



Game  
Programming  
Laboratory

# SandPerSand

"Survival of the Fittest"

TEASER

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# 1

## Formal Project Proposal

### 1.1 Game Description

#### 1.1.1 Overview

We are developing a 2D, round-based, local multiplayer, semi-cooperative platformer race game. The main goal of the game is to navigate a maze-like decrepit tower structure and escape the rapidly rising mountain of quicksand piling up at the below. The game is round-based where the rounds are fast-paced bursts of cooperation, betrayal, and action. A player wins after a culmination of rounds by obtaining the highest score via escapes and collectibles overall.

A player who is too slow to climb or stands on the rising sand for a time, gets stuck in it and is engulfed. That player loses the round and joins the game again at the start of the next round.

The players are engaged in a race to the top as escaping first is the main objective of each round and gives the player the bonus of first-choice in an in-between-round item shop. While there are items to collect during the level, these have relatively minor effects/power ups/buffs compared to those which are found in the round-shop.

Each item can be used both cooperatively and/or adversarially. For example, with a “chain-fling” item, a player can prevent another player from reaching the top by pulling them down, or help another player by flinging them up.

Each level has a number of small built-in challenges which require one or more players to complete. They are simple to understand and quick to complete, and have a boon for completing them (e.g., items or currency). The idea being that completing a challenge requires cooperation but can also lead to betrayal by players. For example, one challenge might require a group of players to stand on a specified platform for the platform to activate and quickly move upwards. But if one player jumps off the platform during its ascent, the platform breaks, leaving those

who chose not to jump off to fall and recover.

### 1.1.2 Background Story

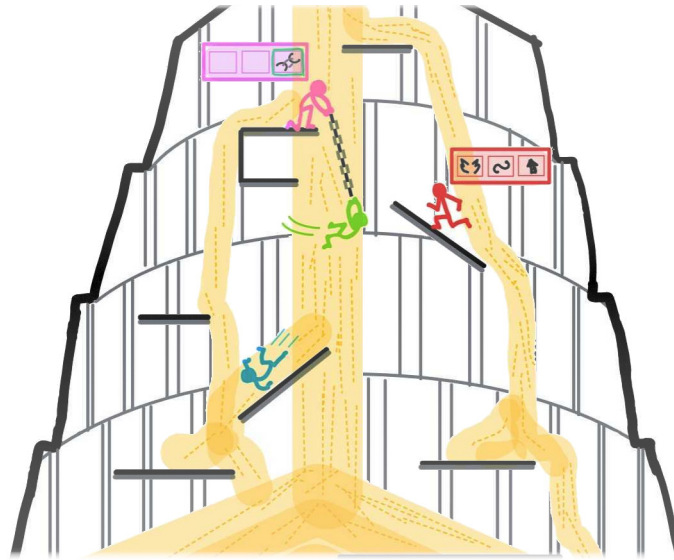
You, as players, are a group of aliens who really love shopping. This is the fantastic shopping trip to the earth that you have long been dreaming of. However, your spaceship crashed when you were entering the atmosphere. All your hard-earned money flew away from the broken window. And, instead of going to a big city, your spaceship hit in the middle of nowhere in a desert. You picked up the only dollar that happened to fall beside you, with tears rolling in your eyes.

Right at this moment, you heard some sound, it was from two archaeologists passing by, they were heading to an underground ruin. From their conversation, you knew there are full of treasures! Following them, you reached the bottom of the ruin. You stopped to stare at the face of a mummy, they didn't look completely lifeless, did they? Unfortunately, as in every mummies' story, you triggered the trap. The poor archaeologists died there. Sands are gushing out from all directions. Now, all you want to do is to grab every single treasure in your sight and head back to the ground!

Wait, what is that? Shops! It turns out there are shops run by mummies, they are alive! They don't seem to be bothered by the falling apart ruin, after all, they set those traps themselves and had fun watching stupid and greedy humans trying to survive( because they can't leave here and they are so bored). They sell powerful items to you for a more exciting escaping show, first come, first served. The passion for shopping is rekindled in your heart. You as a top shopaholic, would not stand that your buddy reaches to each mummy's shop before you do— and rap your first chance of picking the items.

### 1.1.3 Design Decisions

This section goes in detail about the various important components of our game. We first describe the general structure of the game and for what purpose it is designed. After that we go over the central external force in the game, the sand, and how we plan to implement it and how we expect it to behave. We quickly note on Player Death since it is tied to the Sand. We then elaborate on the general level design and the structure of a general level in the game. Then, we go over an element of the level design, the *Challenges* and their role in the player dynamic. We then describe the planned Items for the game and how they will function and interact with the players, as well as rudimentary inventory mechanics. We explain the purpose and function and rules regarding the *end-of-round Shop*. Once this is laid out, we propose a control scheme for the game as well as the expected player state machine as well as some of the more intricate state within it.



**Figure 1.1:** Concept of four players racing to the top with one falling due to sand, and others using an item cooperatively.

### Winning Condition and Game Structure

The game is designed to be played as a group of 2-6 players using gamepad controllers as the input method.

The game is a series of rounds where the number of rounds the game lasts is given before the game is played. Each round is played on a new/reset level.

The winning condition for any player is to have the most number of first-escapes (explained later) and/or collectibles after X rounds have passed. A first-escape occurs when a player finishes the round first.

If two players are tied in the number of first escapes, the next metric is the number of collectibles they have at that moment.

### Round End

Each round ends 10 seconds after the first player reaches the goal at the top of the level. A countdown appears to indicate the time left. Players who reach the end of the level are admitted to the end of round shop.

### Sand

The core mechanic of our game is the rising sand-mountain which acts as the main antagonistic force, swallowing players as they fall into it.

When the rising sand catches up with a player they start sinking into it and become *trapped*. In order to escape the sand, the player needs to spam the jump button (as explained in the Player

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State Machine). If a player falls into the sand from considerable height, or while *staggered*, they get swallowed by it immediately.

When a player dies in this way, they lose their items and a portion of their gems and gold. This forces the players to keep moving upwards and makes trying to loot the entire tower impossible, thereby putting pressure on the players when making decisions.

The sand is falling from the top of the tower, flowing along platforms and interacting with the players. This will be implemented as a separate object from the *rising sand* mound itself. We project that this will be some form of a **cellular automaton** with a grid of a higher resolution than that of the overall level. This dynamically simulated sand will be player-interactable; it will push on players in the direction of flow. Player will be able to stand on this sand as it lays on platforms. Using some *major items* player will be able to both create and/or destroy this kind of sand in the level during play.

### Player Death

Player death can only occur when a player is trapped by the rising sand for the required duration or collides with it at high speed. Player death is temporary, a player who has died enters a countdown. After the countdown has completed, the player is respawned in the last position below the current last player

Player death erases the player's inventory, major and minor item included, and erases a percentage of collectibles they have.

Player death is recorded as a statistic.

### Level Design

The game will have 2D sprite graphics inspired by architectural styles.

The levels will be on a grid with the addition of  $45^\circ$ ,  $\arctan 0.5$  (one up, two across), and  $\arctan 2$  (two up, one across) slopes. In this grid two types of platforms will be placed. The first type can be jumped through from the bottom, the second cannot. *Collectibles* will be placed all over the level to reward players for getting to an area first. These act as in-game currency and will also be spawned upon completion of *Challenges*.

### Challenges

The purpose of challenges is to slow players down and give them opportunities to interact and make decisions. As such they are not in themselves especially challenging, but rather a conduit for interesting social play between the players.

A few challenges we will consider implementing are:

- A lever which opens a door the player themselves cannot necessarily reach.



- Two buttons two players need to stand on to be dropped down a trap door into a room with rewards.
- A fast elevator which only starts when two players are inside it. If a player jumps off, it slows down significantly and traps the remaining player(s).
- Two buttons which starts a button mashing contest between two players standing on them. The winner gets a treasure chest dropped down to them.

### Items

Items are added to the game to give the players ways to overcome obstacles, provide further opportunities for cooperation and betrayals, and to add variety to the game play. There are two types of items, but first we must describe an important input method we plan to use with the majority of items.

#### Directional Selection

Some Items (marked with a "D") are selection directional. These items can target another player and apply effects to them, or if no player is selected when the item button is released, the item effects are applied to self (marked with an "S") or a random player (marked with an "R") depending on the item.

A player with such an Item should press and hold the trigger corresponding to said item. While the trigger is held, the other trigger is disabled. The player can use the right control stick to choose another nearby player. This will be indicated via an outline of that player in the selecting player's color as well as a line from the selecting player to the selected player in the selecting player's color.

When the player enters the selection state, the default selection is themselves. Pointing the right stick in the general direction of another player switches the selection to that player. If the stick is untouched, the default behavior for the item (self, random, or no effect) is performed.

#### Picking Items Up

If a player does not carry a minor item, and they walk over or collide with one, then they automatically pick that item up. On the other hand, once a player is carrying an item, they get the choice of swapping the item they are carrying with the item they walk over using the interact button.

The same is true for major items. When buying a major item in the end-of-round shop while one is already carried, the carried item is lost and replaced by the newly bought one.

#### Minor Items

A minor item can be picked up during play in the level. A player can only hold on to one minor item simultaneously. Minor power-ups should have relatively small effects and are always single use and expire at the end of the level. Minor Items act as reward during play; they are incentives to reach higher and/or solve cooperative challenges which likely require cooperation.

The following is a breakdown of the minor items in the game.

- Freeze Player (D/S)

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This directional minor item freezes the selected player in place and makes them enter the trapped state. The trapped player is trapped for 7 seconds, or until they reach the trapped exit condition. If the player selects themselves, the item affects them.

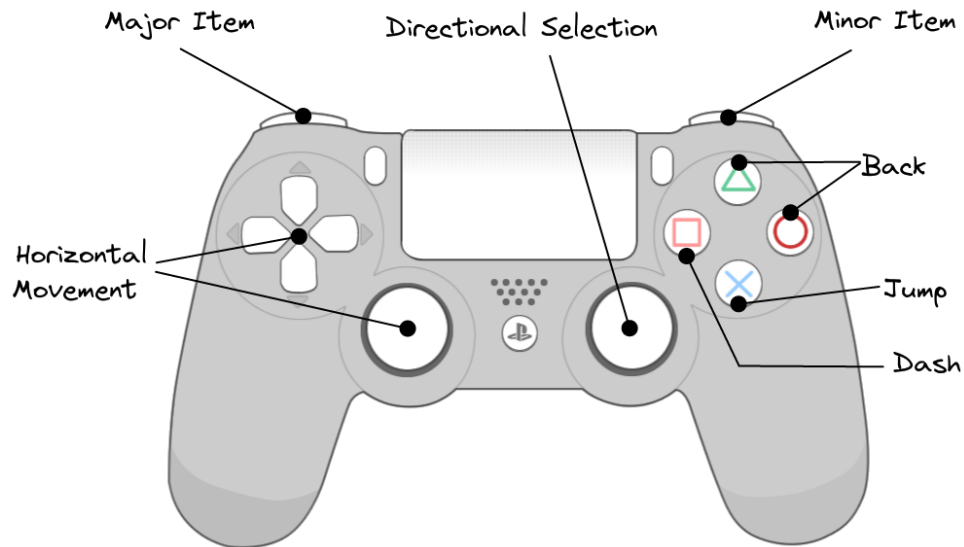
- **Control swap (R/D)**  
This random or directional item inverts the controls of a selected player, or if no player was selected, or a random player (excluding the player who activated the item). The inverted controls are indicated to the affected player via an aura around their sprite or on icon. The inversion lasts for 7 seconds.
- **Temporary speed-up / Slow-down (D/S)**  
This directional item slows or speeds up a selected player or self. After the selection, the next input from the right stick indicates if a speed-up or slow-down is to be applied. While a player is sped up or slowed down, they retain real-time control, i.e., their inputs are not buffered or slowed. This would make certain jumps in the level easier if slowed, or make a longer jump possible. The maximum jump height of the affected player is adjusted accordingly (slightly increased or decreased, respectively). The effect lasts for 7 seconds.
- **Double Jump (D/S)**  
A player who activates this item is granted one double jump. This is indicated to the player via an aura or an icon. They are allowed to jump once more while in the air. Once the jump is executed, the aura disappears, as does their ability to execute a double jump.

### Major Items

Major items can only be obtained from the end-of-round shop. A player can only hold on to one major power-up at a time. Major items can have a large effect on the game and/or the players.

The following is a breakdown of the major items in the game.

- **Player Position Swap (D/R)**  
The player who activates this item selects another player to swap position, and linear momentum with, essentially swapping the players. If no directional selection was carried out, a random player is selected for the swap.
- **Rope of Binding (D)**  
A player latches themselves to another via a rope of fixed length. Thereby, the two players cannot be farther than the rope's length from each other. The rope does not interact with level platforms. After a delay, either player can choose to cut the rope, indicated by the rope changing color. A player can be suspended, hanging from the rope, and swing while in such a state.
- **Create sand - Punch a hole in the wall**  
When a player activates this item, they punch a hole in the back wall in their current position. Sand begins to flow from that point (that grid cell and an area of cells become sand source cells).
- **Remove sand**  
A player can activate this item, and any sand in an area around them is destroyed. This includes source cells. This way, the player can change the flow of the game, literally.



**Figure 1.2:** Control map during play.

- **Slow Motion Time**

When a player activates this item it globally slows down time for a duration of time.

## End-of-Round Shop

At the end of each round, the players who finished the round get to access the shop. This shop will have a different selection of major items for varying prices for sale each round. The players access the shop in the same order they finished the level, so the fastest player gets first pick. However, if the first player to finish does not have enough collectibles/currency, they might not be able to buy the item they want. This detail, we feel, will encourage tactical play instead of the game being purely about getting to the top of the level fastest.

## Controls

See the proposed control maps in Figure 1.2 and Figure 1.3. Controls of our game follow conventions found in other platformer games. The shoulder buttons are used for the respective items (major/minor) and the right analog stick is used for directional selection (see Items section).

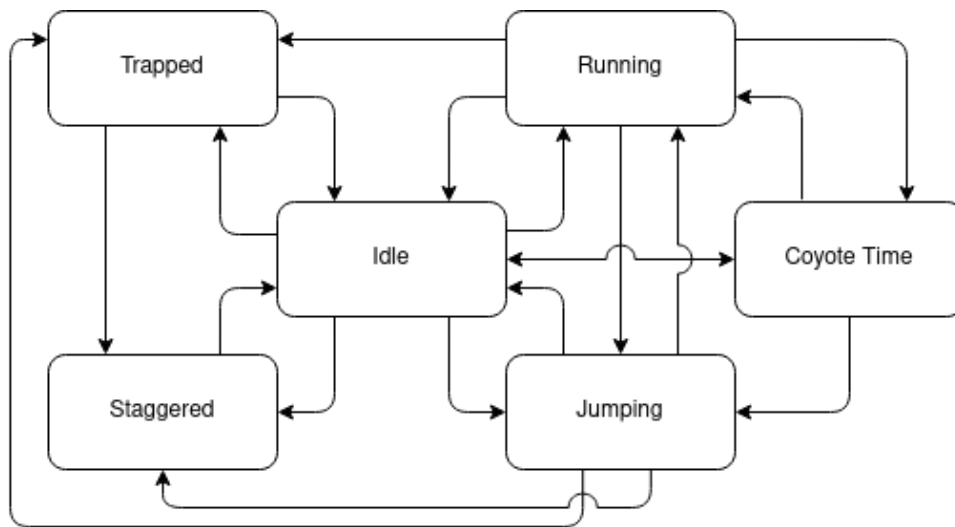
## Player State Machine

We expect the player state machine to have the states and state transitions shown in Figure 1.4. Of important note are the *Coyote Time*, *Trapped*, and *Staggered* states.

A Player enters the *Coyote Time* state if they run off of a platform of the platform disappears below them. In either case, the player is airborne without executing a jump. We would like to allow the player to execute a jump in this state for some number of frames, therefore being



**Figure 1.3:** Control map for UI and Menus.

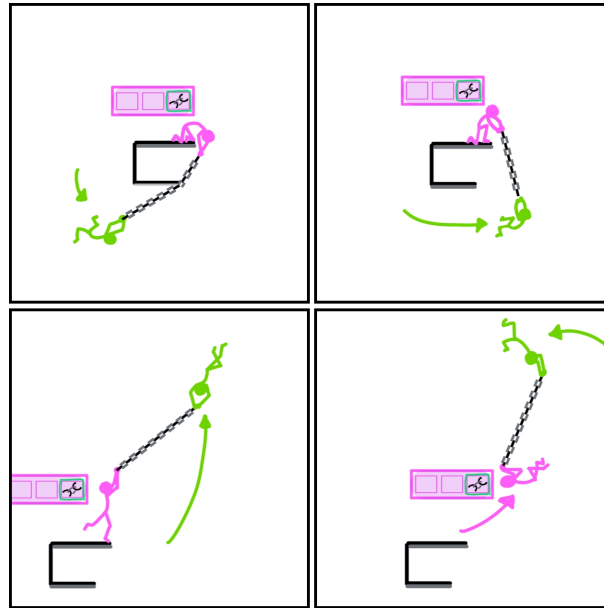


**Figure 1.4:** Player State Machine diagram.

more forgiving to non-frame perfect input. This state will last 5 frames and during it the player can execute a jump as if they are grounded.

A Player enters the *Trapped* state when they either stand on the rising sand for a duration or have an item which induces this state used on them. In this state, the player ceases to be able to control their movement and instead is forced to bottom mash the jump button in order to fill a meter which depletes as a constant speed, before it becomes empty. If the meter is filled quickly enough, the player exits the state, otherwise, when the meter runs out, the player enters the *Staggered* state.

In the *Staggered* state the player is unable to move or make other inputs. They are susceptible to any sand flow and will be carried with greater speed than usual by it. The state lasts for a duration. If a player touches the rising sand while in this state, they instantly are submerged and die, and wait to be respawned.



**Figure 1.5:** Concept of two players using an item cooperatively.

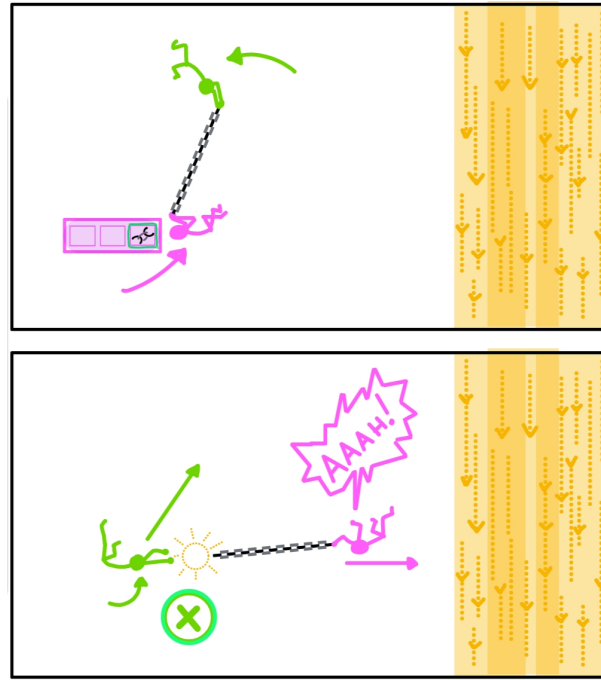
## 1.2 "Big Idea" Bullseye

The bullseye of our game is the social aspect we are trying to achieve. The game will give tools for the player to cooperate and play against one another while ultimately only allowing one winner. Therefore we are expecting alliances of varying durations to form during the game only to be broken at the latest by the end of the game.

The technical components facilitating this will be mini challenges strewn throughout the levels which require multiple players to overcome, but provide ample opportunities for betrayal, as well as the collection of small items and power ups and the input-control design.

## 1.3 Technical Achievement

We plan on the technical achievement of our game to be a Dynamic Sand Simulation. Since the sand plays such a central role in our game design and ties our game to the theme, we will make sure this feature stands out as a technically impressive and well-polished feature of the game. We believe this is an appropriate challenge and that there are several ways we could choose to implement this which proves a sliding scale as to how challenging we want it to be.



**Figure 1.6:** Concept of a player using an item adversarially. One player releases the chain to fling the other into a downward sand stream.

## 1.4 Development Schedule

### 1.4.1 Layered Task Breakdown

The following list presents the different targets that our team aims to achieve, and gives a short description of what each of them contains. We are still in the process of breaking some of these down into concrete work packets.

#### Functional Minimum

The functional minimum is a single-player platforming experience. It includes at least one level where the player jumps from platform to platform. The controls and the collision detection need to be implemented.

#### Low Target

The low target is a local multiplayer game, which uses gamepads. The game is expected to be played by a group of friends at a party, so the rounds will be kept up to at most 4-5 minutes long.

The aim of the players is to race to the top of the level, while sand is rising from the bottom. Touching the sand kills the players. The first player to reach the top wins the round.

Unlike the functional minimum, the players will be animated. This will improve the visual aesthetic of the game and make it more appealing.

### **Desired Target**

In addition to winning the round, the desired target will include conditions to win the game overall. This can be the conclusion of the overarching story of the game, with the winner being clearly shown and congratulated for their achievement by a win screen.

The game will involve buying of items between rounds. Those items will be bought by players with money that will be collected during the level and at the end of each round based on the order in which they finish. Those items can be used to more easily win subsequent rounds, such as speed boosts, power boosts and so on.

The game will additionally have small challenges in the rounds. Those challenges would involve a simple puzzle that may require the collaboration of more than one player. Those challenges will not be mandatory to complete the round, but will give the player additional coins or items.

### **High Target**

The high target will further include breakable sand platforms, which will break after a given set of seconds upon standing on them.

Each round will begin with a starting challenge, that needs to be completed by all players in collaboration before the sand starts rising and the timed part of the game commences.

Additionally, a ranking for the players and statistics for each round will be shown in the end.

The shop will further include additional items to buy.

### **Extras**

Additional rubber banding for the weakest players, so that they continue playing and having fun.

Additionally, sand will be falling from the top to the bottom throughout the levels, which will interact with the player and slow them down or kill them.

A player can trap another player via the cage item. The player can stay close to the cage they have dropped in order to make it last longer.

A binding mechanic which allows players to attach to each other and help with the completion of the levels. The players can choose to detach themselves from each other after a given period of time has passed.

Mini boss fights inside the rounds, in which the players are forced to collaborate in order to succeed.

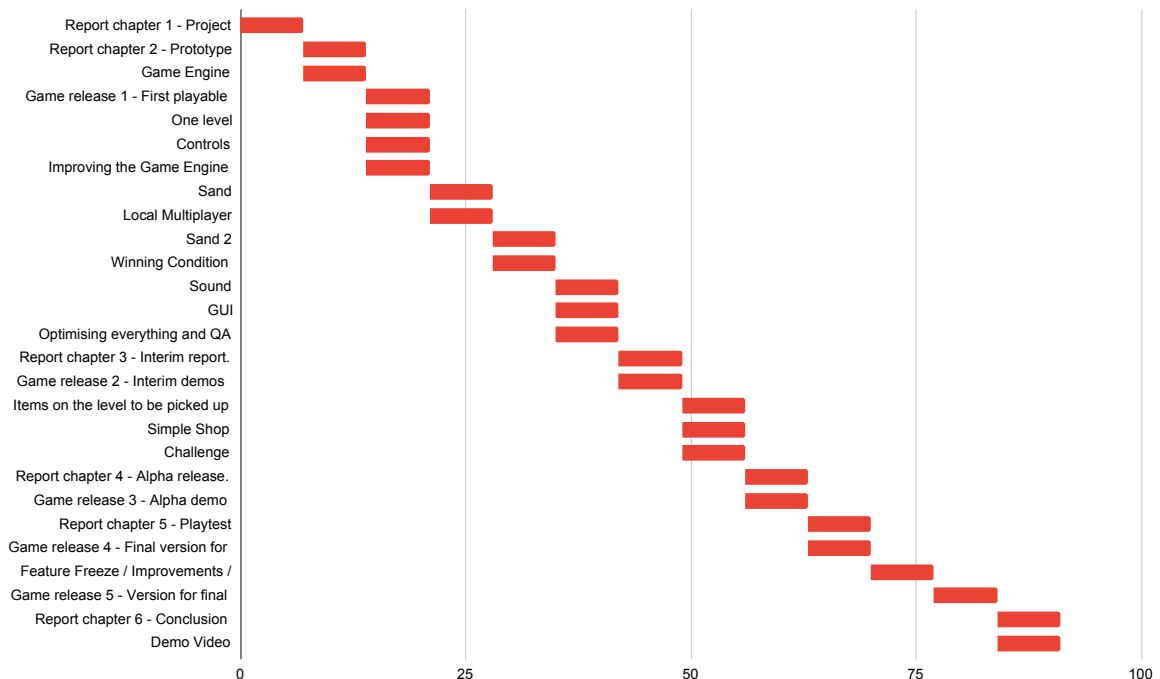
Items can hit the players while they race to the top, which slows them down or kill them.

## 1.4.2 Task List

Task	start date	due date	Responsibility
Report chapter 1 - Project proposal (Final formal version)	5.3.22	12.3.22	all
Report chapter 2 - Prototype	12.3.22	19.3.22	T, Y, C, D
Game Engine	12.3.22	19.3.22	J,R
Game release 1 - First playable demo (Minimum Target)	19.3.22	26.3.22	all
One level	19.3.22	26.3.22	Y,C
Controls	19.3.22	26.3.22	D,T
Improving the Game Engine	19.3.22	26.3.22	J,R
Sand	26.3.22	2.4.22	J,T,D
Local Multiplayer	26.3.22	2.4.22	Y,R,C
Sand 2	2.4.22	9.4.22	J,T,D
Winning Condition	2.4.22	9.4.22	Y,R,C
Sound	9.4.22	16.4.22	D
GUI	9.4.22	16.4.22	Y,C
Optimising everything and QA testing	9.4.22	16.4.22	T,D,J
Report chapter 3 - Interim report.	16.4.22	23.4.22	D,C,Y
Game release 2 - Interim demos (Low Target)	16.4.22	23.4.22	J,T,R
Items on the level to be picked up (Coins)	23.4.22	30.4.22	T,D
Simple Shop	23.4.22	30.4.22	R,Y
Challenge	23.4.22	30.4.22	J,C
Report chapter 4 - Alpha release.	30.4.22	7.5.22	D,C,Y
Game release 3 - Alpha demo (Desired Target)	30.4.22	7.5.22	J,T,R
Report chapter 5 - Playtest	7.5.22	14.5.22	D,C,Y
Game release 4 - Final version for Gobo	7.5.22	14.5.22	J,T,R
Feature Freeze / Improvements / QA	14.5.22	21.5.22	-
Game release 5 - Version for final presentation (High Target)	21.5.22	28.5.22	-
Report chapter 6 - Conclusion	28.5.22	4.6.22	D
Demo Video	28.5.22	4.6.22	R,T



### 1.4.3 Timeline



## 1.5 Assessment

### 1.5.1 Fun-factor

The main fun-factor of our game is the unpredictability of each round. the forming and breaking of alliances will keep the players on the edge of their seats as they scramble to reach the top. While the platforming action is the main appeal, the game also provides abundant opportunities for planning. “Do I just rush past these coins and get ahead, or spend time collecting then for a better item which will help me later in the game?” Of course, other players can and will put and end to your plans which adds depth to the concept.

### 1.5.2 Feasibility

Our planned game is quite ambitious and we believe that we can make this work.

There are many interconnected parts, such as the platforms, sand, items, challenges and the shop. In addition to that, we need to balance the individual parts to reach a state where the players actually need to consider cooperation vs. betrayal.

On the other hand, we limit ourselves to a 2D game which reduces the required effort considerably. There are many libraries available for MonoGame that solve or simplify certain aspects

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of our game. And most importantly, our team consists of motivated members with a wide variety of relevant experience, ranging from game programming to art design and sounds. Some members already helped producing games or worked on their own game.

# 2

## Prototype

### 2.1 Prototype Setup

We designed a playable paper prototype 2.1 and 2.2.

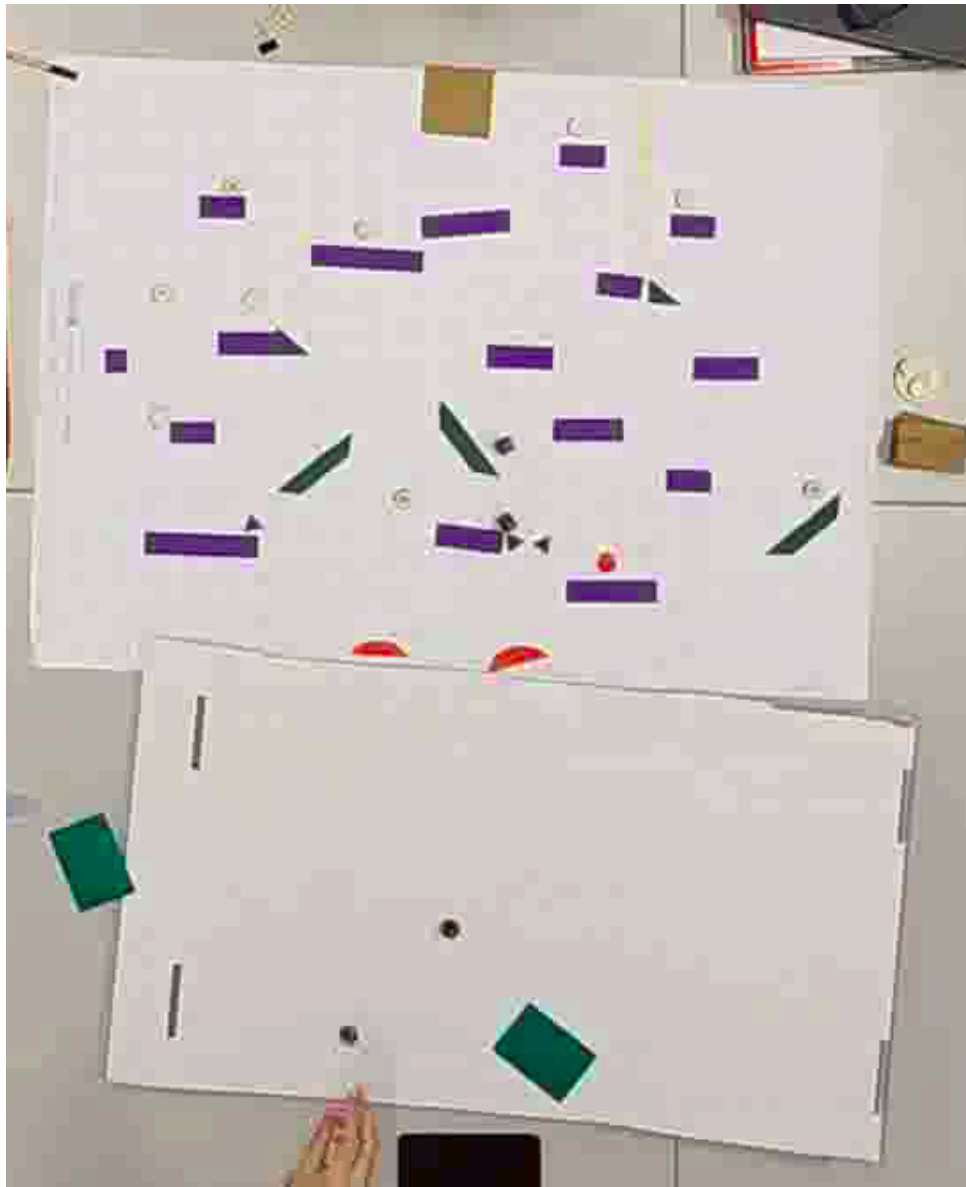
Our design involves two types of people:

1. Players: Play the game. Try to win by reaching the top first.
2. Game Master: Controls the automated game mechanics (such as the rising sand from the bottom) and makes sure the players abide by its rules.

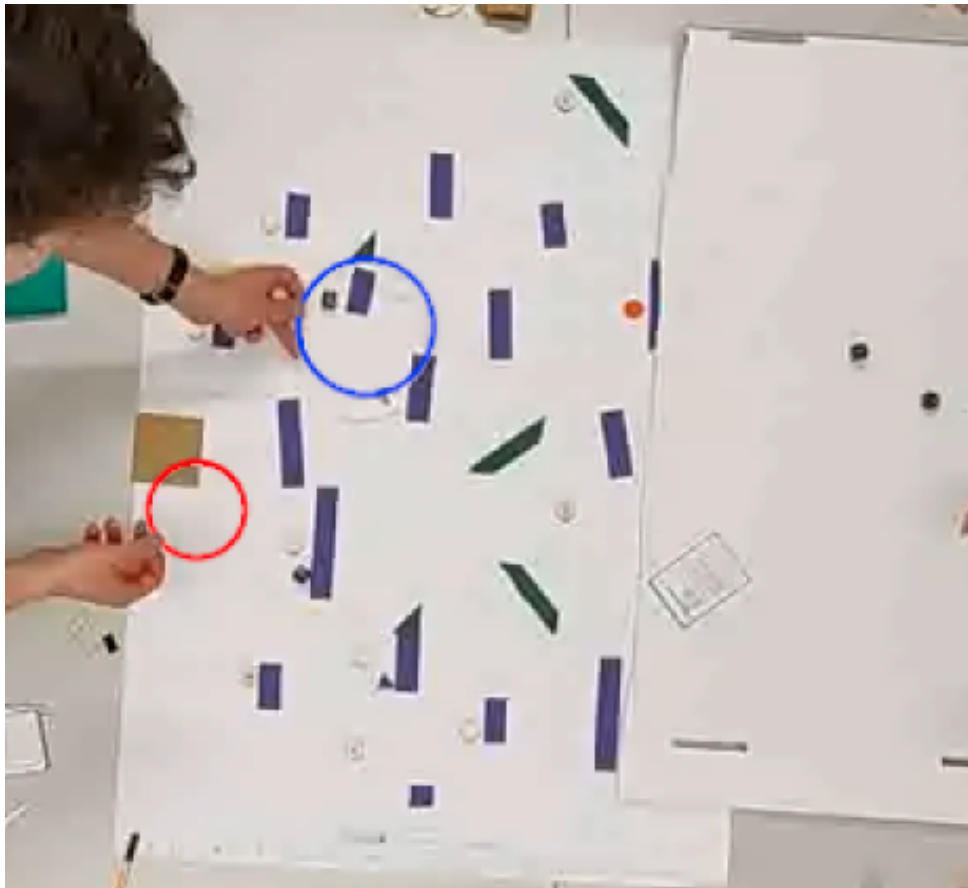
The players move on a grid plane. They take rounds, in each of which they can make a move. The raising sand from the bottom is modelled by a big piece of cardboard, which is moved 4



*Figure 2.1: In the middle of a heated race.*



**Figure 2.2:** Paper Prototype of the Game.



**Figure 2.3:** Game Master determining if a move is legal

## 2 Prototype

squares up every 2 rounds. If a player touches the rising sand, he dies.

On each round the players can move/jump to a new position. There are two type of jump:

- Easy Jump: A jump that does not go through falling sand and which finishes on a platform wider than 2 squares
- Hard Jump: A jump that goes through falling sand or which finishes on a platform narrower than 3 squares.

The players begin at the bottom of the level. Each player is represented by a differently coloured tetrahedron.

At every round, the players have 5 seconds to choose where they want to jump. They state their intended place of movement by putting a dice on their desired location. They can also state if they intend on using an action card. The list of action cards is shown at 2.4 and 2.5.

After the players finish making their choice, the Game Master checks if all of the movements could be performed. This is done by picking up a circle, and checking if there is a position of the circle for which the beginning and ending positions of the players are both points on the circle, and the arc of the circle do not go through any platforms. If this is the case, then the jump is possible. If the player performs a hard jump, he must say "even" or "odd" and then roll a dice. If he correctly calls the result, he successfully makes the jump. If he fails, then the player misses the platform and starts falling. For every platform he passes while falling, he has a chance of recovery. In order for him to recover, he must correctly call "odd" or "even" on a dice. If he calls correctly, then he makes a successful recovery and lands on the platform. Otherwise he continues falling. The falling stops when he reaches the bottom of the level, or when he hits the sand, which makes him die.

The game concludes when at least two of the players reach the top (represented by a brown square at the top of the level).

### **Position Swap!**

*Major Item*

**Price:** 4 coins  
**Target:** Random (Roll d4)  
**Time:** After Movement  
**Duration:** Instant

*Use this item to swap position with another player.*

Roll a four sided die to determine which player you swap positions with. Each player's number is determined clockwise, starting with you. You have the number 1. If you roll a 1, the item has no effect.

### **Spring Rope**

*Major Item*

**Price:** 2 coins  
**Target:** Other  
**Time:** Before Movement  
**Duration:** At least 2 rounds

*Use this item to spring yourself in front of another player via a rope.*

You move to a position collinear with the targeted player, using the *larger circle*.

The targeted player does the same in the opposite direction using the *smaller circle*.

### **Global Slow-down**

*Major Item*

**Price:** 2 coins  
**Target:** All (Others)  
**Time:** Before Movement  
**Duration:** 2 Turns

*Use this item to slow down all other players.*

The targeted players use the *smaller circle* for their movement.

All *hard jumps* become easier for targeted players. Targeted players have two *fall recoveries*.

### **Slow-down**

*Minor Item*

**Price:** --  
**Target:** Self/Other  
**Time:** Before Movement  
**Duration:** 2 Turns

*Use this item to slow down one other player or yourself.*

The targeted player uses the *smaller circle* for their movement.

All *hard jumps* become easier for targeted players. Targeted players have two *fall recoveries*.

**Figure 2.4:** Action Cards.

### **Speed-Up**

*Minor Item*

**Price:** --  
**Target:** Self/Other  
**Time:** After Movement  
**Duration:** 2 Turns

*Use this item to speeds-up one other player or yourself.*

The targeted player uses the *larger circle* for their movement.

All *easy jumps* become *harder* for targeted player.

### **Freeze!**

*Minor Item*

**Price:** --  
**Target:** Other  
**Time:** Before Movement  
**Duration:** 1 Turn

*Use this item to freeze one other player in place.*

The targeted player cannot change their position, but it affected by other effects.

### **Double Jump**

*Minor Item*

**Price:** --  
**Target:** Self/Other  
**Time:** Before Movement  
**Duration:** 3 turns

*Item enables you or another player to do a single double jump for the Duration.*

The targeted player can either use the *larger circle* for one jump or use a jump during *fall recovery*.

**Figure 2.5:** Action Cards.



## 2.2 Playing Experience

We played the game for more than two hours and find it to be quite fun. We found that it is very dependant on the rolling of the dice, and therefore on luck. This is a problem that will be less of an issue with the final product, as there this "luck" aspect will be replaced by the players' skill and ability to do good jumps.

## 2.3 Findings and Conclusion

- We confirmed that this unbounded cooperation-competition gameplay works well.
- Most of our designed items work well and do add uncertainties to the race.
- Current cooperative challenges didn't reach high usage in the prototype. We plan to refine on this part.
- We came to the conclusion that having a normal rope with which to tie two players is unnecessary. This is because it gives the players no clear advantage.

This is the reason why the rope was modified to a "Spring Rope". Instead of tying two players together for a given set of rounds, the "Spring Rope" can be used by a player to quickly move in a given direction, similar to long jump. This makes the mechanics simpler and the item is more usable.



# 3

## **Interim Report**

### **3.1 Progress**

### **3.2 Challenges**

### **3.3 Future Work**



# 4

## **Alpha Release**

### **4.1 Progress**

### **4.2 Challenges**

### **4.3 Future Work**



# 5

## **Playtest**

### **5.1 Playtesting Session**

### **5.2 Questions and Comments**

### **5.3 Design Revisions**





# 6

## **Conclusion**

### **6.1 Final Results**

### **6.2 Experience**

### **6.3 Personal Impressions**