**Methodology Draft**

This section will give an in-depth explanation of the practical project. It will show the planning done prior to implementation within the game engine, as well as how each stage was implemented, and why certain technical choices were made.

**3.1. – Overview**

To answer the research question, the project created a procedural level generator which could be used to make levels for a 2D platformer using the Unity game engine. The project’s primary aim was to create a tool which would make procedural levels, then build this into a very simple 2D-platformer, and send this to participants who would then partake in qualitative tests to evaluate how this would affect their willingness to replay a larger scale 2D platformer which created levels in a similar way to this model’s output.

To complete these tests, participants would play the game for a short period of time, then fill out a survey to give their feedback on how they felt the game’s levels compared to those in other similar titles which they have played in the past.

**3.2. –Research**

**3.2.1. – Overview**

Before practical implementation could begin, some crucial decisions had to be made. These decisions included which engine or framework was to be used, and which coding methods and algorithms would be primarily used within the project.

**3.2.2. – Game Engine**

Since the project was to be built under a relatively tight time-constraint, the most important consideration when choosing a game engine was prior experience, as well as the ease of setting up a basic project which could be built upon. For this reason, three game engines were considered, each with their pros and cons. These 3 engines were:

* Unreal Engine 4/5.
* GameMaker Studio 2.
* Unity.

Unreal Engine was eventually ruled out. Whilst it does offer some very powerful features, and C++ is generally considered as a very fast, efficient programming language, it is not as easy to use for 2D projects. Unreal is often utilized for 3D games, and as such it does not come with as many 2D-oriented features. Although there are some examples of successful 2D games made with Unreal, such as Yoshi’s Crafted World [Nintendo, 2019], it was found to be cumbersome and difficult to set up a basic version of this project.

Another consideration was YoYo Games’ 2D-oriented engine; GameMaker Studio 2. As an engine exclusively used for 2D games, it is extremely simple to use and set up simple projects quickly and efficiently. The problems with this engine however stemmed from delving deeper into the project. Since GameMaker uses its’ own proprietary language, GML, it was significantly more difficult to find references and documentation from other users who have pursued similar uses of procedural generation.

The final option was Unity. Due to an extensive quantity of prior experience, it was known that Unity makes it relatively fast and easy to get a project up and running, as well as having very high-quality documentation, alongside a large community plentiful in code solutions to most issues. It also has built-in Perlin Noise functions, which would help massively during implementation, therefore Unity was the engine chosen for the project.

**3.2.3. – Implementation Research**

The final stage of research was to find practical examples of how to implement the key areas of the project’s build: Markov Chains and Perlin Noise. Whilst Markov Chains was largely logic based, and therefore didn’t require any direct tutorials beyond the prior research needed to understand how they function, Perlin Noise required slightly more technical solutions. As such, there were three key references which proved to be extremely helpful:

* The first of these was a video made on Brackeys’ YouTube channel called “PERLIN NOISE IN UNITY – Procedural Generation Tutorial” [[Brackey’s, 2017](https://www.youtube.com/watch?v=bG0uEXV6aHQ&list=PLS9pgTRs4XDvmyr0WYNx1b89fcbfhSyLO&index=1)]. In this video, Brackeys goes over how to generate a Perlin Noise texture within Unity. Brackeys’ solution was slightly adapted then used in the final project.
* The next was a tutorial created by diving\_squid entitled “2D PROCEDURAL GENERATION TUTORIAL UNITY - PERLIN NOISE” [diving\_squid, 2020]. This tutorial was vastly useful as it explained how to take the generated Perlin Noise and utilize some of Unity’s Mathf functions to convert points on the Noise map to create a height map for the level. The examples used in this video inspired the script used for the first pass of the project.
* The final point of reference came from Unity themselves, through their Unity Documentation pages. Through these pages, a more in-depth explanation of their functions can be found, and this was later combined with the other two tutorials to help with adapting the examples to better fit the context of the project.

**3.3. – Design and Planning**

**3.3.1. – Overview**

It was vital to ensure that there was a solid plan of how the project should run, before any code should be added. Without this design phase, there was a good chance that many features would have to constantly be reworked to allow for future features, and this would severely hinder the project’s chances of completion.

**3.3.2. – Passes Design**

To prevent this, the project was split into five separate scripts, referred to as “passes”. These passes would be run sequentially, with the next one running once the prior one has completed its’ script, and by using this method it allowed for a streamlined development process as each feature would run almost independently of other features, allowing maximum control over editing their outcomes during development without requiring changes to the entire project. This section will outline how each pass was designed, and how it was intended to be implemented.

**3.3.2.1. – Perlin Noise**

Before starting the main passes, it was decided that the Perlin Noise texture itself should be generated from a separate script. To do this, there were four steps outlined in the design plan:

* Generate a random seed for the new level and use this seed to set a random X or Y offset to give a new Perlin Noise map every time.
* Set the pixel colour of every pixel within the map using the Perlin Noise algorithm.
* Store this new map to be used later.
* Begin to run the passes.

**3.3.2.2. – Pass One**

The first pass was to be used to generate a base ground terrain for the level, based on the Perlin Noise values. At this point, the ground would still be solid and would exclusively be used to create hills or dips throughout the level. The steps for this are as follows:

* Scale every point within the noise map to a height value based on the darkness of the pixel at that point.
* Go from left to right across the level and add ground blocks up to the correct point in that position’s Y axis based on the height value at that point in the map.
* Ensure all points fall within the correct constraints, which are:
  + The ground level falls between the maximum and minimum Y values possible for the level. This will be the highest or lowest that ground *can* spawn.
  + Make sure the ground does not have any immediate height changes which will make it impossible for the player to reach the next block.
* Run the next pass.

**3.3.2.3. – Pass Two**

The second pass oversaw adding gaps into the terrain and spawning in platforms for the player to use to beat these gaps. This pass was the beginning of Markov Chains usage, and as such a ruleset had to be created which would modify the passing chance at each state of the chain. The steps for this pass are as follows:

* Go over every point in the level.
* Run the Markov Chain at every position to test if a gap should be made based on the rules and parameters from the ruleset.
* If the Markov Chain passes then remove all the ground blocks at the current X position, otherwise move on to the next position and try again.
* Once all gap checks have been completed, repeat the process for spawning platforms, using the separate platforms Markov Chains.
* If any chains pass for the platforms, then spawn a floating ground block at that position, at an appropriate height above the ground to make sure the player can reach it.
* Once all gaps and platforms have been checked, the third pass should run.

**3.3.2.4. – Pass Three**

**3.3.2.5. – Pass Four**

**3.3.3. – Level Design**

**3.3.4. – UI Design**

**3.3.5. – Survey Design**

**3.4 - Implementation**

**3.4.1. – Pass One**

**3.4.2. – Pass Two**

**3.4.3. – Pass Three**

**3.4.4. – Pass Four**

**3.4.5 – UI**