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To: Professor Jason Moore

From: Hannah Miller, Jack Sisco, Owen Warner, Isabel Zimeri (ME 340, Section 001L, Team 1.5)

Subject: General Concepts for a Children's Science Exhibit at the Discovery Space

Summery

This report addresses the design concepts of an interactive STEM exhibit for the Discovery Space Museum, aimed at engaging children aged 2-12 in science and technology. Based on the identified customer needs including safety, educational value, durability, and appealing aesthetics, the report outlines three design concepts: an adjustable ramp with targets, a pulley system, and a magnetic maze table. The report highlights the importance of safety considerations, educational engagement, and durability in the design concept selection process. After receiving feedback from the Discovery Space management, the maze table was selected to be the team's exhibit. The maze table was chosen because of its simplicity, stability, lack of pinch-points, and safety.

Introduction

According to the U.S. Bureau of Labor Statistics, careers in science, technology, engineering, and mathematics (STEM) fields account for 6.2% of all employment in the U.S. [1]. Additionally, children exposed to STEM concepts early on, such as in elementary school, are more likely to pursue STEM-related careers [1]. To effectively teach children these STEM concepts at a young age, a hands-on approach has been found to be most successful [1]. When the children can experience a scientific principle being applied to the physical world, they will have an easier time understanding the concepts. It is important to give children this interactive STEM experience to pique their interest in the field of science and increase their curiosity towards the world around them.

To provide this hands-on learning experience, the Design Methodology course (ME 340) at Pennsylvania State University has asked our team to design an interactive STEM exhibit. The exhibit that our team creates will be placed in the Discovery Space Museum, located in State College, PA. Discovery Space is a resource for children to learn about science and technology. This learning is done through interaction with many exhibits illustrating scientific concepts. The goal for our team is to inspire the next generation of scientists and engineers through engagement with our exhibit at Discovery Space. To achieve this goal, our product needs to meet several requirements. The target audience is 2-12 years old, therefore the product must be durable, engaging, and accessible [3].

This report presents a description of the customer needs, as well as our design concepts for this project. The customer needs include safe use, educational value, durability, and appealing looks for the final exhibit design. Then, descriptions of each of our three general concepts will be

explained in more depth. Lastly, management feedback will be outlined, including what Discovery Space management liked and disliked about the proposed design concepts.

Customer Needs for Design Project

In this section, the customer needs are ranked in order of importance for the exhibit. Ranking of customer needs will allow our team to design with the most important needs in mind. As the primary users of the exhibit will be children, our customer needs will be targeted towards this group. Our team has identified four primary customer needs: safe use, educational value, durability, and appealing looks for the final exhibit.

The child's safety is most important for our team's exhibit. For example, any corner must have a wide radius fillet. While running or playing nearby, if a child were to fall onto the exhibit, they could potentially sustain injury on a sharp corner. In addition, the exhibit will not include any small loose parts. Because small parts are choking hazards, they must either be out of reach from the child or sealed within the exhibit. Our table should be sturdy enough that a child cannot pull it over onto themselves, nor should it have pinch points. It is also important that the exhibit is accessible for children. The exhibit must be short enough that children can freely interact with it and must not require excessive strength. If the exhibit is not accessible, children could injure themselves trying to reach or climb. The exhibit would also be a hazard for children hitting their head if the exhibit is too tall.

The second most important customer need is that the exhibit is educational. Early exposure to STEM concepts has shown to increase the amount of people that pursue careers in STEM [1]. By creatively displaying scientific concepts to children, our team hopes to teach them in both visual and tactile manners. It is important the exhibit is engaging and can keep a child's attention for at least 5 minutes. For the exhibit to be engaging, it must not be overly complicated. If the exhibit is too complex, the children will not learn anything because it will be too frustrating or confusing. The exhibit should also encourage a child to want to return to Discovery Space.

Another customer need is that the exhibit is durable. Because our design concepts are simple, the exhibit should last Discovery Space at least a year or two. If the exhibit breaks easily, management will not be able to maintain it or fix it over time. Children are often rough on toys, especially ones played with often. To prevent wear from rough use, sturdy materials will be used for the construction of the exhibit.

The design should also look appealing. Children do not have fully developed eyes, so bright and contrasting colors are more likely to draw their attention [2]. Including appealing colors and simple concepts, our team aims to create something simple, bright, and eye-catching.

Table 1 shows the customer needs. The most important needs (highlighted in dark blue) to be addressed are that the exhibit is safe, educational, engaging, durable, and appealing. In addition to the main customer needs addressed, there are secondary needs (highlighted in light blue) that are not fully described.

Table 1. Customer needs for a children's science exhibit in decreasing importance.

Customer Need	Exhibit Considerations
Safe and Accessible	Chamfered edges, no small parts, no pinch points, sturdy
Educational/Engaging	Creative display of topics, easy to use, can be repeated
Durable	Sturdy material choice, can be used repeated times
Appealing	Bright and contrasting colors, clear signage and instructions
Lightweight	Easy to be moved around
Easy to fix	If the exhibit breaks in any way, it needs to be clear how to fix it.

General Concepts for Design Project

Our team started by brainstorming viable concepts for the exhibit. With these ideas, we identified the three best concepts by popular vote. The three concepts outlined in this section are an adjustable ramp with targets, a pulley system, and a magnetic maze. When deciding the three best concepts, safety, education, durability, and appealing looks were considered in the decision-making process.

The Adjustable Ramp, shown in Figure 1, is designed to have a ball go off a ramp and into three different targets. Using an adjustment at the bottom of the exhibit, children will be able to give the ball different launch angles to travel different distances. The purpose of this concept is to teach children about projectile motion and conservation of energy through variation of launch angles and drop heights. Even in its simplest design, there are still a few moving parts which could affect its durability, which presents this exhibit's biggest challenge. This exhibit would need good build quality to ensure that it would not collapse. One advantage of this concept is that it is an engaging game that will keep the children's attention as they learn.

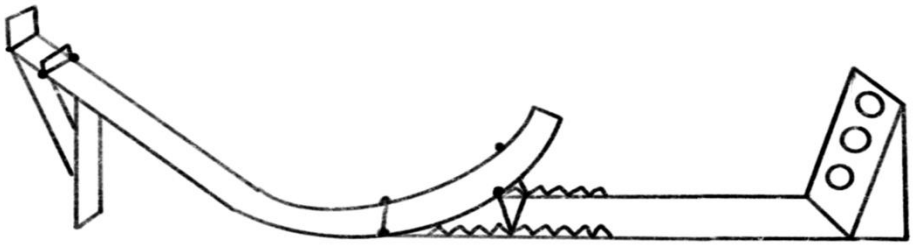

Figure 1. Adjustable Ramp. The bottom adjusts to create multiple projectile distances. The ball is then rolled down the ramp, with the goal of it falling into one of the holes. There will also be a rotating door so that multiple balls may roll down at the same time, this will add competition and increase engagement.

With our Pulley System, shown in Figure 2, children will learn mechanical advantage and force redirection. This learning will be achieved by lifting the same weight with different pulley assemblies. Some of the pullies will require a different amount of force to lift the weight, teaching firsthand of the mechanical advantage that they provide. The pulley will be enclosed behind plexiglass to prevent any possible pinch points but still allow the children to see the pulley's operation. However, one disadvantage includes the number of moving parts, increasing the chances of something needing repair. Additionally, after pulling the ropes once, the children may quickly lose interest and move on.

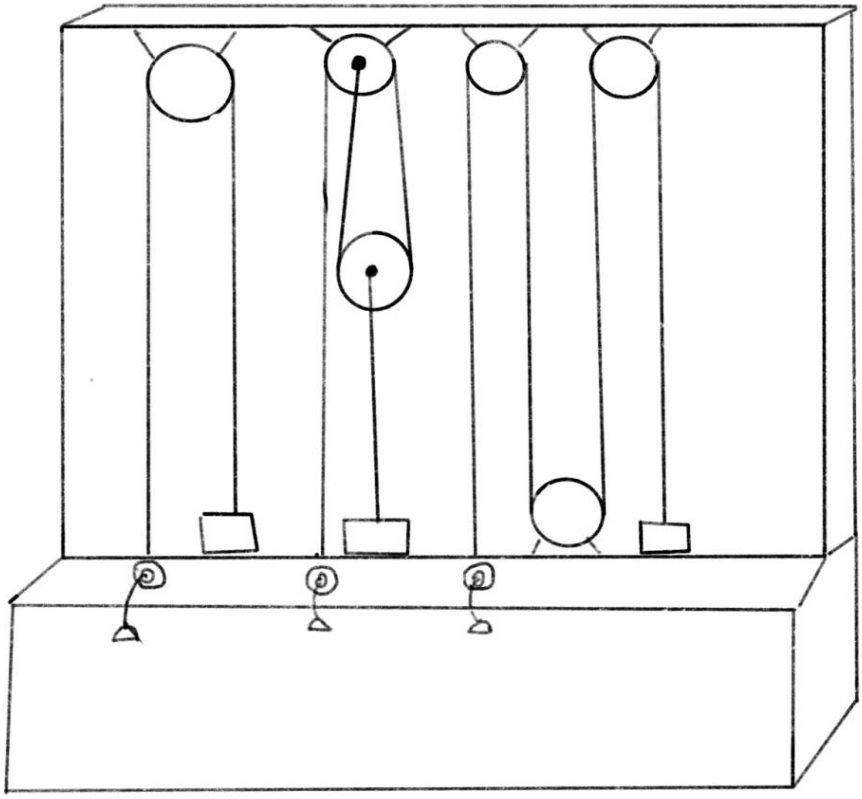

Figure 2. Pulley exhibit. Three different pully systems demonstrate the amount of force needed to lift a weight. The weights will be supported by padding to reduce the impact and potential damage. The hole where the ropes extrude will also be padded eliminating pinch points.

The Magnetic Maze Table, shown in Figure 3, is an improved version of a wall-mounted magnetic maze currently at Discovery Space. The magnetic wall maze is currently having trouble with stuck balls around tight corners. Therefore, we will create a maze design with wider spaces to avoid this issue. The purpose of this exhibit is to show the effects of magnetism, by having the ability to magnetically move the ball through the transparent top. One disadvantage of this concept is the potential for the top to get scratched. However, this problem will be addressed in the selection of material for the top surface. The table will be no higher than 3 ft to allow good

visibility and mobility. Furthermore, the transparent top will help to avoid missing pieces. The table design will be made very simple to increase its durability, and all edges will be rounded. This idea has the potential to keep children entertained as they practice fine motor skills-while learning the concept of magnetism.

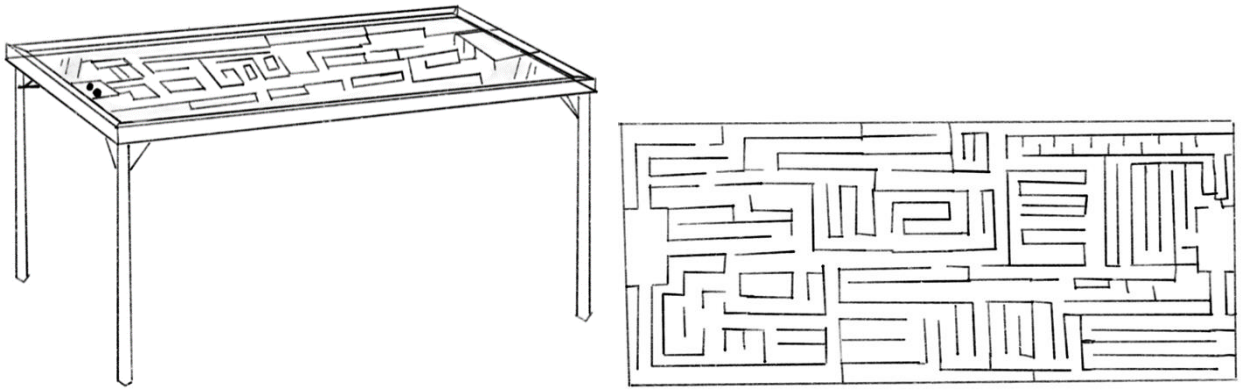

Figure 3. Magnetic Maze Table. A maze table to practice fine motor skills and learn magnetism. Children will use magnets to guide bearing balls through the maze. The magnets will be attached to the table to prevent choking hazards or misplacement.

Management Response to General Concepts

On September 12, 2023, our team presented our design concepts to the management team at Discovery Space. The management team have extensive knowledge of how children play with the exhibits and how they will react to certain concepts. For the pulley, they would like the ropes to be pulled up instead of down. In addition, if there is a baseline with no pulley, the children can see how even one pulley can provide mechanical advantage. Management appreciated how all pinch points and safety hazards were considered.

After presenting the adjustable ramp, management recommended the whole ramp being able to slide closer or further from the target instead of adjusting the launch angle. Sliding the ramp may also help with preventing pinch points. The exhibit could also include marks on the exhibit to show where the children should place the ramp to reach the specific targets. Having preset paths for the ramp will teach children the utility of science and math, along with predicting physical motion of objects.

Overall, management favored the magnetic maze table. They were pleased to hear we covered many safety aspects including choking hazard and pinch points. Furthermore, they liked the 3ft height we established for good visibility and mobility. Management also added that the path for the magnet should be very wide. because the children will get frustrated if the ball gets stuck. Additionally, the maze also should not be complicated to prevent frustration.

Conclusion

This report has presented the task given to our team to design an educational science exhibit for Discovery Space. Our team began by analyzing and ranking the needs of our customers. With these customer needs, we created three exhibit concept ideas and discussed the advantages and disadvantages of each concept. We then presented our concepts to the Discovery Space management, and we received constructive feedback for each concept. After receiving this feedback, our team feels confident that we can choose the right concept as we move into initial prototyping.

References

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