-Term Showfest on December 11th. At the time, the project was early in development, so early that the game didn't have a name and went by *ecoSnafu*. The event was small, but there were about 4 or 5 other MQPs and graduate student projects. Our survey had 7 legitimate responses by the end, showing us how players responded to problems and early design choices in the game. Since the game had no tutorial, barely any UI and no win condition, we weren't expecting much. However, getting feedback on the art direction was a good start, and foreshadowing for many conventions to come.

5.2 MassDiGI Game Challenge

On February 6th and 7th of 2015, *Paper Pests* was entered in the MassDiGI Game Challenge, a pitch competition for student and indie games. The contest had two days: the practice day, when teams showed their pitch to various people in the game development industry, and the pitch day, when teams formally presented their pitches to a team of judges. Formal pitching had two rounds: one in front of a small section of industry developers, and the second to all people in attendance at the event alongside a full panel of judges. After formal pitching on the second day, games could win their category, split between College Alpha or Beta, Indie Alpha or Beta, and Serious Alpha or Beta, the Fan Favorite vote, or the Grand Prize.

On the first day, Rowan practiced the pitch with industry developers Trevor Stricker, Jamie Gotch, Bert Snow, and Tom Lin. Trevor Stricker, President of Disco Pixel, suggested shortening the trailer, originally approximately two minutes, to a single minute, and also emphasized the importance of explaining the importance of an educational game about the environment to an audience that may

not care about environmental issues. Jamie Gotch, CEO of Subatomic Studios, loved that the game's audience, art style, scope, and design all worked together to create a cohesive whole. Bert Snow, Vice President of Design at Muzzy Lane Software, explained the importance of stating a clear educational goal and emphasizing that the game was immersive rather than quiz-based, and also gave advice on how to get an educational game into the hands of players. Tom Lin, Creative Director of Demiurge Studios, suggested removing all the words from the PowerPoint slides in order to keep the focus of the audience on the team's pitch rather than the slides.

On the second day, Rowan and Evan presented the game formally. The first pitch was to four industry professionals from the educational game space, who praised the presentation for being complete with information, in addition to showing a well thought out and executed game. The competition for *Paper Pests* in the Serious Alpha category never arrived to pitch, so the game went to the second round by default. The second round's presentation was to all attendees and judges from a multitude of game development backgrounds. A photo of the presentation can be seen in Figure 39. After a deliberation period, the judges formally announced another game, *Wooplex* by Oles Terletskey, as the Grand Prize winner. The judges approached Evan and Rowan after the announcement and praised *Paper Pests*, expressing that they would have given the game a second place award if possible.



Figure 39: The presentation at the MassDiGI Game Challenge.

The MassDiGI Game Challenge marks the first time that the team had to fully explain and pitch the game to people outside of WPI who had never seen the game before. The results were both

informative and humbling. While we, as the team behind the game, thought that the importance of the educational aspects and the fun of the strategy aspects spoke for themselves, listeners were much harder to convince, especially with people who already mentally wrote off educational games as boring or dry. Once we did show the game in the proper light, however, most listeners became interested in the game, which made their attention that much more rewarding.

5.3 Playcrafting Boston Winter EXPO

The Playcrafting Boston Winter EXPO, held February 24th, was the first revamp event of the Boston Indie Demo Night group. Evan and Rowan brought a computer, the MassDiGI Game Challenge trophy, and Evan's Kokako plush, and new business cards for the game.

The setup of the *Paper Pests* table left a lot to be desired. While we did have the materials above, they took up less than half the table, and the rest of the table went completely unused. Compared to the other tables in attendance, which had banners, multiple computers, tablecloths, and other decorations, the one computer and pile of cards gave an empty and unprepared impression. Rowan borrowed a roll of tape from another table and created tape writing on the empty part of the table, reading "The EcoKids and the Paper Pests." People passing the table found the empty space fix amusing and appropriate for the game's style. The demo table can be seen in Figure 40.



Figure 40: The Playcrafting table.

After watching people play the game and listening to the questions they asked, we started to get a good idea of what game elements caused the most confusion. We knew we were going to have to make a simplified tutorial for PAX so that we didn't have to hover over the game answering questions, but we still needed to keep it short so players could get right into gameplay. This last playtesting session before PAX was a huge help in steering the direction of that tutorial.

This event hammered home the importance of giving a professional and prepared impression at events. While we did get people to walk over and play the game, our table was less attractive than most at the expo, and saw less traffic than the tables around us because of it. Tables with banners and decorated tables, on the other hand, typically drew large groups at a time. Interest in tables, while affected by the game itself, appeared mostly determined by how flashy the table looked. Compared to tables with big TVs, standing banners, and other interesting sights, *Paper Pests* and the empty table set up could not compete.

5.4 Made in MA

The Made in MA Pre-PAX Party on March 5th was the first event in which we debuted our promotional materials. We had business cards, a standing banner, and the game was finally built on iPad for the first time. Just the act of getting all of this equipment to the event was an enormous struggle that lumped more unnecessary stress onto the already exhausted team directly before PAX.



Figure 41: Made in MA players.



Figure 42: The table at Made in MA.

This was the first time the general non-game-developer public was going to see the game in large quantities, so we had to make sure it was shown off with the best promotional materials and on its preferred device. Despite some delay-related trouble with the delivery of the banner and iPad lock, we were able to demo the game on its target platform. Kiara also had our business cards printed, which we handed out to everyone we met. There was a pretty good flow of people coming through at all times and both of our demoing devices were in use a majority of the time. Most of the feedback we received was related to issues identified at the Winter Expo. Photos of our table at the event can be seen in Figure 41 and Figure 42. Our new, quick “Convention Tutorial” helped explain the goals and mechanics of the game, but it was clear we needed to implement the full tutorial first thing in D Term.

5.5 PAX East

PAX East is a large convention, hosting nearly 70,000 attendees and a multitude of triple-A game companies. On March 6th 2015, we brought *Paper Pests* to the convention to represent WPI at its booth. We were able to gain feedback while also attracting potential student applicants to WPI.



Figure 43: *Paper Pests* at PAX East

Paper Pests is not a convention style game. Demoing the game at these smaller events, we were able to connect more personally with the players and they were more willing to sit down with the game to learn how to play. In a large crowd, however, we could not interact with every potential player.

The booth as a whole was a big success for WPI. There was a TV in the front that showed gameplay from some of the student projects that were running on PCs. This did a good job catching the eyes of attendees walking by. The booth was also in a great position, directly to the left of the entrance and far enough away from the AAA games that we could still comfortably hear the visitors. *Paper Pests'* position in the booth was not ideal, being placed in the corner where the volunteers of the booth dumped their backpacks and coats, but we still demoed with many players. A photo of *Paper Pests* location in the booth can be seen in Figure 43.

5.6 Boston University Day of the Devs

This was the Boston University Video Game Society's first year running a Day of the Devs event. The room was well decorated and had a posh carpet, unlike most of the auditoriums or convention halls that we usually demoed in. Every table had a table cloth, which made the room look

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cohesive. There was also an a cappella group and a string quartet performing video game music for part of the event, which added a nice feel of professionalism. A photo of our table can be seen in Figure 44.



Figure 44: The table at the BU Day of the Devs.

There were about fifty other indie developer teams at the event. We had met the student in charge of running the event at the Winter Expo where Rowan and Evan were interviewed for the trailer of the event. Advertising directly to indie developers worked well for them, seeing as how most of the Winter Expo crowd was present here as well. This meant that many people showing games had already seen *Paper Pests* and could comment on changes.

The traffic was light throughout the entire event. We had learned from the Made in MA Pre-PAX party that it was wise to bring multiple devices, but we never had more than two players at a time. The event was also extremely long, running from 10am to 7pm. Our iPad and Nexus 7 tablets kept dying, so we ended up using the Windows Surface and PC exclusively by the end. We also had a little miscommunication prior to the event about who was bringing what materials, so we didn't have the banner, which would have made us look more professional.

Even though traffic was light, the interactions with players felt a lot more personal. There were a few aspiring artists who came by that had conversations with us about making indie games. Some people were interested in the educational aspects and wanted to hear more in regards to that. Since the event was so long, people were more willing to sit down and play the game to completion.

At this point, the game was the most balanced that it had ever been. We had a range of people winning and losing with varying skill levels and levels of understanding. The convention tutorial was

still the only source of instruction unless the player asked questions, but some players were able to figure out the game using just that.

5.7 WPI Arts & Sciences Advisory Board and IMGD Closer Look

Towards the end of the year, the IMGD Program asked us to show the game at two events: a talk with the Arts & Sciences Advisory Board at WPI and the Prospective Freshman IMGD talk, titled IMGD Closer Look. Both of these presentations were designed to get the listeners interested in the IMGD program rather than the game itself.

The Arts & Sciences Advisory Board showed us the reaction non-gaming people had to *Paper Pests*. Once the demo was being shown, the board became interested in the workings of the game, asking questions about the scientific background and educational benefits of playing such a game. They appeared impressed by the deep researched background and educational aspects of the game.

The IMGD Closer Look did not give us a response to the game itself, but instead to the IMGD program and the project's development. This talk was focused on showing prospective freshman the development of the MQP as a capstone project for the entire IMGD program. After both projects, *Paper Pests* and *Hikari Michi*, presented their game and briefly explained the methods of development, the audience asked about how people fell into the roles of the projects and how the teams worked together to come up with a single unified idea. Looking back, our team always knew who would act in which role, but finding the single idea for *Paper Pests* was a long struggle, which is elaborated on in the Production Postmortem section of this paper.

5.8 General Public Relations

From the very beginning, every member on this team had the mindset that they wanted this game to be shown to the public as much as possible. We aimed to win awards and were willing to put in the effort to be recognized. To reach this goal, we attended events and created marketing materials, all of which helped the game gain recognition. The conventions that *Paper Pests* attended are elaborated on in the Conventions section of this paper.

5.8.1 Twitter

To keep the fans up to date with our development and gain more publicity, we created a Twitter for the game: @PaperPests. The home page of this Twitter can be seen in Figure 45. Occasionally, the artists would create custom art for publicity's sake, such as Valentine's Day cards with *Paper Pests*

puns on them. Selected tweets are shown in Appendix D. Mostly the twitter was used to retweet #screenshotsaturday tweets that team members would make as they were developing the game and photos of our booths at the various conventions we attended. It also served as a good way to keep players that we encountered at conventions and other areas up to date on the game's progress.

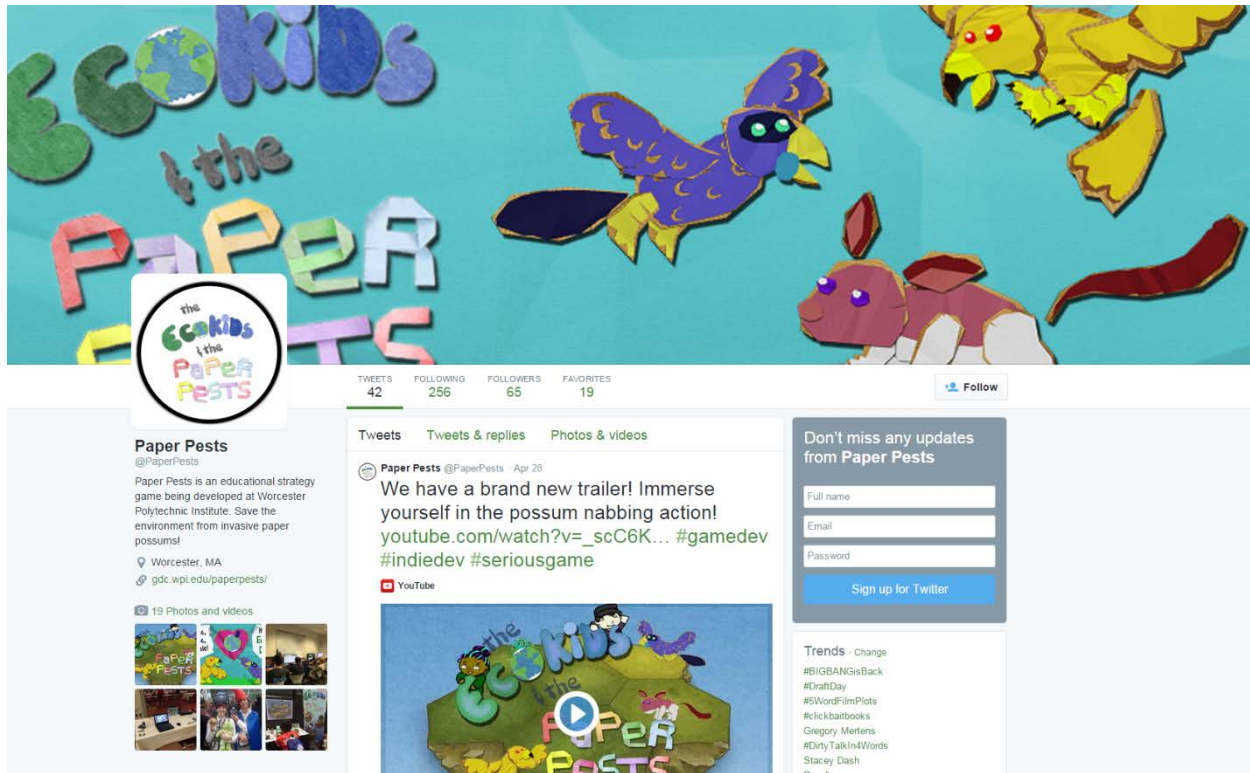


Figure 45: The Paper Pests Twitter page.

5.8.2 Website

Knowing that we would be meeting a lot of people at all of these conventions, we knew there had to be a central hub of information we could direct our fans to. We bought the domain <http://paperpests.com> for the next five years, and Evan designed and constructed a custom website from scratch. The full homepage of the site can be seen in Figure 46, and the different pages can be seen in Appendix D. The site was only two pages for streamlined navigation. The main page had a banner at the top, two buttons for downloading the game or playing it online, a javascript image slider to show screenshots and trailers, a twitter feed built in, and a description of the game. At the top of the main page was a link to another page with all of the team members, images drawn by Kiara in the *Paper Pests* style, and links to our portfolios. After we won our award at the MassDiGI Game Challenge, we put a little drawing of our achievement on the site under the banner as well.

One regret is that we never implemented Google Analytics to track the views of the site between conventions. This would have helped inform us of the effectiveness of our advertisements. Had we implemented the analytics tracking, we could have seen how many more views our trailers and website had received after each convention to determine which was the most useful to attend. We also could have had concrete statistics on how effective the business cards and banner were in grabbing attention.



Figure 46: The main page of PaperPests.com

5.8.3 Business Cards

In order to get the website and twitter handle names into as many hands as possible, the team made business cards showing the *Paper Pests* art and logo on one side and the names and characters on the other. Images of the cards can be seen in Figure 45. The cards were popular with players; after trying the game or seeing someone else play, many players would almost instinctually grab a card to remember the game later. While we did have many players picking up the cards, we still had a great deal of cards left after our last big event. The original order was for 1,000 cards, which we now realize is more cards than *Paper Pests* called for.



Figure 47: The front and back of the business cards.

5.8.4 Banner

During the Playcrafting Boston Winter EXPO, the *Paper Pests* table was one of the only tables without a banner of some kind to show off the game on a large and noticeable surface. The team had discussed purchasing a banner previously, but this event hammered home the importance of the advertising tool.



Figure 48: The banner design.

The banner was purchased before Made in MA and PAX East with the goal of having it attract people from the busy convention areas to the game's booth. Due to a delivery sorting error by the WPI Mail Room, the banner almost didn't make it to Made in MA, but the problem was sorted out and the second half of the event had the banner standing on a large banner stand.

The banner, shown in Figure 47, had a clear impact on getting attention from people wandering by the booth, meaning we had more players trying the game. Looking back, buying the banner for previous events could have really helped the game get the attention of players for earlier playtesting. The final design of the banner can be seen in Figure 46.

5.8.5 Trailers

We created trailers to demonstrate the game at the MassDiGI Game Challenge and to send to people who wanted to see a demo of the project. Trailers serve as a quick and engaging introduction to any game, and we hoped to have that introduction with the *Paper Pests* trailer.

The first trailer was made in B term, when several screens of the game were still placeholders. We had Kiara speak over gameplay and matched her dialogue to game events representing what she was talking about. For this trailer, we used some stock background music from Newgrounds, a free media sharing site, since our composer, Jacob Hawes, had not yet taken his Independent Study Project to help us with the audio.

The second trailer covered the same gameplay, but was tailored more for the MassDiGI Game Challenge. The only audio was the background music for the game and the presenters at the Game Challenge talked over it when presenting. The original video was two minutes long, but we shortened it to about a minute after taking advice from developers on the first day of the Game Challenge.

The final trailer was developed for Project Presentation Day. Our composer and sound designer had more of a role in this trailer, working closely with Evan for audio assets and timing. We also used paper pop-ups with text explaining the gameplay to look more professional. The trailer was also made in Adobe Premiere instead of the previously used Windows Movie Maker.

6. Potential Funding through Grants

The past year of development for *The EcoKids and the Paper Pests* has been focused on creating a strong proof of concept for the game and proving that the project has the potential to be a strong educational game. In order to continue the game outside of Worcester Polytechnic Institute, the team can seek grant funding in order to cover the costs of full-time game development. If this route is pursued, the team would have to write a grant proposal, proving to the grant's review board that the game is worth funding. Writing a persuasive grant proposal requires an understanding not only of the basics of grant writing, but also the rhetorical strategies that are most convincing, especially in the realm of funding digital games.

In the first section of this chapter, we look into grant writing, educational games, and how grants can be used to fund game development. In the second, we analyze an existing educational game grant proposal and four successfully granted game's white papers for rhetorical strategies used to persuade the reader to fund them. We then take each of these strategies and tie them into potential ways we could write a grant for *The EcoKids and the Paper Pests*.

6.1 Grants and Games

Games are a relatively new medium, but grant funding has existed for many decades. In order to get a project funded through grants, the grant writer must follow the existing framework for grant writing, and work to convince the review board that the project is worth developing. With games, the writer must also prove to the review board that games are a valuable pursuit rather than just a source of mindless entertainment. The grant writer must prove the worth of games as a whole in addition to showing the value of the game project they seek to fund.

6.1.1 The Methods of Grant Writing

Grant writing is all about trying to sell a project or research in order to receive funding to see that project or research to completion. This makes grants a type of persuasive writing, though in grants the writer is attempting to convince the readers of an idea without being too pushy or obvious about their intentions. In this way, in grant writing, “one must persuade without seeming to persuade” (Connor, 1999). In order to do this, the grant has to prove not only that the idea is worth funding, but also that those seeking the grant are the best fit for the grant’s request. “They need to capture the attention of the reader, describe the idea, show the need, and establish the writers’ competence” (Connor, 1999).

In general, grant writing follows a format that outlines the project’s goals, methods, and funding needs. The proposal’s format can change based on the subject of the project, such as science versus visual arts, or the funding agency that the proposal is being sent to (University of North Carolina, 2012). Funding agencies have specific application guidelines that proposals have to follow to be considered, but in order to get the grant sent to as many agencies as possible without taking too much time, grant writers create a ‘white paper,’ or a general framework of the proposal that can be rearranged or made more specific for different institutions (University of North Carolina, 2012). Overall, there are three main questions that grant reviewers are looking at the proposal to answer: what will we learn that we don’t already know, why it is worth knowing, and how will we know the conclusions are valid (Przeworski, 1995). If those three questions are answered, the deciding factors of whether or not to fund a proposal comes down to whether the project well planned and feasible, and whether the investigators qualified to execute it (University of North Carolina, 2012).

Before getting into the project specifics, the grant proposal has four general introduction sections: the title page, the abstract, the introduction, and the literature review. The title page acts as a very short abstract about the project, those involved with it, and the budget. The title of the proposal is very important; the arrangement of words shows which topics are the focus of the project (Learner Associates, 2001). The people involved with the project allow the reviewer to connect the proposal to

previous projects and research, and the project dates and budget give the reviewers a quick idea of the project's scope (University of North Carolina, 2012). After the title page is the, abstract, which serves as the summary and first impression of a project proposal. It outlines the key elements of the proposal in the future tense, indicating the general purpose, specific goals, research design, methods, and significance of the project (University of North Carolina, 2012). Grant proposal reviewers will use the abstract as a reference point to get a quick idea or refresher on the general project ideas, both before and after reading the other sections of the proposal. After the proposal is the introduction, which covers the key elements of the project and its goals. A statement of the problem, the purpose of the research, the research goals or objectives, and the significance of the research. An important question to answer in the introduction is how the project is different from previous research and projects, to show reviewers that the project is worth funding (Przeworski, 1995). The last introductory section is the literature review, which shows preliminary research into the project's topics. The purpose of the literature review is to have selective and critical research in order to show an understanding of topics involved with the project (University of North Carolina, 2012).

After introducing the project and its goals, specifics of the project and its budget are in the last four sections: the project narrative, the personnel, the budget, and the timeframe. The project narrative is the meat of the proposal, split up into multiple sub-sections to supply all the details of the project. The problem statement is explained in more detail, the research objectives and goals are clearly outlined, and the hypothesis, methods, procedures, and outcomes or deliverables are explained (University of North Carolina, 2012). The project narrative should pre-empt and answer all the questions a reviewer could have about the details of the project by explaining reasoning and making connections between the various sections (Learner Associates, 2001). After the narrative is the personnel, which explains staffing requirements of the project. This section shows the skill sets of the existing staff and notes where additional staff will be required (University of North Carolina, 2012). After the personnel is the budget, which shows the allocation of funding to areas of the project. Tables are often used to show a clear organization of funds, and the budget justification goes through the items on the table and connects them to the needs of the project (University of North Carolina, 2012). The last explanatory section is the time frame, which shows dates of milestones or deliverables for a project.

6.1.2 Types of Game Grants

In order to fund educational game development, some developers have turned to grant funding. Ben Sawyer outlines five main sectors of grant funding that may accept a game proposal (Sawyer, 2013). The first, and most ideal, are development grants. These grants put money directly

into development of the game, and are usually awarded to spur certain areas of the economy through the funding of incubators and competing companies. The second are Small Business Innovation Research (SBIR) and Small Business Technology Transfer Program (STTR) grants. These grants are awarded specifically to for-profit small businesses, and are used to promote emerging or smaller-sized companies in the economy. The third are foundation grants, which are grants given by public and private institutions. The fourth type of grants are government and foundation contracts. In these contracts, the government sector or foundation gives funding in order to develop a pre-determined product.

The fifth and final type are research grants, which use games to answer a research question. In these grants, the development of the game is secondary to the research and analysis of the game's effect on the research question. These grants can be used by game developers, but are typically written and utilized instead by researchers in the sciences and humanities who wish to use games to research or educate others on a topic (Roxworthy, 2010).

6.1.3 Grants and Educational Games

The role of educational games may be predictable and measurable through research, but their development is still uncertain. The serious game development space, and in that the educational game development space, has been increasing in recent years, with the Centers of Excellence survey showing 46% of game companies report current or planned development of serious games (Centers of Excellence, 2008). The market size of educational games is ~\$2B, experiencing 30% yearly growth (GSV Edu, 2012). Despite these increases, the term 'educational game' still carries negative connotations of being either a test in disguise or low-quality content, and higher quality games may struggle with getting the attention of teachers and school administrators (Watson, 2010). Focused development of educational games for many companies is not sustainable, and they are instead developed as a side project during the development of an entertainment game or contracted project (Sawyer, 2013).

Grant funding for digital games is a new concept, but one that is gaining popularity. During his March 2011 speech in Boston Massachusetts, President Obama called out for developers to create "educational software that's as compelling as the best video game. I want [students] to be stuck on a video game that's teaching [them] something other than just blowing something up" (Obama, 2011). Research grants are currently the most common grant awarded to game development, though these grants focus on answering a research question rather than the core development of the game (Sawyer, 2013). Because of this, research grants only fund the development of the essentials of a game prototype for the purpose of study.

While research grants are the most common grant, other grant types have started awarding funding to games. In May 2013, over half of SBIR grants were creators of educational games, totaling twelve games being made by that source of funding alone (Associations of Public Television Stations, 2013). These twelve games had some common themes in their design and educational traits (DeLoura, 2013). The games had an element of adaptive difficulty to adjust the challenge to the player, they used story-based narrative to engage students, they had rewards or competitions to award gameplay, and they were designed with the classroom environment in mind. Several also had a form of teacher dashboard built into the game, so the teacher could see student progress and send students messages with instructions or additional educational content (DeLoura, 2013).

6.2 Grant and White Paper Analysis

In order to properly create a framework for a grant proposal for *The EcoKids and the Paper Pests*, Rowan researched existing game grant proposals and white paper analysis of grants in progress. A selection of these were chosen for more in-depth analysis. The grant proposal chosen, titled “Scaling Digital Gaming to Humanities Pedagogy and Praxis,” proposes a series of humanities based educational games, along with an editor to allow players to create their own peer-reviewed game scenarios. The four white papers, titled “Red Land, Black Land: Teaching Ancient Egyptian History Through Game-based Learning,” “Drama in the Delta: Digitally Reenacting Civil Rights Performances at Arkansas’ Wartime Camps for Japanese Americans,” “A Digital Role-Playing Game for the History of Medicine,” and “Travelling While Black,” are all reports on the history, current progress, and future plans for successfully funded educational game grants in various stages of development.

The grant proposal and white papers were read and analyzed for rhetorical methods, strategies, and arguments that were successfully used to receive funding. By identifying these common traits between the projects and investigating how they were used to create a stronger proposal, we can piece together how to propose *The EcoKids and the Paper Pests* with the best chance of successful funding.

6.2.1 Innovation through Interactive Experiences

Throughout the proposal and white papers, one word and its synonyms appears as the major tool of persuasion for funding: innovation. The games are described as “innovative,” a “first effort,” “transformative,” “new,” bringing “new life,” “pioneering,” and otherwise unlike other current projects or

research efforts. Overall, the proposal and white paper continuously repeat and try to sell the idea of their project being something that is new and different than what currently exists.

The grant proposal most clearly hammers in the idea of innovation as a rhetorical strategy. The paper opens by stating it “seeks to do for digital humanities what publishers have done for books,” and dedicates its second section, after the abstract, to a “Statement of Innovation.” A later section, titled “Innovation: Methods and Digital Technology,” starts with this introductory sentence: “This project contributes important innovations to digital humanities pedagogy, technology, and scholarship.” The sections afterwards, titled “Innovation in new humanities gaming content,” “The first authoring workflow for humanities games and simulations,” and “Pioneering digital peer review” all describe the game in further detail, repeatedly making note that the games and tools they describe do not yet exist. In addition to using the word innovation and its synonyms, the sections state that “no digital tool exists” that works as the proposed project does, and that the game “speaks to the innovative potential of digital mediums for next-generation humanities pedagogy and practice” (Spielvogel, 2013). Additionally, the section titles themselves repeat the innovation point that the grant seeks to convince the reader of in every possible way.

Innovation, defined as “something new or different,” is a huge part of grant proposal writing, especially in the digital game space (Dictionary Reference). In order to receive funding, a proposal must show the need for the project it seeks to fund, and a revisit to an existing idea without changes has no reason to be funded. The educational games space has a slight advantage over other projects in that games are a relatively new medium, and one that still holds untapped potential that grant proposal writers can appeal to. As a new medium, developers believe that games can provide a lot more value than what is currently seen on the market, especially with the addition of advancing technologies (Paraskeva, 2010). Pointing out this potential and connecting a project to the advancement of innovation in the digital games space works to set the game project apart from other proposals, making it more likely to be funded.

The EcoKids and the Paper Pests is unlike many turn based strategy games in that it, in addition to being educational, is targeted at a younger audience. Turn based strategy games are commonly targeted at older audiences, as shown with the Civilization series, XCom: Enemy Unknown, and Endless Legend, among others. Because of this, these games have many different units, economical factors, and other stats and numbers to keep track of during gameplay. In *Paper Pests*, players are given only two units to use, focus on a smaller map within the world as a whole through the strategy board, and have less actions to strategize with. The player’s progress is also denoted with a smiley face sticker system instead of showing numbers and percentages, which could confuse

players. The core strategy of the game is still present and engaging without overwhelming the younger audience, many of whom will never have played a turn based strategy game before. Showing the innovation of the educational digital game space through *Paper Pests* is a quick way to get the reader interested in the project, and one step closer to funding it.

6.2.2 Reinvigoration of the Humanities

A major argument throughout the grant proposal is that the humanities are boring or inaccessible to current students, and placing humanities information in an interactive medium such as a game will fix these problems. The paper's third section, the Statement of Humanities Significance, claims that "[their previous game] project has gained a national reputation for how gaming and simulation can be used to transform digital archives from largely static, search-only repositories to interactive digital narratives that offer exploration through collaboration, performance..., authoring, and critical thinking" (Spielvogel, 2013). The goal of their current project is stated to be "enlivening and enriching the ways primary documents are accessed, absorbed, and critically examined" (Spielvogel, 2013). This overarching goal for reinvigorating the humanities is repeated throughout the paper, placing emphasis on the player's interactions with the game space as a learner-centric educational method. The paper cites a humanities professor as an authority on the difference between "*prescriptive learning systems* and *emergent learning networks*," the former being "closed, pre-determined knowledge," and the latter being learning that is "open and created and distributed largely *by the learners themselves*" (Spielvogel, 2013).

In addition to these full quotes, both the grant paper and the white paper reports refer to the games they discuss with words such as "appealing," "active," "accessible," an "experience," and "engaging". One paper described the educational game as a "cohesive tapestry of experience," which will "inform, inspire, and provide a platform" for education on their game's subject matter (Williams, 2014).

The reinvigoration of humanities from a static to interactive medium is not a new concept. In her 2003 paper, Gretchen Schwartz of Oklahoma State University analyzes and calls for an increase in the utilization of media literacy as a way to connect the learning of the humanities to the new generation, noting that "an ongoing challenge in the humanities and across the curriculum lies in creating curriculum that actively engages students... the media offer diverse ways of understanding the humanities and diverse ways for students to express their own discoveries and ideas" (Schwarz, 2003). Reports of games in the classroom environment repeatedly note the game's ability to naturally engage students and create communities interested in the game's content, claiming that this natural

interest in the interactivity of games allows for self-motivated and self-focused learning methods (Squire, 2003).

The claim of natural immersion and, therefore, natural interest and self-education through educational game spaces, is as broad as it is appealing. The claims of immersion and engagement through the gaming medium is never sourced to actual research on the subject, but is instead treated as an unquestioned fact about digital games. The research on gaming does state that it is an immersive medium, but this is assumed to be so unquestioned that it does not require sourcing (Jennett, 2008). The writers of the grants and white papers not only make this unsourced claim, but then connect the natural immersion of games to be evidence of their educational potential without showing any previous research or testing on their game's educational potential. Connecting these two claims is a rhetorical method to generate belief that this new medium can bring new life to the humanities simply by placing humanities-centric information in an interactive space.

For *The EcoKids and the Paper Pests*, creating a real-world simulation of the New Zealand case study for educational purposes falls into the rhetoric of reinvigoration of the humanities. Reading the data and studies of the possum pest problem and its effect on the kokako bird and harrier hawk is less engaging than seeing and interacting with a digital simulation of the same events. Using the argument of interactivity bringing new life into humanities subjects is an easy claim to make with a few sources identifying games as an interactive medium, and brings a large persuasive impact to the body of the grant. The grant proposal paper dedicates the third section of the paper to the "Statement of Humanities Significance," which makes the argument of games reinventing the humanities in full, then revisits the claim throughout the paper. Using a similar method with the *Paper Pests* grant would add an additional push to the grant's readers to give the game funding.

6.2.3 The Appeal of Games

The proposal and white papers all note the innate appeal of interactive media to the audience, and use this as evidence of the project's potential. The papers describe games as "engaging," "active," an "experience," "immersive," "enjoyable," and "accessible". They then use the interactive traits of games to claim that games will innately interest their players. One game is described as "using 3D video game technology as an accessible and appealing medium to engage the curiosity of the general public" (Roxworthy, 2010). The other states that "Red Land/Black land communicates complex socio-cultural, historical, and epistemological concepts in an easily approachable and enjoyable learning experience" (Watrall, 2012).

The engagement of games is a defining trait of the medium; it places the user in a place of control over the experience. Educational games allow the player to be part of the learning process,

rather than an observer to it. In this position of control, players are more willing to be engaged by the material being presented to them, giving them the ability to explore and experiment within the educational space (Watson, 2010). It also allows the player to speed through or slow down areas that they may understand completely or need more help with, making the information and the speed at which it's presented more appropriate for each student and their learning needs. Games also put educational material in a visual context, allowing players to make connections between the game and real world information, which increases the chance of understanding the material and its relation to previous topics or experiences the player can relate to (Anetta, Cheng, Holmes; 2010).

For *The EcoKids and the Paper Pests*, the appeal of digital gaming is a strong point to make to the review board. The game has already gone through minor testing to check if its audience, children aged 10 to 14, are interested in the game as a source of entertainment as well as education. The results show that players are interested in the game, and returned to it for multiple playthroughs, some even going to the website after the playtesting session and playing for their own entertainment. Emphasizing these results and explaining the interactive aspects of digital games as a way to engage players with educational content would strongly serve to prove the value of the game to a grant review board.

6.2.4 The Educational Value of Digital Games

As previously noted, games have the potential to be educational tools. The grant proposal and white papers make the assumption that player interaction will lead to player education, using the interactive nature of the medium as evidence of educational potential. One white paper explains that in the game, “an immersive 3D environment allows a fuller view of internment history because the donning of avatar personas provide ‘player-controlled surrogates’ that allow Americans to finally experience the internment not as spectators but as engaged participants, thus deepening the public’s understanding of significant humanities questions” (Roxworthy, 2010).

The players often are expected to learn through direct interaction with the game and supplementary text that appears in-game to give context for game events. After playtesting, one white paper noted the misjudgment of a game being innately educational because of real-world content. “The responses also served as a reality check on a too-optimistic view of the game as an educational tool to impart knowledge. Most playtesters could list a new fact or concept in the history of medicine that they had learned while playing the game, but far fewer could list a new fact about social history or the Edinburgh context” (Rosner, 2013). Despite this note, every paper uses game interactivity as proof of potential learning transference, with the quoted white paper blaming the previous design of the game for educational failures.

The use of educational digital games in a learning environment is a subject that has high potential in the eyes of current educators. Teachers and professors both show interest in using the educational ability of digital games in a classroom environment. When surveyed by Project Tomorrow, 65% of United States teachers showed interest in incorporating educational games into their classroom, 50% wanted to learn more about the process of using games in the classroom environment, and 11% already use educational games in their classrooms (Project Tomorrow, 2008). The United Kingdom fares a little better, with 35% of teachers using games and 60% expressing interest to do so in the future (Sandford, Ulicsak, Rudd; 2006).

The EcoKids and the Paper Pests has gone through minor playtesting with children aged 10 to 14 to analyze its current educational potential. When surveyed with a pre-gameplay test and post-gameplay test on invasive species, players showed increased understanding of how an invasive species can damage an ecosystem and the other animals within it. Taking this data and showing it as distinctive evidence of existing educational potential, then going a step forward and elaborating on how the educational potential will be increased with further development and testing, would give a strong basis for *Paper Pests'* value as an educational tool and give it a greater chance of being funded.

6.3 Conclusions and Next Steps

Innovation, reinvigoration of the humanities, the appeal of games, and the educational value of games are all strong arguments for the funding of an educational digital game. These core strategies show the grant reader that the game is different than what currently exists, appealing to a large audience, useful as an educational tool, and has a larger impact on the state of humanities education as a whole. Hitting on all these points creates a whole and strong argument for the funding of the game. The existing game and playtesting data that the team has is also a very strong argument for the game's funding, as these aspects show that the game, as it exists currently, is already a fun and educational tool, and granting funding for continued development will make it a strong and polished product. If grant funding is pursued, using these strategies and elaborating on the final *Paper Pests* product will serve as strong persuasive tools to get the game funded.

7. Team Role Postmortems

The team of *Paper Pests* was split into four sections: Production, Programming, Art, and Design. All four sections had a lead, and two team members doubled as an assistant for a role. Rowan was Lead Producer and an Artist, Sam was Lead Designer and a Programmer, Kiara was Lead Artist, and Evan was Lead Programmer. In addition to the senior team, another student, Jacob Hawes, took the Lead Composer and Sound Designer role for his Independent Study Project. Each section brought its own successes and hardships to the game.

7.1 Production Postmortem

The production of *Paper Pests* gave the game a strong organizational and public relations platform during development. Rowan had previously worked as the Lead Producer of another game, *Many Mini Things*, but that project extended for eleven weeks rather than a full school year. Additionally, *Paper Pests* was much more demanding in terms of team organization, meeting scheduling, and event planning.

7.1.1 What Went Right

The roles that each team member took were the natural fit for each person, and no one felt misplaced. Rowan's previous leadership background made him fall into the Lead Producer role, Kiara's heavy focus on art led her to the Lead Artist role, Sam's interest and experience in design fit with the Lead Designer role, and Evan's lengthy tech experience, including his Blizzard internship, worked well with the Lead Programmer role. Rowan also acted as an artist and Sam acted as a programmer from their secondary backgrounds. After the initial discussion sorting the team in this manner, each person adopted their responsibilities without issue, allowing the team to work as a cohesive unit without internal role politics.

Unlike work in a summer internship or studio environment, there were no pre-determined times when the team was guaranteed to be working in the same room. We chose to spend two hours per weekday in the Zoo Lab as a full team working on the game, in order to better communicate progress and needs to other team members. These times varied by term, as organized and some terms had days when a two-hour block was impossible to attend by all team members at once. Regardless,

having this 10 hours per week of dedicated game-making time with the team in close proximity greatly helped with communications on tasks and progress.

Having a single Google Drive folder and shared SVN repository allowed information and assets to be quickly shared with all team members. Starting with the design documents and continuing through the writing of this paper, each stage of development had records and explanations in documents, spreadsheets, and the weekly summary presentations for advisers through Google Drive. Once the SVN was set up, artists could quickly upload and share assets with the programmers, not only for the game itself but also for online and advertising materials.

Event attendance was regular and extremely helpful for getting public feedback on the game. Having a presence in the Boston game development scene allowed the team to see how potential players responded to the game's artistic style, design aspects, and educational content. Planning these events and which team members would be available for them went smoothly, and there were few times when problems arose with event attendance.

7.1.2 What Went Wrong

During development, weekly adviser meetings were arranged so the team could discuss game progress and difficulties with the three advisers assigned to the project. Unfortunately, having three different advisers with very different schedules meant that getting all three, plus the four team members, to be free at a single time was often impossible. Additionally, advisers would often miss meetings due to lack of sufficient reminders, conferences, or other conflicting meetings, meaning that meetings often only had one or two advisers, who would only be able to discuss certain aspects of the project.

The purchase of the business cards and banner were relatively late in development, meaning that earlier event attendees had no way of remembering the game and finding the website in the future. After seeing the radical difference in attendance at the table and follower count on the Twitter account after the advertising materials were present at tables, we realized that having these materials earlier could have helped us find playtesters earlier in development, which would have helped with our later playtesting struggles.

At the start of the game's development, Rowan was more hands-off with his approach to monitoring team progress, which created a problem when milestones for asset creation were not being met. The problem went on longer than it should have due to his belief that the problem would be sorted out through team member's internal motivations to get assets done. After speaking with the team on the importance of actively working on the project and communicating when problems were arising, the

team got back into the rhythm of reaching milestones, and Rowan continued to be a more active lead to keep the team's focus on their tasks and goals.

7.1.3 Different Approaches

Overall, the production of *Paper Pests* went well, but there is always room for improvement. Looking back, there are sections of the production line that, while they didn't go completely wrong, could have gone smoother with a different approach.

While Google Drive worked well as a record of all activity in game development, having more unified documentation for team tasks and goals would have made monitoring team progress easier. For the first half of development, the art and tech tasks were in separate locations. Both sides could access the other, but it was out of the way if the team members weren't actively searching for it. During the end of development a single spreadsheet was created to keep track of final art and tech tasks being done, which allowed the team to have a clearer picture of the game's progress and what other members of the team were doing.

Rowan's approach to organizing adviser meeting times and keeping wandering team members on task started out too lenient for optimal development. Starting the development of the game with a stronger hold of the leadership role could have prevented several problems down the road, such as a lack of assets and the absence of multiple advisers for the middle of development.

Starting the marketing aspect of the game earlier would have helped with the lack of playtesters that the game ran into during the final leg of development. Having the website, Twitter, trailer, business cards, and banner set up before a majority of the events would have made keeping in contact with players easier, and also would have opened the potential of finding possible players through social connections. Additionally, having these marketing materials already set up gives the impression of preparation and professionalism, something which the game lacked at the first few events when all the team showed was the demo on a development laptop.

7.2 Design Postmortem

Designing *Paper Pests* presented a unique challenge: we wanted to make an educational strategy game about invasive species, and make it fun and welcoming so that kids would be interested in it. Additionally, since the game was targeted at a younger audience than most strategy games, we tried to design it to be more accessible and fast-paced than its contemporaries. Ultimately, we believe we were successful in meeting our goals, and player response has been strong, but trying to balance fun, education, simplicity, and depth proved to be a particularly strong challenge.

7.2.1 What Went Right

One of the things we got right from the very beginning was setting clear design goals based on our audience, and sticking to them. We wanted the game to be simple and quick-to-play, and every decision factored in those constraints. As a result, young players who tried our game at conventions were able to understand the game and its concepts, and get playing almost immediately. Whenever we iterated and refined the game, we were careful to avoid anything that would complicate or slow the game.

The process of iteration itself was another success for *Paper Pests*. From the beginning of the project's development we iterated several concepts on cardboard and paper, which allowed us to experiment with several ideas at a rapid pace. As a result of early prototypes, we were able to start the main production cycle with a proven design, and focus on implementing to our best ability. We continued to test throughout the project's cycle, examining balance and flow at every step. As a result, we were able to catch critical usability problems early on, and could make *Paper Pests* an extremely frictionless experience.

7.2.2 What Went Wrong

Unfortunately one of the mistakes we made was not giving enough time to experiment and iterate with the long-term strategic planning part of the game. The split between strategy board and tactical board arrived relatively late in the pre-production cycle, and as a result of time constraints, the strategy board didn't get as much time or iteration as the tactical board did. Most of the early ideas that were tested for the strategy board were either scrapped due to complexity or infeasibility within our time budget, and as a result, the game has a far less engaging long-term component than we desired.

Additionally, for better or worse, it should be noted that there were some challenges that arose from choosing to base the game scenario on reality. By using a real scenario instead of a fake one, we were able to add more tangential educational value to *Paper Pests*, and potentially introduce players to a concrete problem that exists outside the game, but the design was also constrained.

We had to avoid misrepresenting the source material, even as we abstracted it, and thus certain potential design variations were avoided since they would be inaccurate. This was particularly difficult when designing player actions, as there are a limited number of effective actions to combat each invasive species, and many of them were not engaging, particularly after simplifying the actions to a level of complexity suitable for a beginner. Although we are still proud of the chosen scenario and

actions, as well as the extra tangential education provided by a real scenario, this constraint proved tough throughout the project's early design phases.

7.2.3 Different Approaches

Ultimately, most of the challenges with designing *Paper Pests* could have been resolved by allocating more time up-front for flexible high-risk prototyping. The strategy board was added late in the prototyping phase, partially because the problem of large game boards wasn't initially prevalent, but also because most of the early attempts at solving the problem were mild, due to concerns about development overhead for managing two boards.

Additionally, the challenges that arose from using a real-world scenario could have potentially been avoided with extra time to experiment with a wider variety of scenarios. In the development of *Paper Pests*, research and game play mostly conformed to a specific scenario envisioned early in development to meet our educational goals. An alternative approach might have been to approach the prototyping process a bit more flexibly, experimenting with a variety of animal types, both real and fake, to find the most fun and informative scenario before researching or creating animals to match it. If we had taken this approach, we may have been able to discover even more effective game mechanics, with less restraints up-front.

7.3 Technical Postmortem

When all things are considered, we are pleased with the technical implementation in *Paper Pests*. The code enabled the project to easily adapt to changes as necessary throughout its development, and a strong set of tests helped ensure that the game was working correctly throughout all major milestones. Even though our code-controlled approach often made asset integration a hassle, and although the implementation of the tutorial system wasn't smooth or elegant, we are pleased with the overall end result.

7.3.1 What Went Right

Given the experimental and ever-changing nature of *Paper Pests*' gameplay in early paper prototypes, we decided early on that flexibility and modularity would be more important for our project than most. We spent time early in the project attempting to separate every component of the code as much as possible so that individual pieces could be changed out at ease.

This was a major asset in development and enabled us to further speed up early testing and iteration, as we could swap out features such as grid shapes, different piece types, and player actions with minimal effort. Our efforts to maintain modular class design continued to benefit us throughout the course of the project as we were also able to create and extend a highly extensible board generation system, and optimize portions of our code by swapping out implementations late in the project. At all points in development, our code made iteration simple, allowing us to tailor our game to testing feedback easily.

The development of the board generator and its file format also proved to be a great success for testing and iteration. Although it took time to design the board generator and to program all of the file reading capabilities, it paid off by making the process of designing and refining scenarios fast and straight-forward. In particular, the file format's automatic compatibility with new rules proved to be highly useful as rules were often added in the process of creating scenarios.

Another key success was the early establishment of automated testing procedures, which allowed us to ensure that our game was working properly at all iterations. Whenever a new feature was added in code, new automated tests would accompany it. Similarly, when a bug was fixed, a new test would verify that the bug was no longer occurring.

In addition to proving that code worked the first time it was implemented, these tests could be re-run each time a new feature was added to ensure that older code was not impacted negatively. By having a large suite of automated tests, we were able to gauge the health of our code and catch errors before they became significant. At multiple points in the project we were able to debug errors that might have otherwise remained undetected and ensured that we had largely bug-free playtesting sessions.

7.3.2 What Went Wrong

Unfortunately, although individual mechanics were largely bug-free, real-time visual elements often provided more of a challenge. *Paper Pests* is turn-based, and the code was designed and planned around concrete turns. However, elements like animations and transitions are run in real-time, and our code was not planned accordingly to handle these elements. As a result, the implementations of real-time elements, particularly those that had to coordinate their timing with other real-time elements, proved to be challenging and error-prone at points in the development.

This was not the only problem that we had with visuals and other assets, as our pipeline required a lot of programmer involvement. In most Unity games, game objects are created and loaded

in scenes using a drag-and-drop editor. This typically allows anybody in the project to import assets without needing programmer involvement.

In contrast, for *Paper Pests*, to keep the visual representation of the game consistent with the underlying grid-based simulation, our code loaded, generated, and controlled the scenes of the game from scratch. This meant that all assets were initialized, placed, and tweaked through the code, and although we used Unity's drag-and-drop editor to import and organize content smoothly, programmers had to take time to implement all new art or audio assets, which could have been better spent elsewhere.

Coming late in the development period, the full playable tutorial was rushed in the final term of development. If it was started earlier in the year, we could have made some of the gameplay functions more malleable so the tutorial could better guide the player through the gameplay. We ended up digging back through the code to add optional parameters to a lot of common functions so the tutorial could restrict a player's actions and know when to advance the dialogue. We also should have spent more time designing the tutorial state system to build on the base state machine code more. We could have made the system more scalable by abstracting out common tutorial patterns and simple passing parameters into pre-built tutorial state classes to construct new dialogue pieces much faster. It would also have been nice to have the tutorial automatically read the dialogue from a file that the writers on the team could polish up instead of requiring a programmer to manually paste the dialogue line-by-line in the state machine.

On the topic of state machines, the robust game-wide state machine to control the game state came a bit too late in the development process. We only added it after the strategy board was already implemented and we had challenges integrating animations with our original systems. At this point, we retroactively added a state machine to transition between the player and environment turns for the tactical and strategy boards as well as animation states for each. This took a lot of time to debug and ended up being on the messier side as a result. We would certainly advise teams to consider using a state machine from the beginning of the development process even if the game only starts with one state.

7.3.3 Different Approaches

If we had to program *Paper Pests* again, we would likely spend more time in the initial design phase, as the extra planning and foresight would have likely eased most of our challenges. Most of the technical issues in *Paper Pests* arose when we had to design and code features at the same time, usually when we made an oversight in the initial design phase of the game.

In particular, the presence state machines and real-time events could have been improved with more concrete planning before we began coding. The strategy and tactical board split came relatively late in the design process, and if we had taken the time to design a state machine around that split, then we may have avoided some headaches later in the project when we had to transition to a state machine system anyway. Similarly, if we considered the real-time elements in our planning phase, we may have designed an event messaging system or other common solution for handling the synchronization of real-time factors in our game.

More planning time would have also benefitted the tutorial greatly. Although the gameplay vision for the tutorial was designed early in the project, we didn't have a concrete technical vision for the tutorial, which caused several issues when we needed to implement the tutorial late in the project. With more planning, the technical design and code quality of the tutorial could have been greatly improved, and we may have also estimated implementation time more accurately.

In addition to spending more time on design, we also believe that we should have taken more time and effort into improving tools and content pipeline for assets across the board. Both the implementation of art assets and tutorial text proved to be cumbersome and unintuitive, which resulted in a programmer bottleneck for much of the game's content. Given how much time we saved comparatively by exposing functionality in our board generator, we would have likely benefited in the long run from simplifying the content pipeline for art and text.

7.4 Artistic Postmortem

The EcoKids and the Paper Pests has been noted repeatedly for its artistic style. The game's colorful, bright, and overall playfulness create a fun inviting atmosphere, which draws players in to try the game. This is thanks to the work of the team's artists, Kiara and Rowan, who created all assets in the game. As Lead Artist, Kiara primarily cultivated the art style and set the theme for future designs. It all began after following a curious idea of overlaying a design of an invasive species with a fabric texture. This one idea sparked the entirety of the "Arts and Crafts" theme. Beginning with cloth animals, it soon spread to construction paper trees, burlap bunnies, and cotton ball skies. Though animals ended up with a different style, the cardboard cutout style remains consistent. As expected, all of these "crafted" assets did not make it into the game. Regardless, the style of *Paper Pests* was cemented, and from there it was all too easy to design a User Interface that flowed seamlessly with the art from gameplay. Rowan quickly adapted and influenced the style of *Paper Pests*, especially as the core of his work covered everything not seen during gameplay. Rowan worked beautifully within the art style and devised clever ways to perpetuate the Arts and Crafts motif throughout the game.

7.4.1 What Went Right

The singular cohesive art style between the two artists gave the game a level of artistic professionalism that was repeatedly noted by playtesters and other viewers of the game. The arts-and-crafts style allowed both artists to get away with having their own stylistic elements in their assets, since the differences matched the mismatched look of the game. This is most notable with the character art versus the animal art; the characters are ink and colored drawings while the animals are paper cutouts on cardboard. The two artists were also able to use programs they were already familiar with due to the different character styles. Kiara animated the characters in Photoshop while Rowan animated the animals in Spine, creating two distinct styles of movement for the different units. These artistic differences are visible in Figure 49.



Figure 49: The character art versus the animal art (left), and the app icon showing both (right).

Originally, the artists had split the work into four sections: UI, terrain, animals, and characters. Rowan was responsible for animals and characters while Kiara would do UI and terrain. During development, however, Rowan struggled with character creation while Kiara felt uninspired for the UI. The two team members decided to switch roles, leading to the adorable human characters based on the artists by Kiara and the interesting arts-and-crafts UI by Rowan. Being honest about their struggles and open to switching roles for a better fit allowed both artists to create better work.

7.4.2 What Went Wrong

The biggest obstacle for Kiara was getting assets in in a timely manner. When it came to any art asset, be it a model, a still image, or an animation sequence, Kiara struggled with getting assets for the pipeline in in a fashion that was conducive for her teammates. The problem for this stemmed from a mixture of lack of focus, to a desire to make every asset perfect before submitting. The first

problem could have been addressed by creating a complete asset list, and sticking to it. Rowan, the Lead Producer, suggested this once the concept of *Paper Pests* was firmly established, but it went unused for a large part of development.

7.4.3 Different Approaches

The asset creation issue could have been solved with a large and used asset list for both artists to track. Though a skeletal asset list was created Kiara did not stick to this document after its creation, and either made assets as were necessary for implementation or that helped pull together the artistic style of the game.

The timeliness was more of a mindset shift Kiara should have worked on addressing. Instead of working meticulously on one piece, just getting assets in the game to make sure they worked would have been a better approach. The assets could then be polished to a higher quality. This work progression would have saved time and made it so that the tech portion of the team had time to fully implement all art.

Hurdles and obstacles aside, the art team worked well together and produced high quality work that really enhanced the experience of *Paper Pests*. Rowan's speed, and skill with art along with his relaxed demeanor coupled well with Kiara's somewhat capricious nature, and her slower, more laborious method of creation. Both artists agree that the time spent working on the *EcoKids and the Paper Pests* was an enjoyable one, and that if possible, would be open to continuing work on the game, or on different future endeavors.

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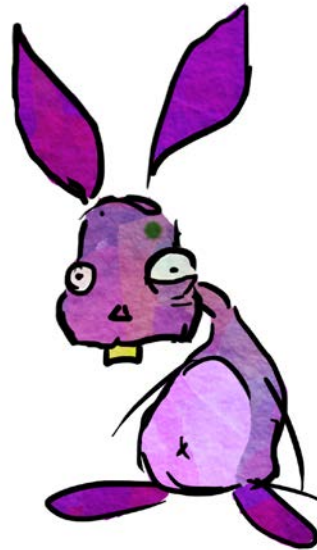
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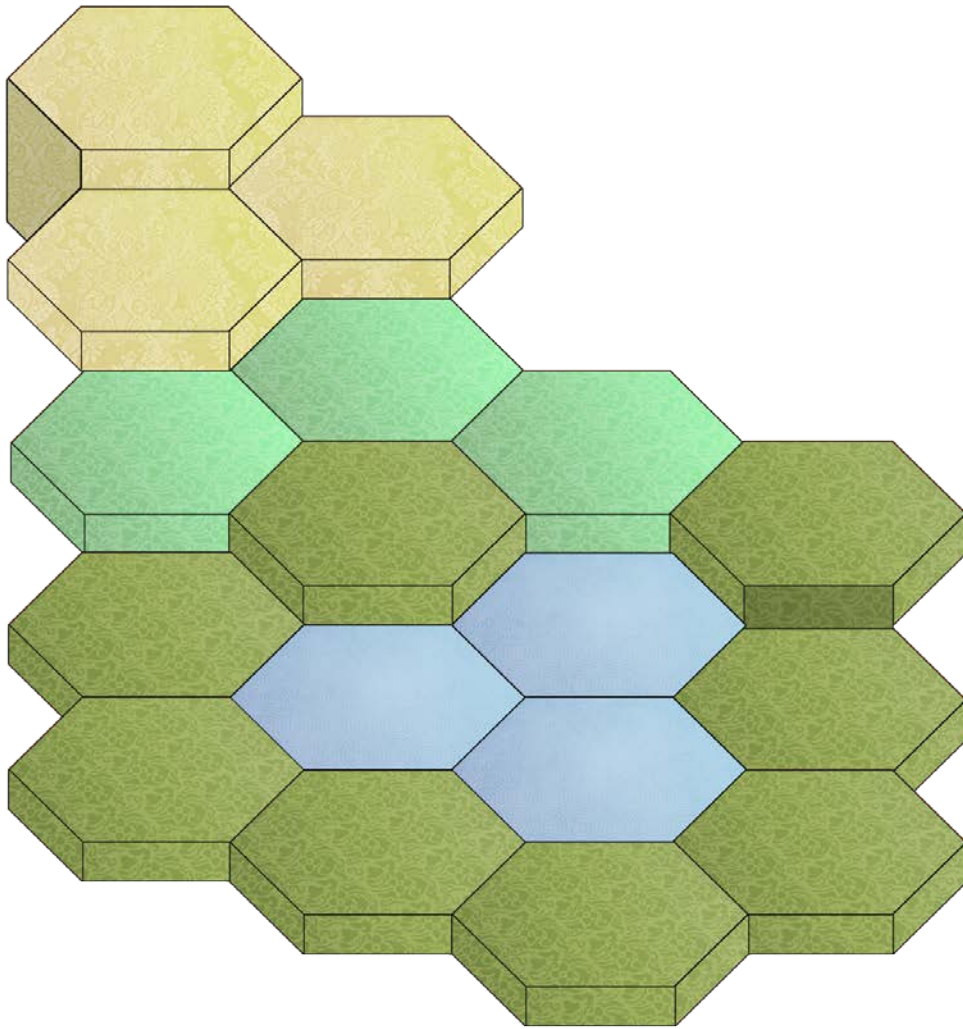
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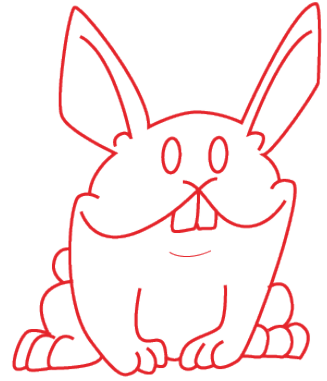
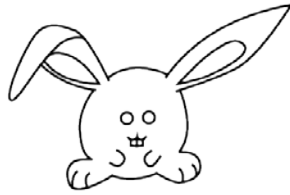
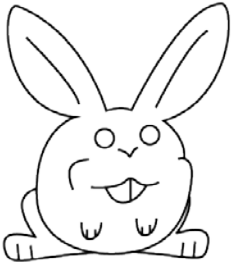
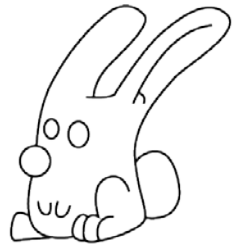
Williams, R. (2014, May 2). Traveling while Black. Retrieved March 1, 2015.

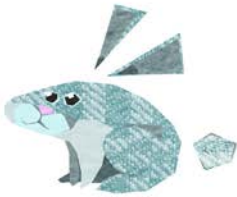
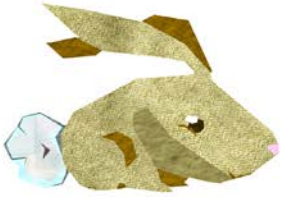
Appendix A: Art Concepting

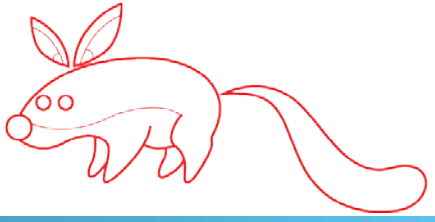
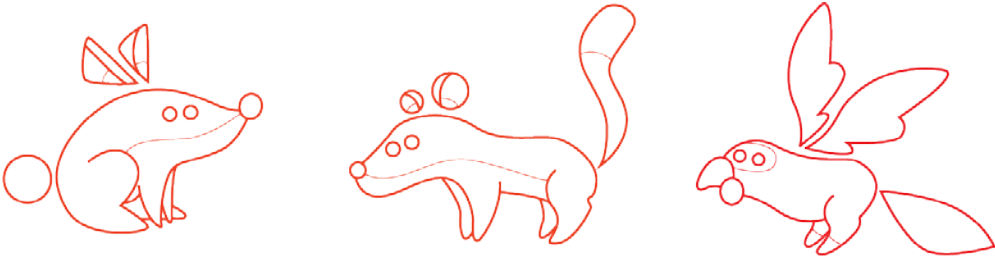








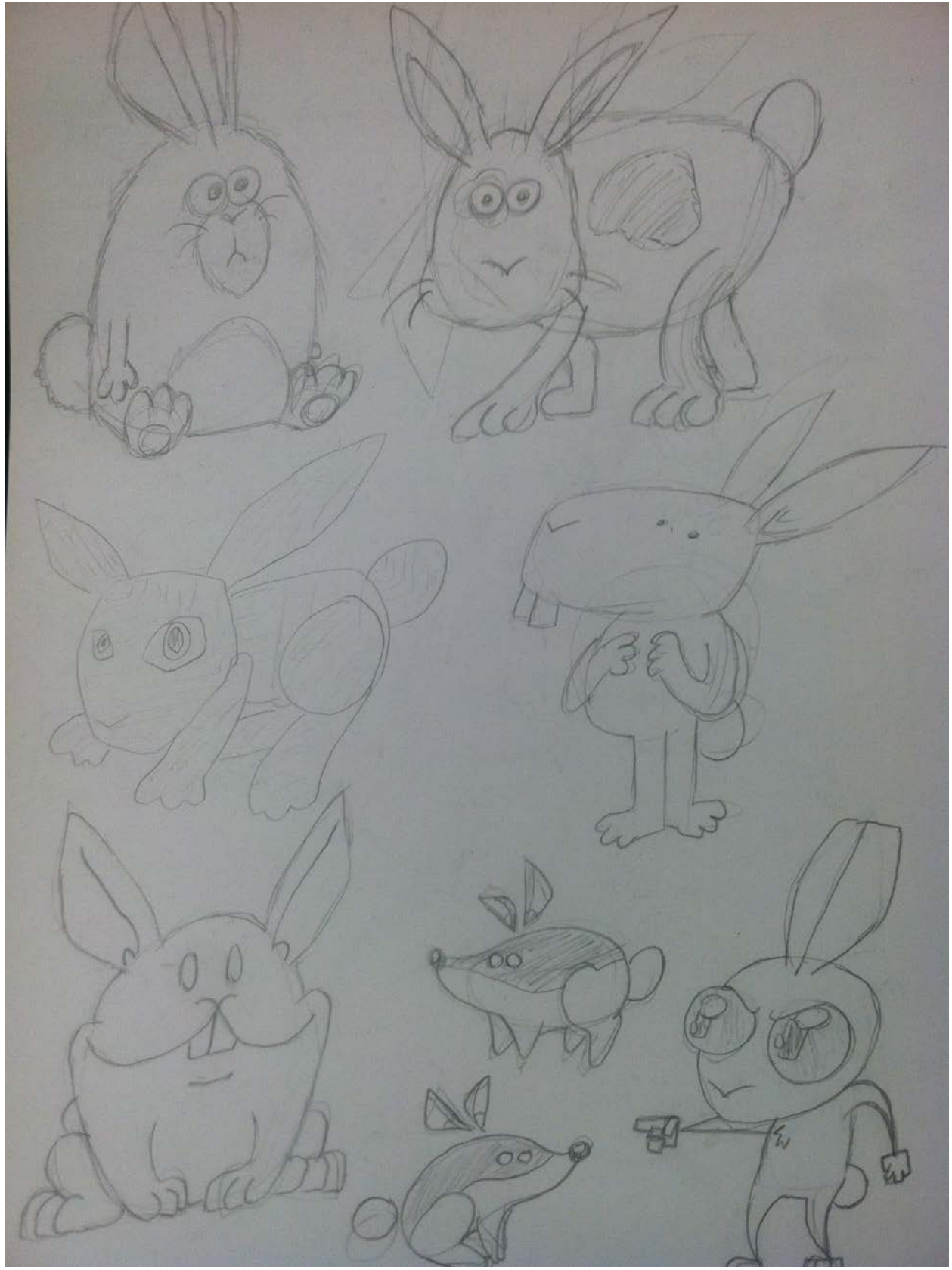


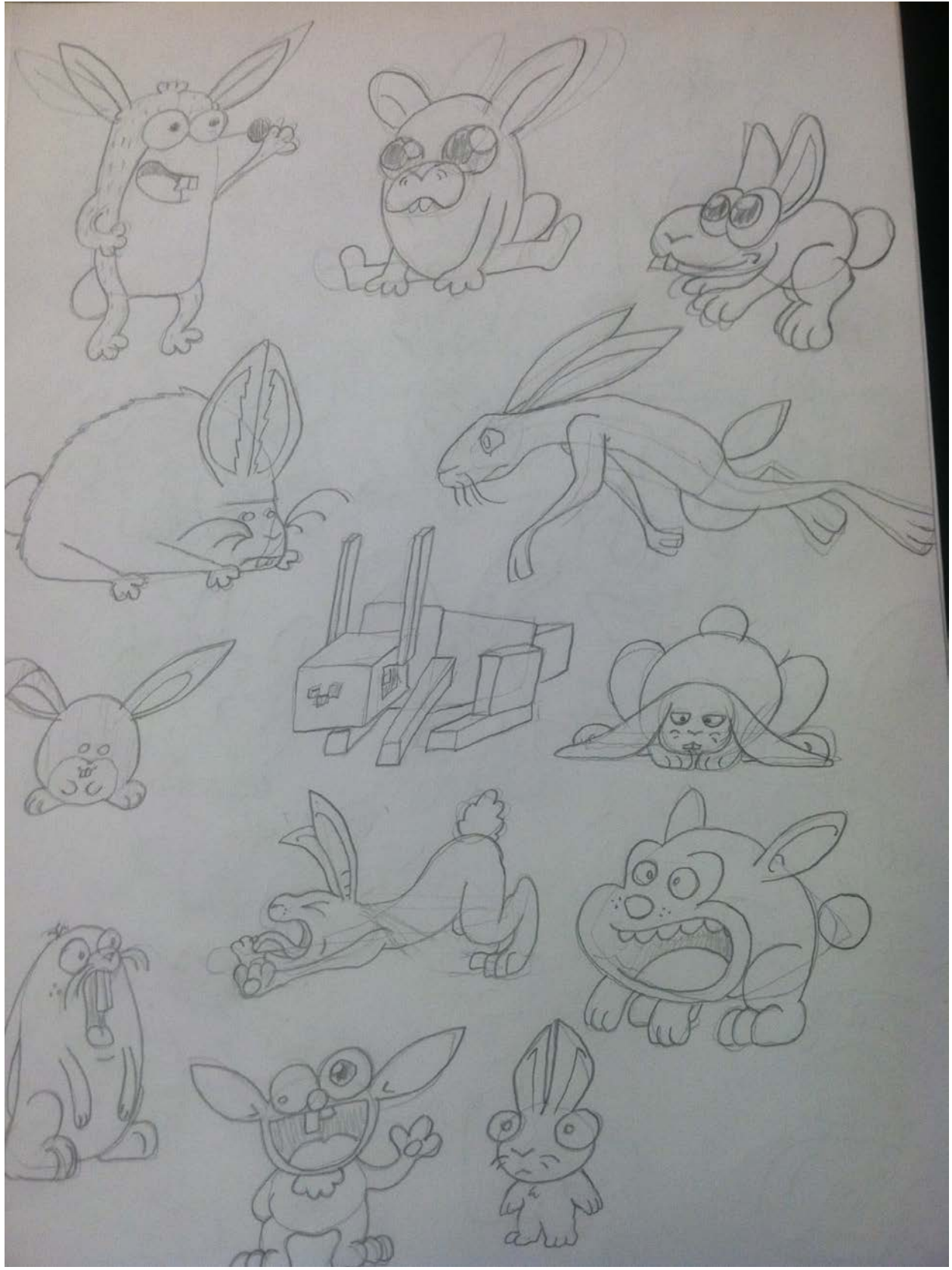


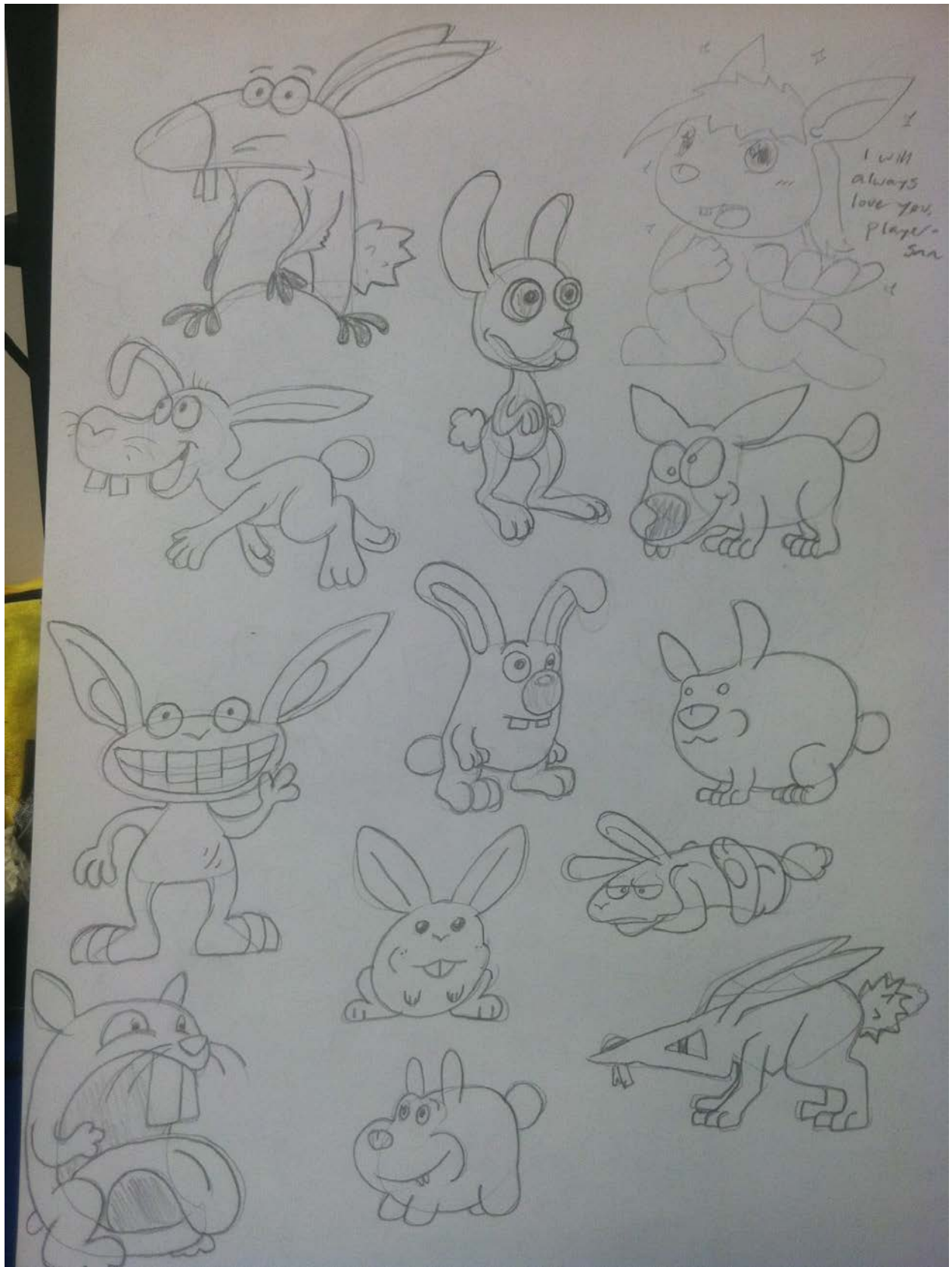


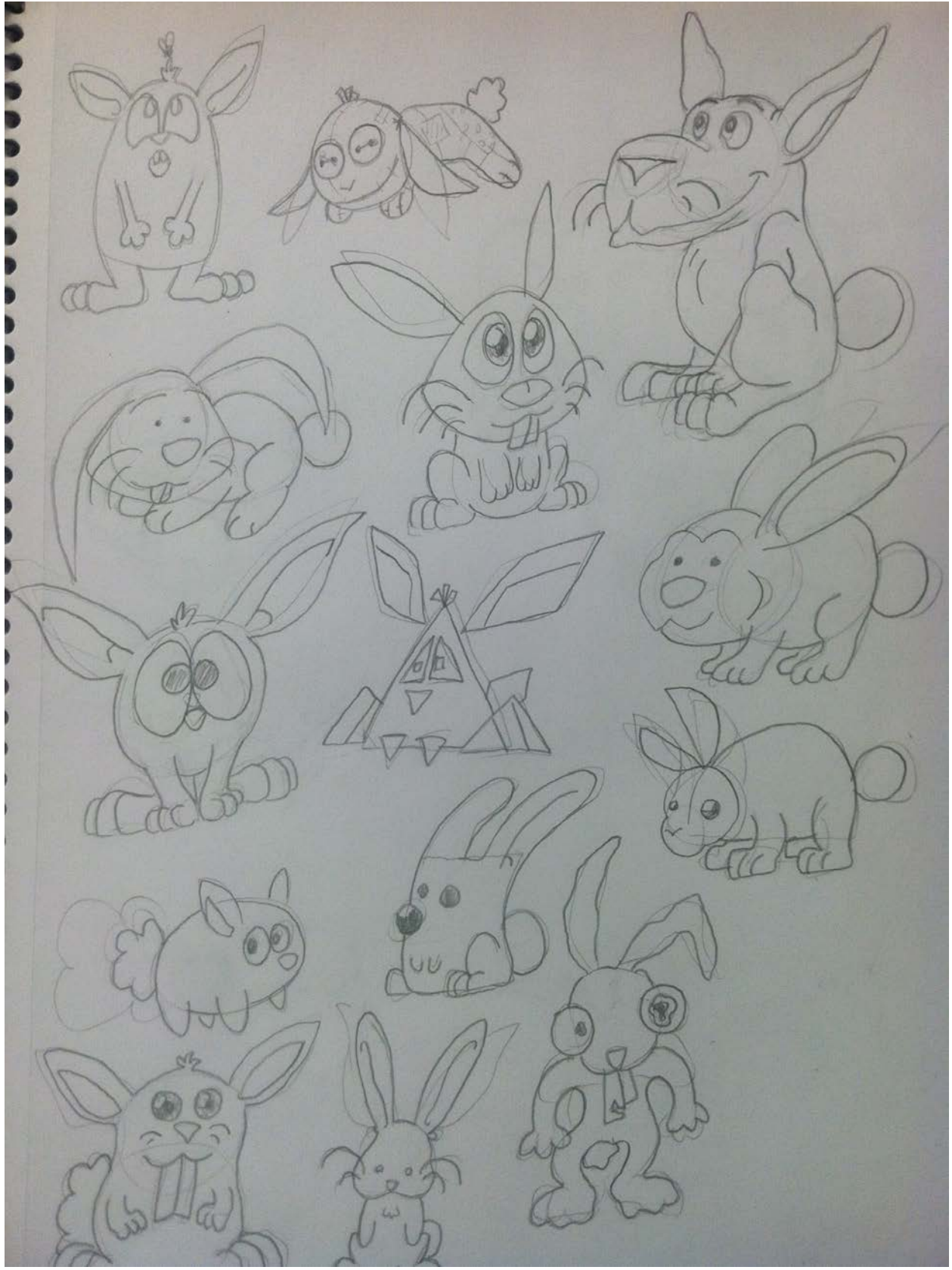












Appendix



B: Advisor Meeting Agendas

C-Term Meeting 1

Studio REKS

New Name

EcoKids
and the
Paper Pests



The image displays a meeting agenda for 'C-Term Meeting 1' by Studio REKS. It features a title section, a 'New Name' section with the text 'EcoKids and the Paper Pests', a circular logo for 'the EcoKids & the Paper Pests', and a screenshot of a game interface. The game interface shows a tree with a sign that says 'PLAYER TURN', a '6 Turns Remaining' indicator, and an 'Actions' button.

Talking Points

- Booth Submissions
 - PAX East
 - Boston Indies Demo Night (Feb 24)
- iOS Certificate
- Jake got ISP credit

Website

<http://gdc.wpi.edu/paperpests>

- Image/video slideshow
- Contact info
- Game Description
- Twitter Feed

Tech

- New UI and Menus
- Board generation framework 70% written and tested
- End game condition

Rowan's UI Work - Gameplay



Rowan's UI Work - Pause Menu



Rowan's UI Work - Environment Status



Stickers appear in upper right hand box

Status Report

The Good	
Living Trees	<input type="checkbox"/>
Saplings	<input type="checkbox"/>
Kokakos	<input type="checkbox"/>
Kokako Eggs	<input type="checkbox"/>
Harriers	<input type="checkbox"/>
Harrier Eggs	<input type="checkbox"/>
The Bad	
Possums	<input type="checkbox"/>
Dead Trees	<input type="checkbox"/>

Notes

Rowan's UI Work - Settings Button & Menu



Rowan's UI Work - (from top left to bottom right) Main Menu, Level Select, Journal, and Credits



*Note: full sized image could not be
uploaded to Google Slides or
Imgur, shrunk version is shown*

Rowan's Animation Work

- Eggs hatching
- Birds take off and landing
- Birds eating
- Possum startled
- Possum trapped

Note: Animations are still in Spine

Kiara: Character Animation

Hide



Going forward

Tech

- Finish board generation framework, start iterating quality of generated boards
- Polish up UI, fix menu related bugs

Art

- Rowan: Finish table menus (main menu, level select, journal, credits) & finish first runs of all animal and egg animations

All

- Prepare MassDiGi Slides/Video

C-Term Meeting 2

Studio REKS

MassDiGI Game Challenge

Won the
Serious
Alpha
Category!



Demoad the game and made
industry connections



Demo

<https://drive.google.com/?authuser=0#folders/0ByJI7J9mnHriUFhsMDJZOFIGQkk>

Evan's Work

- Piece Variation
- Phone
- End Screen
- Popup



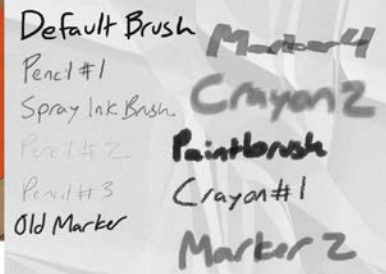
Sam's Work

- Explored audio frameworks; wrote stress test
- Fixed bugs
- Rewrote player action framework

Rowan's Work

- Kokako bouncing animation
- Minor edits throughout UI
- Added assets and blurb to website
- MassDiGI Game Challenge preparation and participation
- Research and note-taking for Professional Writing side of MQP
- Twitter updates

Rowan Art Stuff



Next Week - Tech

- Run the stress test
- Design and implement audio integration
- Begin Tutorial
- Implement player animations as received

C-Term Meeting the Third

Studio REKS

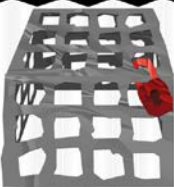
DEMO

<https://drive.google.com/?authuser=0#folders/0ByJl7J9mnHriUFhsMDJZOFIGQkk>

Tech Work

- Card buttons for selecting avatars
 - Avatars now fade when unselectable
- Stress tested audio framework
- Optimized board generation
- Tutorial functionality
 - Pointers, camera movement, text popups

Rowan's Art



Next week (tech)

- iPad
- Undo actions
- Start save functionality
- Create more “scenarios” for random generation
- Continue working on tutorial

Next Week (Art / Writing)

Rowan

- Continued synthesis work
 - deWinter meeting Thursday
- Business Cards
- Banner
- Miscellaneous asset editing
- Boston Playcrafting 2/24

C-Term Meeting 4

Discussion Points

- iPad updates?
- Playcrafting Boston
- PAX IQP Info Session - Tomorrow 2pm

Tech

- More work on tutorial functionality
- Undo ability
- Started saving functionality

Art: Animations

- Rowan Revegetate-Complete
- Kiara Revegetate-Line Art Complete



Banner
Design (in
progress)



Next week (Art)

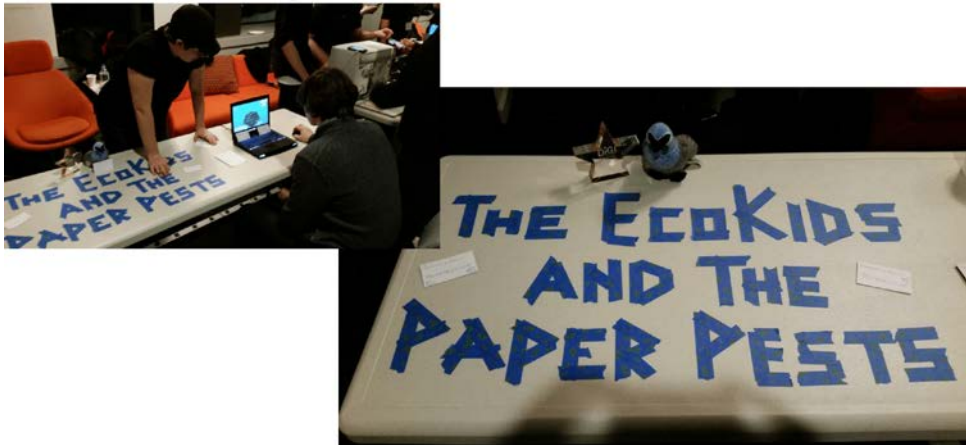
- Complete Revegetate Animation
- Capture Animation
- Complete New Tiles
- Business cards for Pax Printed

Next week (tech)

- More tutorial work
- Wrap up saving
- Start transitions between menus and boards

C-Term Meeting Five

Winter Expo



tion

- Business Card
- Banner
- iOS Icon
- iOS License
- iPad Lock
- Made in MA
- East
- Stinging F



Tech

- Integrated saving
- Designed and tested board transitioning ideas
- More tutorial work
 - Placeholder tutorial for conventions
- Touch screen support

Website Headshots



Welcome to The EcoKids and the Paper Pests!

Your goal is to protect these birds and their habitat...
...by stopping the invasive Possums!

This is the Overhead Board. It shows the entire ecosystem.

Select a tile with Possums to enter that area of the ecosystem.

The animals interact with the environment in different ways

As the EcoKids, you can...
Place Traps Catch Possums Replant trees

You have 8 turns in an area before returning to the Overhead Map

8 Turns Remaining

All areas are taking turns with you while you're in an area. The Map will show these changes

If you need help, consult the Stats screen!

Status Report

The Good	Notes
10	Only a few possums in this area, try to catch them before they cause any damage!
The Bad	
7	

7 Turns Remaining

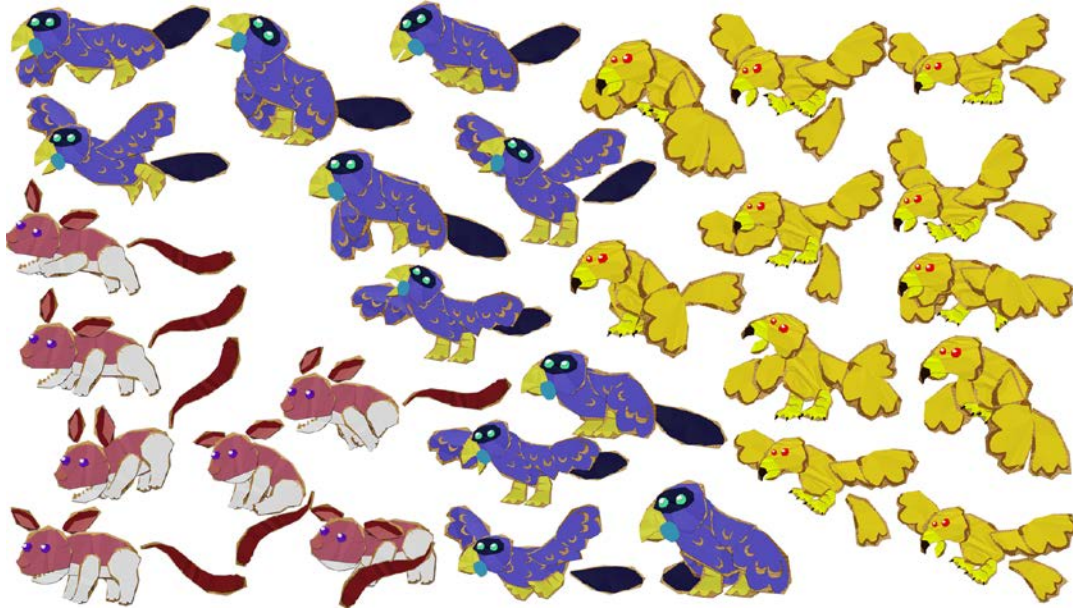
Ready to play?

I'm confused, show it again

Let's go stop those possums!

Tutorial Files





Next meeting (tech)

- Complete some form of transition between boards
- Begin programming animations for global board
- Build on iPad
- Implement player animations/Traps/Tiles
- Back to full tutorial

D-Term Meeting I

Six Weeks Remain

Demo

<https://drive.google.com/open?id=0B7c1Ed0Oghf0MVdDQmtVeGNCZHM&authuser=0>

Tech

Board transitions

Started global board animations

Fixed Possum AI

Art Implementation

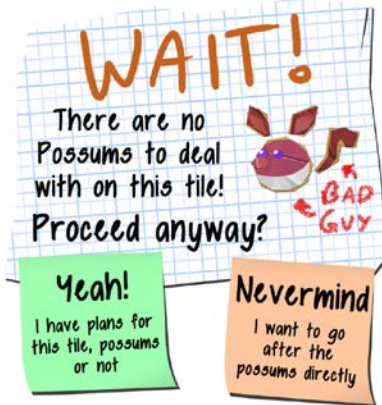
Trap animations

Falldown animations

Sprite rotation

Cap flipping

Rowan Art



Rowan Art

Other Art:

- Hunger Animations
- Death Animations
- Spritesheet Edits



Kiara Art



Events

Destination Imagination - Saturday

Boston University Day of the Devs - Sunday

Next week (tech)

Continuing global board animations

Work on full tutorial

D-Term Meeting 2

5 weeks left to thrive

Demo

Day of the Devs



Tech

Tutorial popups and text

Character emotions

Resolution Support

Strategy Board Animations (mostly)

Fast-forward functionality

Undo and “Are You Sure?”



Rowan's Art



Next Week - Tech

Add tutorial board generation
Implement second tutorial
Tweak strategy board animations
Add fast-forward button

D-Term Meeting 3

4 Weeks to Do More!
4 More Weeks to Do!

Demo

Tech

Finished strategy board animations
Asset integration
Tutorial Dialogue System and Board Gen

Next Week: Tutorial Work

Art

Fixed up animations for Kokako and Harrier

Playtesting

IRB Approval

- if we are in educational institutions, do we need any sort of permission?
- irb form review
 - see attached

Final Paper

- All sections roughed in
 - art, tech, design, research, conventions, playtesting, post mortems



D-term Meeting 4

Demo

Presentation

- Trailer
 - Starting recording on Wednesday
 - Jake will assist on Audio
- E3 Presentation
 - Friday (probably?)

Playtesting

Safe Homes last Thursday

2 more this week

Tech

More tutorial work
Art implementation
Bugfixes

Art

- New idles
- Background
- Other stuff

Next Week Tech

Tutorial!

Work on Level Select

Work on Camera Following

D-Term Meeting 5

Dawn of The First Day
72 Hours Remain

Trailer



Demo

Misc

E3 Presentation

Playtesting

Project Presentation Day [Slides](#)

Paper

DeWinter read it

Sam read it; wrote all the comments

Tech

Finished Tutorial 1 and 2

Camera follows pieces

Slight balancing

Bugfixing

Next week - Tech

Tutorial 3 and Level Select

More balancing

Appendix C: Playtesting Results

C-1 Assessment Pre-test Results

Timestamp	Do you know what an invasive species is?	A new herbivore is introduced to an environment where it has no natural predators. It easily finds shelter and a food source. What sort of impact will this animal have on the ecosystem?
4/9/2015 19:11:55	Yes	2
4/9/2015 19:18:32	Yes	1
4/9/2015 19:38:22	No	2
4/9/2015 19:53:32	No	3
4/9/2015 19:58:13	Yes	1
4/9/2015 20:14:55	No	1
4/9/2015 20:30:45	No	4
4/15/2015 10:55:51	No	1
4/15/2015 10:55:53	No	1
4/15/2015 10:57:03	Yes	1
4/15/2015 10:57:21	Yes	5
4/15/2015 10:57:37	Yes	5
4/15/2015 10:59:43	Yes	4
4/15/2015 10:59:45	No	3
4/15/2015 11:00:41	No	3
4/15/2015 11:02:56	Yes	3
4/15/2015 11:03:08	No	3
4/15/2015 11:03:43	No	3
4/15/2015 11:06:34	Yes	5
4/15/2015 11:14:47	Yes	2
4/15/2015 15:35:17	No	1
4/15/2015 15:39:01	Yes	4

A new carnivore is introduced to an environment where it has no natural predators. It easily finds shelter and a food source. What sort of impact will this animal have on the ecosystem?

2

A new species of rabbit is introduced to a small island. The rabbits have no natural predators on the island, and there is an abundant food source for them. The rabbit population increases quickly. What happens to the other island animals that share the food source with the rabbits?

The original species will struggle to find food that was before easy to find and will likely die out.

1

they die out

3

Begin to starve

1

They run out of food

1

They die.

1

there going to die

2

They run out of food. the other specie's population will decrease.

1

i think that the other anamils will starve

1

i think the rabbit is going to have a heart attack some day and the other animals are going to starve

1

They might not have any food left.

1

The other animals will die.

4

The other animals would die becaues the rabbits dont have a predator

2

The other animal species' population will slowly drop the more the new rabbit species' population increases. Unless the other species is carnivorous, the species will reach extinction.

1

there will be way less food & space for all other animals on the same island.

4

they will eat most of the food and they might eat the rabbit or they might fight over the food

3

some carnivor's can eat most of the rabbitts so the population will stay good except if theres no carnivor;s on the island then that would be a problem

4

they might fight for the food bigger animals might feast on the rabbits. Then they might starve.

4

they might run out of food but they would have to run around and find food but they might get heart

- 1 They might die and the rabbits, when the population increases, will take over the island and there might not be enough food left!
- 1 the other animals will not have as much food to eat as they used to because the rabbit is eating some of the island food too.
- 5 a. the rabbits die
- b. the animals that share the rabbits food go extinct
- 3 if there is limited amount of a food source some animals may die because some animals may not get enough food to survive. on the other hand if there is an unlimited amount of food ,no animals will die

A number of these carnivorous bird were set free in a forest where they have no natural predators, and many animals to feed from. The population of these birds quickly increases. What happens to the other animals in the forest?

If an invasive species was damaging an ecosystem, would it be a good idea to introduce its predator to the ecosystem to control the situation?

- I dont know 3
- the forest becomes full of only those birds 5
- Drops? 6
- The birds eat a lot of the smaller animals 4
- It drastically decreases. 6
- the forest will get less diverse 1
- I assume that biodiversity is the variety of species in an environment. the birds will take over and they will have the highest population in the forest. 7
- i think that the bird is going to die 1
- i think that the bird is going to die from starvation 1
- they will get eaten!!!!!!!!!!!!!!!!!!!!!! 8
- The other animals will die 6
- the birds will kill the animals in the forrest 8
- The other animals_ with an exception of poisonous animals_ will increase in population. 5

their population will quickly drop due to all of the carnivorous birds swooping down & killing them.	4
the bird will fight the other animals or it will turn the other animals into it's lunch or the other animal will be small an hide in deep holes or the other animal will be a little more stronger or even be tuffer and it might run faster than the bird	7
the population of the other animals in the forest decreases and that would also be bad	7
The birds will eat the little predators for a snack. And there will be not a lot of animals	4
the bird can n ot eat	6
the animals will start to be endangered!	8
the bird usually eats like mice and smaller birds so the population of other birds/animals will deacres because they will die if the other animals need food from prey	4
the other animals have very little population	8
if the birds are huge, many of the other animals may die but if the birds are small there may just be slight changes.	6

What would happen if a new carnivore were introduced to this environment?

What would happen if a new herbivore were introduced to this environment?

What would happen if a new plant species were introduced, and it competed with resources of the native plant?

negative	negtive	negtive
negative	negative, less plants	competition would eventually cause one to adapt or die
negative effect	positive?	positive
There would be a negative effect	Everything would stay the same	Everything would stay the same
Smaller animals would die, plant population would increase.	Plant population would decrease.	Native plant population would decrease.
it would be bad to have to meat eaters	it would good	it would be good
negative	negative	positive
negative	negative	negative

negitive	negitive	negitive
negitive /no	negitive/no	neg/no
It would be a negative result	I think it will be alright	It would be negative
i gess you could say every thing would stay the same	it would stay the same	positive
Depend on what kind of meat the carnivore eats	That would be a negative result	Depends on what is living in that enviornment
all of the herbivores would be overruled	all the plants will be devoured	there would be too many plants
positive and the bird will start eating people	negative no it will start hurting people	posititive yes
positive result beacause there arent a lot of the carnivore species	positive result because it would keep everything the same	negitive
there will be a positive and. everything will not stay the same	positive	positive
\some things might stay the sane and some might not	no	yes
there won't be enough food for the carnivores, nothing will be the same.	there will be a negative effect, there wont be enough rood for the herbivores Nothing will be the same	there willnot be enough food for the trees.
a negitive result because the carnivore eats meat and not plants and meat is animals nothing would stay the same	negitave result because a herbivore eats plants and plants are living	negitave because the plant will grow and take up room
no nothing would stay the same	probaly they would stay the same	yes because probaly no animal would eat it
negative result	negative result	positive result

What would happen if a new plant species were introduced, and it used different resources than the native plant?

postive
stay the same
positive

What is your name?

It would have a negative effect

Both species would thrive.

okay

positive

positive

annabelle

positive

isabella

neg/no

monaeya

everything would be the same

evan

negative

Joseph

Everything would be the same

Quinton

something would go wrong

ori

negative no

kayla

everything would stay the same

Navid

negative

kioni

no

nakheyla

it would be good

Samantha

positive because the new plant will not eat the exact same food or use the exact same room so the new plant will not take over the native plants space

sophie

yes

eric

negative result

sarah

C-2 Assessment Post-test Results

Timestamp	Do you know what an invasive species is?	A new herbivore is introduced to an environment where it has no natural predators. It easily finds shelter and a food source. What sort of impact will this animal have on the the ecosystem?
4/9/2015 19:44:28	Yes	1
4/9/2015 19:49:25	Yes	1
4/9/2015 20:00:35	Yes	2
4/9/2015 20:19:52	Yes	3

4/9/2015 20:34:28	Yes	1
4/9/2015 20:40:40	No	1
4/9/2015 20:44:32	No	3
4/15/2015 11:16:43	No	1
4/15/2015 11:17:40	Yes	1
4/15/2015 11:18:31	Yes	5
4/15/2015 11:19:26	Yes	1
4/15/2015 11:19:52	No	1
4/15/2015 11:19:55	Yes	3
4/15/2015 11:20:01	Yes	2
4/15/2015 11:20:32	Yes	1
4/15/2015 11:20:47	Yes	1
4/15/2015 11:20:55	No	4
4/15/2015 11:21:00	No	3
4/15/2015 11:21:24	Yes	3
4/15/2015 11:21:34	Yes	1
4/15/2015 11:22:17	Yes	2
4/15/2015 11:22:19	Yes	5
4/15/2015 16:14:04	No	3
4/15/2015 16:17:19	Yes	4

A new carnivore is introduced to an environment where it has no natural predators. It easily finds shelter and a food source. What sort of impact will this animal have on the the ecosystem?

A new species of rabbit is introduced to a small island. The rabbits have no natural predators on the island, and there is an abundant food source for them. The rabbit population increases quickly. What happens to the other island animals that share the food source with the rabbits?

- 2 the animals who were there originally would suffer and possible die out
- 1 the other animals die out.
- 3 They'd have to leave to find a new food source
- 2 They'll run out of food and eventually die out
- 1 They die.
- 1 they will die
- 3 they decrease
- 1 no
- 1 have no food
- 4 it will kill every thing
- 5 nice
- 1 the rabbit will have a heart attack and the animals will die from stavation
- 2 Their population drops.
- 4 other animals die
- 1 all the other ainmals will not get food because the rabbits will eat food and not leave any for the other ainmals and the rabbits will spread
- 1 They die because the rabbit is using all the food from the harvivors .
- 4 they need to get food
- 1 their food source will decrease & die.
- 4 it might eat most of the food and it might fight with the rabbit
- 1 They will die
- 1 they might eat other animals and the other animals will fight
- 2 to many animals can effect the ecosystem by taking its resorces

4
3

they fight over the food that the rabbits and the other animal share
idk

A number of these carnivorous birds were set free in a forest where they have no natural predators, and many animals to feed from. The population of these birds quickly increases. What happens to the other animals in the forest?	What would happen if a new carnivore were introduced to this environment?	What would happen if a new herbivore were introduced to this environment?
Those birds could take over many of the resources that other birds or animals need,	negative	negative
the birds eat all the food, then they die because they exhausted all food	negative	negative
drops	positive	negative
It shrinks	The producers would grow more	The amount of producers would go down
The prey dies, plant population increases.	The prey population would decrease, the plant population would increase.	The plant population would increase.
bad	good	bad
they take over	negative	negative
no	negative	negative
will die	negative	negative
it will kill every thing	good	bad
i don't know	positive	positive
it will die from starvation	negative	negative
They will go closer to extinction	Depend on what kind of meat the carnivore eats	Negative result
other animals die	negative	positive
all the other animals will die because they will eat the animals	take over	take over
they ... will die.	not good because it will eat all the animals	not too good because they will eat all the plants
all they need to find food	no	yes
they all die quickly .	not good all animals die	not good on account of food going down

it might kill other animal or it will hurt or eat most of the food	negative	positive
They become endangared.	negetive	negetive
the bird will eat the mice and stuff	negitive	negitive
they could eat to many of the animals	negative	stay same
they over populate	no	if they would be able to share
idk	negative result	negative result

What would happen if a new plant species were introduced, and it competed with resources of the native plant?	What would happen if a new plant species were introduced, and it used different resources than the native plant?	If an invasive species was damaging an ecosystem, would it be a good idea to introduce its predator to the ecosystem to control the situation?
negtive	postive	5
positive	stay the same	3
negative	positive	7
Everything would stay the same	It'd probably cause a negative effect	4
The native plant population would decrease.	They would both thrive.	6
bad	good	1
positive	positive	7
negative	positive	1
negative	posidive	1
good good bad good	gooooood	8
positive	neg	8
negative	positive	1
negative result	stay the same	5
negative	negative	6
take over	take over	8
The first plant species will die because they take the the first plants things to live.	They will peacefully be.. well plants	8

no	no	2
not that big of a deal	definitely not good	5
negative	positive	7
negetive	negitive	8
negitive	posotive	1
negative	stay same	5
idk	idk	8
positive result	negative result	6

What would you rate your enjoyment of the game? What is your name?

Option 1

Option 1

Option 1

Option 1

10	annabelle
10	ag
4	Joseph
5	Monaeya
10	isabella
7	Quinton
10	evan
10	sophia
10	th
5	nakheyla
10	ori
10	kayla cruz
10	Samantha
7	kioni
10	Navid
10	eric
9	sarah

C-3 Playtesting Survey Results

Timestamp	What is your age?	How easy was it to navigate the user interface?	What, if anything did you find particularly confusing or unclear?
3/2/2015 23:48:32	22-30	5	I couldn't figure out how to control the camera. And though I understood the

				rules screen I'm not sure children would. There were so many pages and it was hard to keep track when all the info was thrown at me at once.
3/4/2015 11:37:26	22-30	4		The controls were intuitive, but it would have been nice to have had a brief screen that explicitly said "click on this to do so-and-so". Instructions on how to control the camera would have been nice as well.
3/29/2015 13:19:57	18-21	2		
3/29/2015 15:30:33	18-21	3		
3/29/2015 16:13:17	18-21	2		Don't like to read tutorial
4/9/2015 20:47:12	14-17	7		im just tired
4/15/2015 11:21:08	10-14	4		no
4/15/2015 11:21:32	9 or Younger	1		
4/15/2015 11:21:43	10-14	2		no
4/15/2015 11:22:18	10-14	2		
4/15/2015 11:24:51	9 or Younger	3		
4/15/2015 16:01:16	10-14	3		killing the animals how come i didnt kill birds
4/15/2015 16:06:16	10-14	3		
4/15/2015 16:12:07	10-14	5		The environment

Any other feedback you'd like to give?

How difficult did you find it

How easy was it to understand the

	to complete the game's objective?	objective and rules of the game?
Break your instructions into short interactive tutorial segments and allow the player to zoom out and rotate the board.	6	3
Running the web version on a Mac 10.10.1 and Google Chrome.	4	4
If there is supposed to be music on the intro screen and the instruction pages, it wasn't playing.		
Graphical glitch on settings: Sound effects slider was vertically displaced (moving it back and forth worked, it just was located five squares above the line).		
It would have been nice to receive positive or negative feedback after completing your turns in each area of the ecosystem. You could click in the top right corner for a status report, but since it immediately exited to the overworld once your turns were up you could miss out on a final report.		
Not sure if it's possible to change the angle of the camera, but I would have liked that.		
It seemed like maybe the stats didn't update until after the next turn loaded, since at one point I captured all the possums and it claimed there was still one running around. That was misleading.		
I like the music and sound effects. Only played one game so if there is more variety maybe I missed it, but it does get repetitive.		
	4	4
	3	5
	5	4

	7	7
i think that you should add levels	3	1
	6	5
no	4	1
	5	4
	4	3
it was fun	4	3
	2	7
	5	4

Do you feel that you understood how the environment worked?	What did you think of the art style?	Do you feel that you understood the player interaction with the environment?
I did not understand animal movement	I enjoyed it	I understood everything
I understood everything	I enjoyed it	I understood everything
I did not understand animal interactions, I did not understand the plants	I enjoyed it	I understood everything
I did not understand animal interactions	I enjoyed it	I did not understand the Trap action
I did not understand animal interactions, I did not understand the plants	I thought it was okay	I did not understand the Trap action, I did not understand the Plant action
I did not understand anything	I thought it was okay	I did not understand anything, maybe im just stupid because everyone else got it lol XD
I understood everything	I enjoyed it	I understood everything, I did not understand player movement
I understood everything	I thought it was okay	I did not understand capturing possums
I understood everything	I enjoyed it	I understood everything
I understood everything	I enjoyed it	I understood everything
I understood everything, I did not understand animal interactions	I enjoyed it	I understood everything
I did not understand animal movement	I enjoyed it	I did not understand the Trap action
I did not understand animal movement	I don't have an opinion	I did not understand the Trap action

I did not understand animal interactions, I did not understand the plants I enjoyed it

I did not understand player movement

Did you play to a Final Report screen?	Why do you think the game ended as it did?	Would you suggest this game to someone else?
No, I stopped beforehand	Couldn't tell what was going on b/c the camera zoomed in and focused only on whatever character i selected last	No
Yes, I failed to stop the possums	I don't know. Apparently the possums spread too quickly, but I had been successfully capturing nearly all of them...	Yes
No, I stopped beforehand		No
No, I stopped beforehand		Yes
Yes, I stopped the possums	I defeated all possums	Yes
No, I stopped beforehand	i stopped	No
No, I stopped beforehand		Yes
No, I stopped beforehand		Yes
Yes, I failed to stop the possums	i could not fiuri nout	Yes
Yes, I stopped the possums		Yes
No, I stopped beforehand		Yes
Yes, I failed to stop the possums	lose	Yes
No, I stopped beforehand	one	Yes

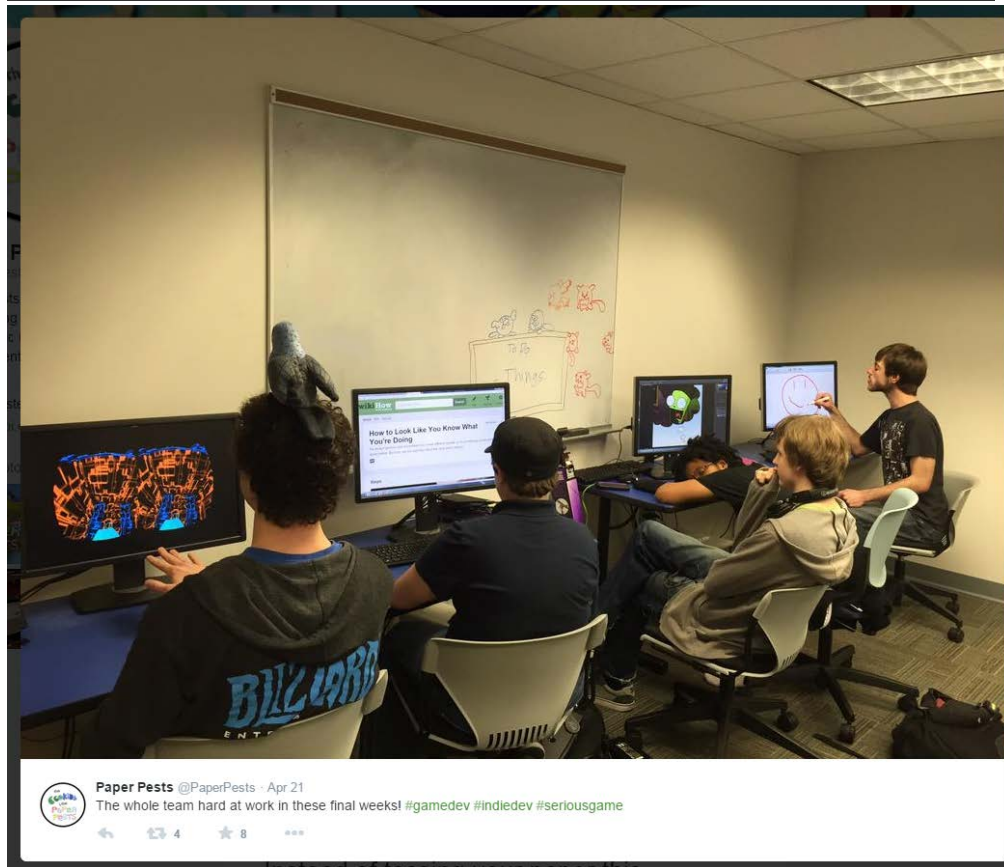
Yes, I failed to
stop the
possums

i think it ended like this to make it a challenge

Yes

Did you find the game engaging?	Did you find the game fun?	Would you play the game again?	During gameplay, what did you want to do? Were you able to do it?
No	No	No	
Yes	Yes	Yes	
Yes	Yes	Yes	
Yes	Yes	Yes	I ran into a glitch where the environment turn didn't end.
Yes	Yes	Yes	I was able to do what I wanted
No	No		i didnt get it lol
Yes	Yes	Yes	i do not now
Yes	Yes	Yes	
Yes	Yes	Yes	walk more
			make my own person. - Monaeya Andrade
No		Yes	have more turns and move around a little more
Yes	Yes	Yes	I wanted to go near the animal but it kept running way
Yes	Yes	Yes	I wanted to go other places then the small space I was not able to do it

Appendix D: Website and Social Media Content





Paper Pests @PaperPests · Feb 19

Welcome to the newest member of our team! Translating from Kokako to English is hard, but we'll get it down soon



for our kokako?



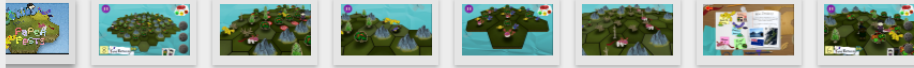
Paper Pests @PaperPests · Feb 12
Looking for the perfect Valentine to send? Look no further! Our cards are loving & educational! #indiedev #valentine



Paper Pests @PaperPests · Feb 12
Looking for the perfect Valentine to send? Look no further! Our cards are loving & educational! #indiedev #valentine







Description:

The EcoKids and the Paper Pests is an educational tablet game focused on biodiversity and invasive species. Modeled after real world events in New Zealand, the player is responsible for lessening the damage of the invasive brushtail possum on the ecosystem.

The environment naturally consists of trees, which provide fruits and berries, the herbivore kokako birds, and the carnivore harrier hawks, which all keep each other in balance. Once introduced, the possums eat the eggs of the kokako, as well as destroy the trees the kokako eat from. The harrier hawks do not keep the possums in check due to not recognizing them as a food source, allowing their populations to skyrocket. Left unchecked, the possums lead the kokako into extinction, which in turn kills off the harrier hawks.

The player uses real-world responses to invasive species to preserve the ecosystem against the possums through the EcoKids, a group of volunteers dedicated to helping nature. They can manually capture possums by sharing a tile, place traps to capture any possums that enter that tile, and replant trees where the possums have left destroyed ones. Using these actions, the player has to protect the environment and the species within it despite its invader.

This game is focused on educational value through immersive experience. By playing in the role of the EcoKids, players learn the interaction between different species in an ecosystem and how quickly things can become unbalanced by introducing non-native species. They also learn about how to combat the negative effects of these species in a way that does not put other species of the ecosystem at risk. There is also a Journal feature, where players can look at pictures and information about the possums, kokako, and harriers that exist in the real world, connecting the creatures in the game to those of New Zealand. All this information together will bring a basis of understanding for biodiversity and the threats of invasive species, allowing players to make informed choices on not only their personal interactions with nature, but also on voting for government legislature on ecological topics.

Tweets

Follow



Paper Pests @PaperPests 28 Apr

We have a brand new trailer!
Immerse yourself in the possum nabbing action!

[youtube.com/watch?v=_scC6K...](https://www.youtube.com/watch?v=_scC6K...)

#gamedev #indiedev #seriousgame

Show Media



Paper Pests @PaperPests 22 Apr

Happy #EarthDay2015!

Instead of tossing your paper this #EarthDay, how about you make paper trees for our kokako?

pic.twitter.com/a1NOLWLwrf



Expand



Paper Pests @PaperPests 21 Apr

The whole team hard at work in these final weeks! #gamedev

#indiedev #seriousgame

Tweet to @PaperPests





*Play
the
Game*

Core Team:



Pat Roughan: Lead Producer + Artist

[@patroughan](#)

www.patroughan.com



Evan Polekoff: Lead Programmer

[@epolekoff](#)

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Sam Kodzis: Lead Designer + Programmer

www.onemansam.com



Kiara Vincent: Lead Artist

www.kiaravincents.com

Special Thanks To:



Jake Hawes: Composer + Sound Designer

<http://www.jakehawesaudio.com/>