

# The Magic Seesaw

## A Digital Learning Aid of the Lever Principles

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### Introduction

The Magic Seesaw is a simulation application that aims to introduce and familiarize young learners from 7-12 years old with basic physics, particularly Lever Principle in an engaging and fun experience.

Our learning objective is around lever. It is one of the most introductory machines that lays the foundation for advanced machines and other classic physics concepts such as mass, force, moment and energy. It is often covered in the secondary curriculum in K-12 Education. Lever is a versatile machine that can apply to multiple situations. In the Magic Seesaw, we will focus on the simplest lever, seesaw, which only involves concepts of moment arms and weight. When learning lever, students not only learn about the principle and equation (in this case,  $Weight_1 \times Arm_1 = Weight_2 \times Arm_2$ ), but also familiarize themselves with these concepts and prepare for future learning. Moreover, the Magic Seesaw is an easy and intuitive simulation that can facilitate students into using more advanced digital learning aids in the future.

When designing the simulation, we value the accessibility and affordance of the product.

Therefore, it will be available on multiple platforms and the interaction will be simple and intuitive. We take a combination of realistic and cartoonish approaches in visual design, trying to keep both the accuracy of simulation and attractiveness to kids. In addition, we incorporate Mayer's Principles of Multimedia Learning, Cognitive Load Theory, and Dual Coding Theory in our design to improve effective learning.

## Background

Lever is the most basic machine in physics education. It involves several principles and equations of different complexities depending on the situation. Therefore, the span of where it is covered in the curriculum is very wide. From our research, lever can be first introduced to preschool kids, age 3-6, as hands-on practices. And it can also be reintroduced together with other machines to middle school students, ages 10-12.

As for the Magic Seesaw, we mostly focus on teaching beginners to gain a pre-understanding of principles of lever in informal learning settings before formal teachings of the subject in classrooms. For example, it can be assigned as preparation exercises before the next class by middle school/primary school science teachers. It can also be presented as teaching aids for preschool and primary school classrooms to form warm up activities.

## Needs Assessment

### Learning Objectives

- Learners will be able to apply the Lever Principle with heuristics to resolve the challenges posed by the simulation.
- Learners will have a better understanding of the use and importance of Simple Machines.
- Learners will be familiarized with other physics concepts including moment arms, mass, gravity, force, and energy.
- Learners will improve their problems solving skills particularly with lever.
- Learners will raise interests in Physics in general.

## Learner Characteristics (Personas)

- Amelia, an 8-year old Spanish speaking girl at a public school who has never heard of the term Lever Principle, and doesn't have access to mobile electronic devices.
- Noah, a 10-year old English speaking learner at a private school who has learned the Lever Principle but didn't quite understand it and has just the mere interest of learning physics.
- Mia, a 7-year old learner who is about to enter primary school and her parents provide her access to multiple learning simulation games of natural science to intrigue the learner.
- Thomas, a 11-year old learner who has learned about Lever Principle but did not fully understand it. Has access to laptop, tablet, and cellphone. Need to review the Lever Principle as a prerequisite for middle school physics.

## Description of Content

1. Beginning Page
  - a. Tutorial Scene
  - b. Play Scene
  - c. Options
2. Tutorial Scene
  - a. Text Instructions
  - b. Voice Narrations
  - c. Animation Overlays
  - d. Interactive Demo
3. Play Scene

- a. Character Presets Window
  - b. Animals Options
  - c. User Input and Interaction
  - d. Mass, Weight, Objects, and Moment Arms
  - e. Positive Feedbacks
4. Options
- a. Languages
  - b. Sound Effects
  - c. Window/Font Sizes

## Market Analysis

**1: Popular videos at TedEd:** <https://www.youtube.com/watch?v=YIYEi0PgG1g>

This competitor is in video medium. It has better accessibility and affordances than a simulation game. The knowledge covered in this video is more advanced and detailed. However, the vocabulary and theories of this video might be too hard for young learners to understand. And the video lacks a hook to keep learners focused and engaged.

### The Magic Seesaw's Advantages:

- Better Interactivity
- More Fun
- Easier Content that are more suitable for our target audience

### The Competitor's Advantages:

- Wider Accessibility
- Better Affordances
- More Professional

## **2: MathGameTime:** <https://www.mathgametime.com/games/lever-physics>

This competitor is in the video game medium. It is in 2D cliparts graphic style which is not as effective as 3D models for simulation purposes. It has multiple levels and a mechanic of limited time, which makes it a game instead of a simulation. The sign indicators are very effective for users to be aware of where they are and what they should do next.

The Magic Seesaw's Advantages:

- A "Realer" simulation with better visual and physics
- More customization options
- Better interactive experience

The Competitor's Advantages:

- Good use of semiotics
- Level Designs

## **3: Gizmos:**

<https://gizmos.explorellearning.com/index.cfm?method=cResource.dspView&ResourceID=646>

This competitor is a digital simulation of the same topic. It is in 2D "Flash" style which is not as appealing. There are less places on the lever where users can apply force with.

The integrated informative UI gives users better understanding of Forces,

The Magic Seesaw's Advantages:

- More attractive
- More flexible interaction

## The Competitor's Advantages:

- Informative UI
- Available on browser, better accessibility and affordances

## Design

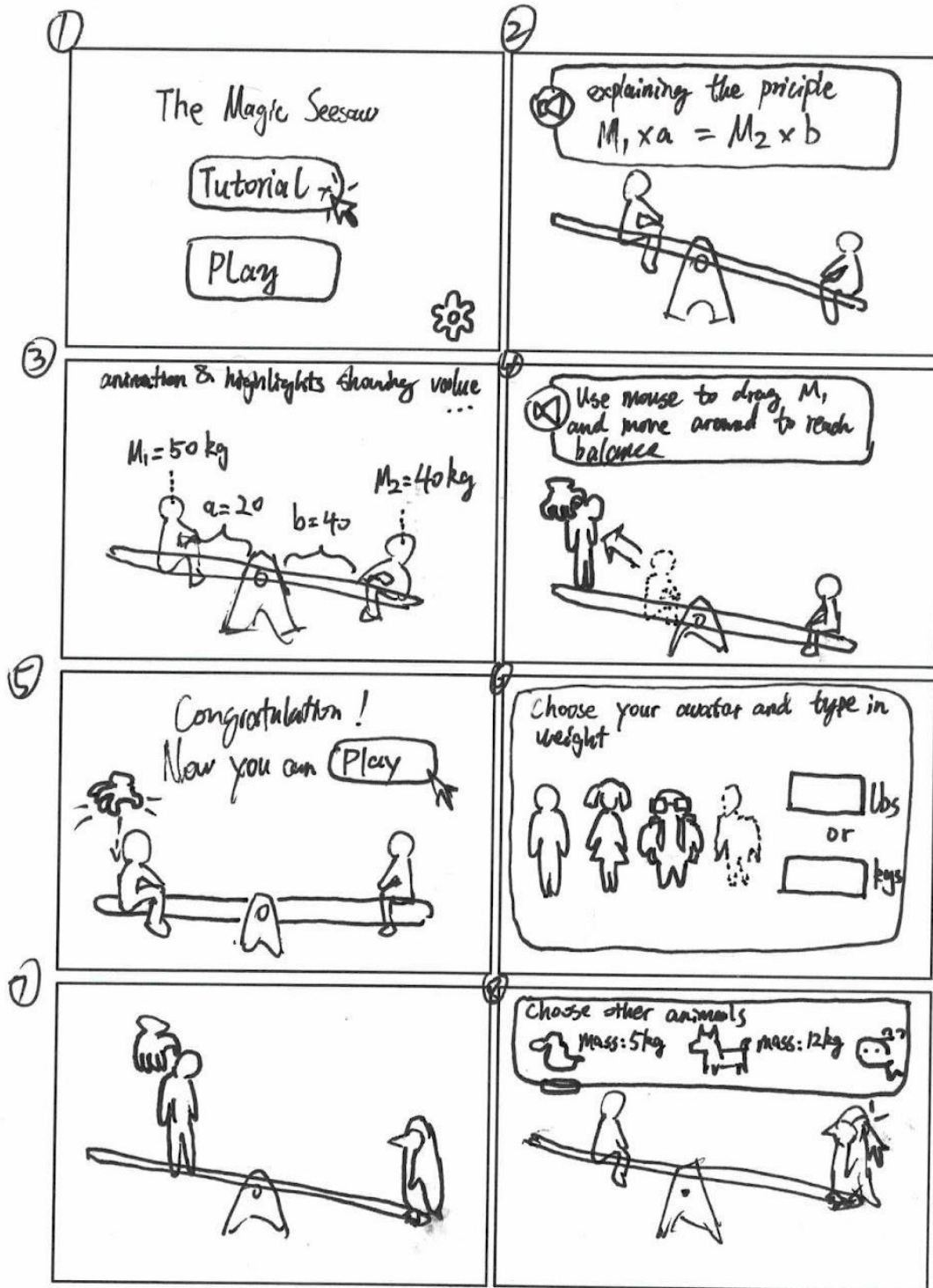
### Overall Ideas

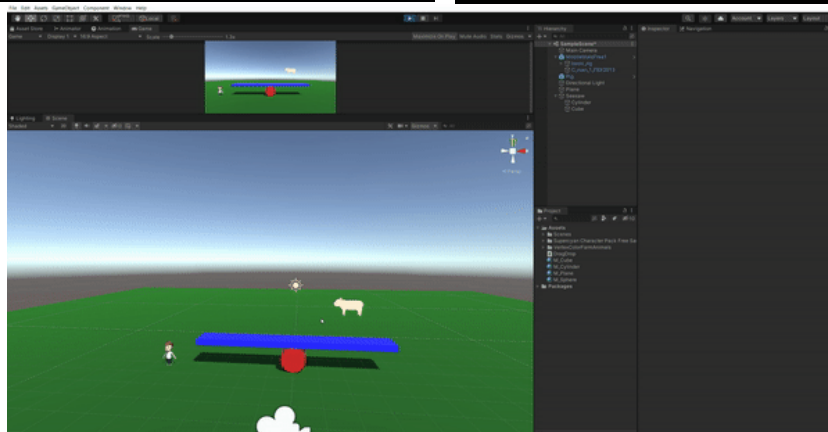
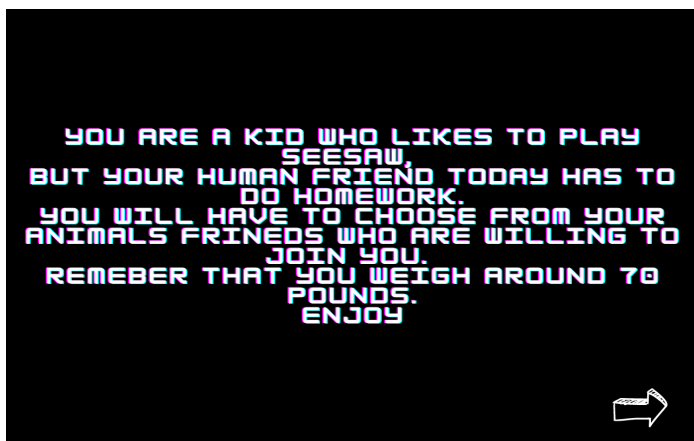
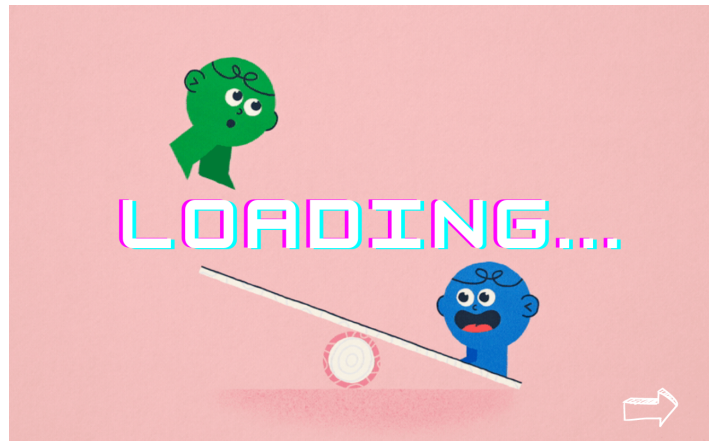
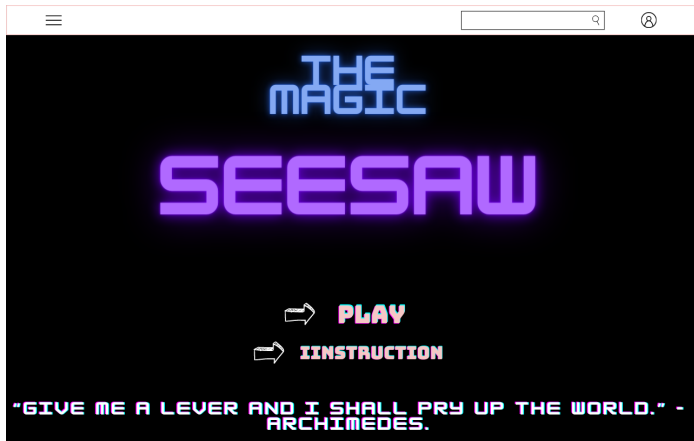
The overall simulation idea is simple. The user will play a kid who's playing seesaw with animals. The simulation can be considered as a series of challenges for learners to understand and apply the principle and equation ( $M_1 \times D_1 = M_2 \times D_2$ ). There will be an optional tutorial level with instructions on how to move and control, and elaboration on the science principle. As for interactions, learner can drag their avatar to change their position on the seesaw, therefore change  $D_1$ (distance from avatar to fulcrum); they can also drag animals to change  $D_2$ (distance from the animal to fulcrum); they can also change the seesaw to uneven to increase lengths on each side so they can lever heavier animals such as a hippo. When entering the Play scene, there are several avatar presets of different appearances and a weight input for users to choose. In Play, users are going to drag their avatar on the left side and animals on the right side to reach a balance for the seesaw.

The finished product will be available on multiple platforms, as many as Unity supports: PC, laptop, mobile, tablet. Users need either mouses or touch-screens as input devices to play. The visual design is in low-poly 3D style.

# Storyboard, Wireframes, and Prototype Demo:

## Storyboard for : The Magic Seesaw





## Description of player experience (walk-through)

User X double clicks and opens up *the Magic Seesaw* on his laptop. At the starting page, he sees two big buttons (Tutorial, Play) in the middle and a small button (Option) at the right bottom corner. To find out how to play, he clicks on “Tutorial”. After a short loading time, he enters a new scene. On the green grass, there is a seesaw with one 3D character on both sides. The top of the screen pops up an animated dialog box with a voice narration explaining what a lever is and how a lever works. X feels the narration is too slow so he clicks on the dialog box, and the full texts are shown and the narration stops. He clicks on the ‘next’ button at the bottom right of the dialog box. The dialog box closes and an equation shows up in the air “ $M_1 \times D_1 = M_2 \times D_2$ ”. Correspondingly, animated signs highlight where  $D_1$  and  $D_2$  indicate, and the value of  $M_1$  and  $M_2$ . X thinks it's easy and wants to play the seesaw right away so he clicks in the air. An animated arrow shows up, pointing towards the character sitting on the left side of the seesaw. X moves the mouse over the character and the mouse turns into a grab hand. He left-clicks and grabs the character to the tip of the left side. But the seesaw does not balance as he wishes. The instructions show up again, but this time, there is an animation of how to calculate the correct  $D_1$  in addition to the previous instructions. After the animation ends, an indicator appears on the seesaw. X grabs the character and puts it on the indicator's position, the seesaw balances. Then, a text shows up in the air “Congratulations! Now you can progress to ‘Play!’” with the sound effect of Christmas Crackers. X clicks on “Play” and he enters the Play scene. The first thing he sees in the Play scene is an avatar selection window with four available avatars and two dropdown menus where he can choose his weight. X lives in Vancouver so he puts 38 kilograms as his weight and chooses the avatar he thinks represents him. After entering the Play Scene, X finds that besides his avatar and the seesaw, there is a highlighted barn in the background. He clicks on the barn, the animal selection window pops up. In the animal selection window, the animals are listed with their appearances, names, and weights in kilograms. X likes penguins the most so he clicks on a penguin. Right after he makes the

selection, a penguin falls from outside of the screen onto the right side of the lever. And X starts messing around right away.

## Theory

We've incorporated three big theories with multiple principles in our sim design. The purpose and reasoning of each theory is described below.

### Mayer's principles of Multimedia Learning:

The medium we chose is video game, therefore, multimedia principles are inherited embedded in our design. We intentionally incorporate the following principles to better utilize the advantages of the medium.

- Coherence Principle: in the tutorial, we keep the visual concise and direct, avoiding all possible distractions and extraneous information.
- Signaling Principle: in the tutorials, signs and highlights are used to guide users' attention to key information.
- Redundancy Principle: Suppose some users might be too young to read the full text, we use voice-over and text description at the same time. However, users have the option to turn one of them off.
- Contiguity Principle: We delicately design the layout of the Tutorial Scene to make animations and texts appear close to their corresponding objects. And we put the narration in synchrony with the animation. (if the user chooses to leave the voice on)
- Modality Principle: Thanks to our choice of an easier topic, we are able to minimize the amount of text shown on the screen and keep the narration short as well.

- Segmenting Principle: Users are given plenty of choices, such as turn-off audio, show all texts, proceed to next...
- Pre-training Principle: We use the Tutorial Level to pre-train users before entering the free Play scene.

## Cognitive Load Theory

The target audience of our choice are young learners. Therefore, it's crucial to manage their cognition load in our learning design. We did the following in response.

- Manage Intrinsic Load by simplifying the physics: rather than a complex physics model in real life where countless variables affect the results, we only keep weight and moment arms for users to consider when solving problems.
- Minimize Extraneous Load by Redundancy Principle, Contiguity Principle: as stated in the Multimedia Principles part, we cut much of the unnecessary information and distracting contents when introducing the knowledge.
- Maximize Germane Load with: a tutorial level, which includes synchronous instructions; Incorporation of semiotics to reduce users effort for locating key information; Intuitive interaction designs to help users hands-on more quickly.

## Dual Coding Theory

The objective of the simulation is to not only understand, but also apply levers. Therefore, Dual Coding Theory is an ideal approach to teach the verbal knowledge and non-verbal knowledge simultaneously, and helps users transfer their knowledge faster.

- Verbal Knowledge with Non-Verbal Aids: The text and narration of the scientific background about levers are supported with supplementary animations.
- Non-Verbal Knowledge with Verbal Aids: The visual experience of interactive tasks and challenges are supported with codes, texts, and equations presented verbally.