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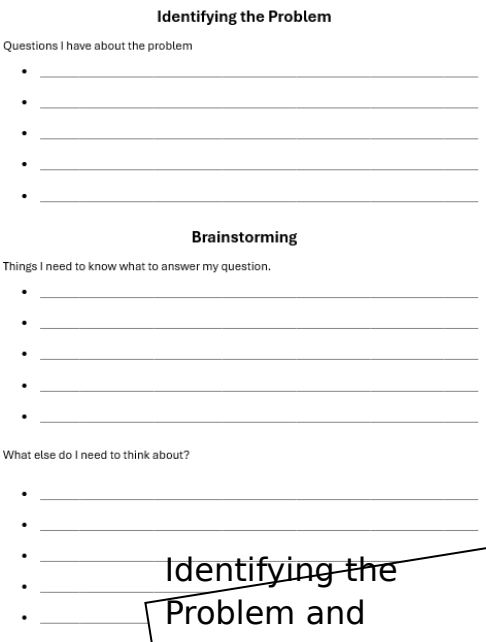
Engineer’s Notebook

Pinball Machines

I wasn’t the only one who created an Engineer’s notebook. I was so inspired that I wanted my students to learn and create one of their own. To scaffold for their needs I created a journal for them and added pages for each part of the process.

Identifying the Problem


Identifying the Problem

Questions I have about the problem

Brainstorming

Things I need to know what to answer my question.

What else do I need to think about?

Identifying the Problem and

How can we make a pinball machine that functions as a playable game?

Do we understand what the purpose of Pinball machine are?

How can we make it fun to play?

How will be able to get the functions to work correctly?

Limitations and Conditions

Limited materials available to us. Those materials are: Cardboard, glue, tape, dole rods, rubber bands, coins, popsicle sticks, toothpicks, pipe cleaners and other recyclable materials.

Limited time to design and create. It must be completed within given time.

We must learn about the following concepts to be successful:

Force or motion- How will we be able to direct the ball in the direction we want it to go? How can we apply the right amount of force to make sure the ball moves in a way that it can continue without slowing down?

Slope- How can this help us make sure the ball continues to return to us without having too much trouble getting it to go back up?

Friction- What materials should we use to make sure the ball can roll without getting stuck or stopping in an unreachable space?

Magnetic pull- How can we create tricks to increase the amount of fun and interest in the machine? How does magnetic pull work for a trick? How will we get the ball back after the magnet has taken control?

Brainstorming

Launcher Ideas- Dole rod push launcher, rubber band spring launcher, Drop in launcher.

Trick ideas- Rubber band bouncers, coin spinners, magnetic stick and release, ramps for increased interest, Catch the ball.

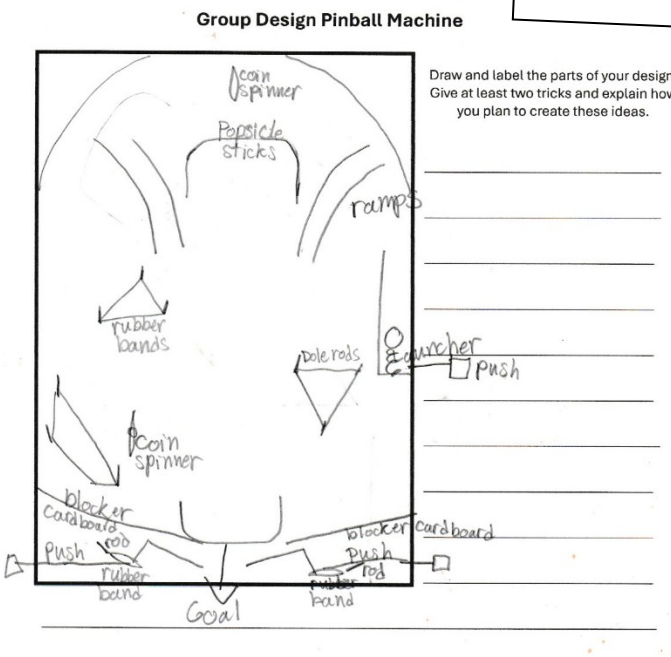
Return- Where will the ball go when it is out of play? Drop into a space to return to me. Tunnel return, Trick returns, curved sides so it doesn't get stuck in the corners.

Releasing Magnetic tricks- String to detach the ball once caught, extre flipper to move the ball once caught,

Material ideas- Smooth material that helps the ball roll quickly and doesn't require too much extra energy. Using carboard as main base material.

Design

Many design pages were added. An individual design, a group design and



In my design I want to use many elements to make it interesting. I know I want to create a curved design at the top so I decided to base it off of a hockey rink with two goals. One goal will be where I want to score points on the other team and my goal where I lose the ball.

I plan to use some coin spinners and rubber band triangles to bounce around and score more points.

I want to try and make my flippers and launcher with a push of a button on the side. I will pair it with a rubber band to help snap it back into place.

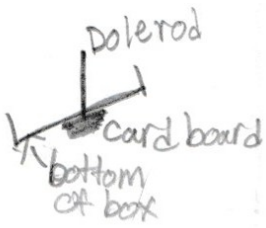
Build/Test/ Redesign

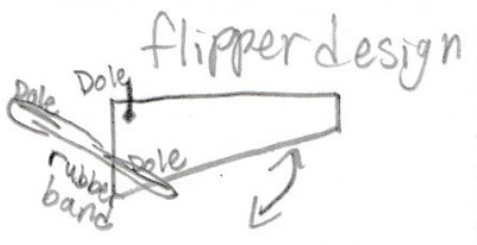
To support my students in the building stage. I had them write things to keep in mind from our lessons that they wanted to remember while building. I also gave them an additional page of things to write down while they built to say what was going well and what needed redesign. Both of these pages can help future engineers creating a design like this.

These parts were not linear. I have added the steps for building below. There were some things that needed to be omitted or redesigned as I tested them. I have added additional notes for the redesigning of the project along the way.

Notes while building

- Begin by creating the basic shape and curve of the machine first. This will ensure that the ball will not roll into a corner of the machine and get stuck.
- Flipper design needs to be completed very early in the design. It is a pivotal part to the success of the end design.
- When creating the flippers I glued multiple pieces of carboard together to try and make the, strong enough to withstand the constant hitting into them.
    - (REDESIGN IDEA)- My students only used one layer of carboard and they were already falling apart before the project was completed from testing.
- When creating the flippers I tested the friction of the material against the base material. I found that the raw cardboard worked best on against the cardboard base it was the easiest to slide against one another versus the printed paper side.
    - REDESIGN - At first, I made my flippers larger but this didn't allow enough movement for them and the mechanical pieces to fit in the box. I decided to cut them down to half the size this allowed enough room to put in the mechanics to create movement, allow the ball to pass between them and allowed for space to add a goal behind the flippers.
- I then decided to attach the flippers from the bottom with a dole rod. I put a piece of carboard on the bottom to help keep them in place. Once the flippers were made and attached, I used a rubber band to hold them back. The

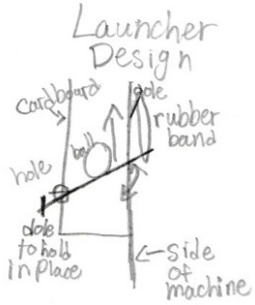




rubber band then allowed them to spring back into place creating the pinball up and down flipper design shown.

- I created a button out of the side of the machine with a dole rod and wrapped it with carboard pieces.
    - Redesign- At first, I simply placed the buttons in position, but they didn't always hit the flipper the way I intended. To solve this problem, I added a straw to help guide the button into the exact position each time, which made the flippers more consistent and reliable.

- Once the flippers were created when I tried to play the ball would get stuck in the flipper mechanics so I put a piece of carboard to guide it down to the flippers for continuous movement.
- The next step was to add a launcher to get the ball into the machine. I decided to change this design from an average pinball machine because when my students tried theirs, they tried to put the launcher at the bottom of the machine and often had trouble getting it moving fast enough. I decided to put it in the middle for a couple reasons. First, it would allow it to be partially up the slope so it wouldn't have to have as much pressure to get moving. Second, my flipper design was in the way of the side where I would have put my launcher, so I needed to move it to a different location so it didn't interfere.



- The launcher works similar to my design of the flippers using the rubber band to snap back into place giving the correct amount of forces to shoot the ball. Instead of a flipper though, I used a stick to push the ball into the curved sides of the machine.
- After the main mechanics had been built I decided to put in the additional tricks and obstacles to make the game fun and engaging. The goal of the machine is to get a goal in the hockey rink. Each eliminate is explained below.
- The rink has two goals, one where you want to score on the other team at the top of the board. On the underside of the goal I added a magnet and if you get a goal it will stick in the goal and you score the jackpot points with the magnetic pinball. The second goal is at the bottom of the machine. If you fail to catch your ball before it goes down between the flippers it lands in your goal and the other team scores points.
- I also added some spinners in as obstacles. If you hit the coins at the top you scores points and can shoot for those as well. The three-sided

spinner at the bottom allows the ball to slow down and helps it from getting stuck behind the launcher. All of the spinning elements are on dole rods attached to the underside with cardboard. The spinning elements are created with a straw and the extra pieces this allows them to spin freely when hit by the ball.

- The last element I added was a rubber band wall to allow the ball to go back up if it came to the side of the machine. This allowed it to keep moving rather than going back to flippers each time. It also helped guide the ball in another direction.
    - Redesign- The ball would originally
    - get stuck on the side where the cardboard bumpers were put it to guide it always from the flipper mechanics. It would get stuck and sit in the corner. The rubber bands obstacle and a smoothing out of glue in the crack helped guide the ball more efficiently around the machine.

Reflection and Share Solution

Before presenting their solutions, I had the students reflect on their process. What went well, what didn't and how did they overcome their

This project seemed like it would be a fun and engaging experience for both my students and me. At the beginning, many of my students didn't even know what a pinball machine was and asked questions like, "Will we really be able to make one?" After spending time observing, discussing, and exploring concepts such as slope, friction, and forces of motion, their excitement grew. They became eager to apply what they had learned by designing and building their own pinball machines.

My students and I quickly discovered that there were many elements that needed testing and adjustment. I learned a lot from observing their process and the challenges they faced. Many students began by focusing on the launcher, decorative designs, or special features. Because of this, some were unable to finish their machines, or their flippers didn't function as intended. When I created my own model, I decided to start with the flippers first, as they were a crucial component. This approach allowed me to

focus on a key part of the design before adding any other elements. I wanted to ensure that the flippers could withstand repeated hits from the ball. Once they worked properly, I was able to test the slope, friction, and direction of forces generated by the flippers.

If I were to do this project again, I would complete it alongside the students rather than afterward. I created my design after they had finished theirs, but during my process, I discovered several things that could have benefited them while they were building. For example, I learned that certain materials worked better for specific parts of the design, and allowing students access to those same materials might have helped them be more successful. Many students also struggled with figuring out how to make their flippers move. If they had seen my model, it could have sparked additional ideas or inspiration to help them improve their own designs.

My finished product ended up being a little different from my original design. I originally planned to include more elements, but as I began building, I realized it was becoming too busy and interrupted the overall flow. While my final version may have one fewer element than planned, I felt it was important not to overcrowd the space and make it too difficult to score a goal. The result is a functional, fun design that allows for smooth gameplay and easier scoring. My students had the opportunity to play with the finished pinball machine, and they had a great time testing it out.

Overall, this project was an excellent opportunity for my students to engage in hands-on learning that connected science concepts to real-world problem-solving. They not only learned about slope, friction, and motion but also practiced collaboration, perseverance, and creative thinking. For me, this experience reinforced the importance of modeling the design process alongside students so I can anticipate their challenges and guide them more effectively. In the future, I plan to build prototypes with my class earlier in the project and encourage more peer collaboration and testing. This project reminded me that when students are actively creating and experimenting, their curiosity and understanding truly come alive.