CU Senior Design Spring 2019

EcosySTEM ARTS: Designing a STEAM Toy for Patients at Children's Hospital, Colorado

Redesign Test Report

Team #6

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1. Redesign Overview

Based on user testing and the use of thick polycarbonate, it was necessary to change the design of the toy to bring down the overall weight. Instead of four interlocking and adjoining cubes, the toy was redesigned to have only two cubes connected by a tube and flange assembly. This design allowed the toy to retain its circular playability while still retaining its strength, all the while decreasing weight. The tube and flange assembly, made of aluminum, added additional strength and support to the polycarbonate cubes to compensate for the lost support from the removed cubes. The design of the cubes remained unchanged from the previous prototype. Quarter inch bent polycarbonate was still used for the walls and eighth inch polycarbonate for the lids.

2. Mechanical Testing

After making the dramatic design change, we needed to make sure the toy would still be safe enough to introduce to the hospital setting. The tube and flange being made of aluminum meant that the materials of the toy would all be strong and capable of being sterilized. Since we already tested the polycarbonate cube, we just needed to test the tube and flange assembly at its connection to the polycarbonate walls.

We created a testing system identical to the final toy product that included the curved aluminum tube, two aluminum flanges, two polycarbonate walls, one interlocking 80/20 extruded aluminum part, and all the fasteners required for the assembly. This setup was then placed in the Instron and a point load of compression was applied. The initial setup and final stage of compression are shown in Figure 2. There was no material failure, but a large amount of deformation can be seen in the polycarbonate walls (seen on the right).

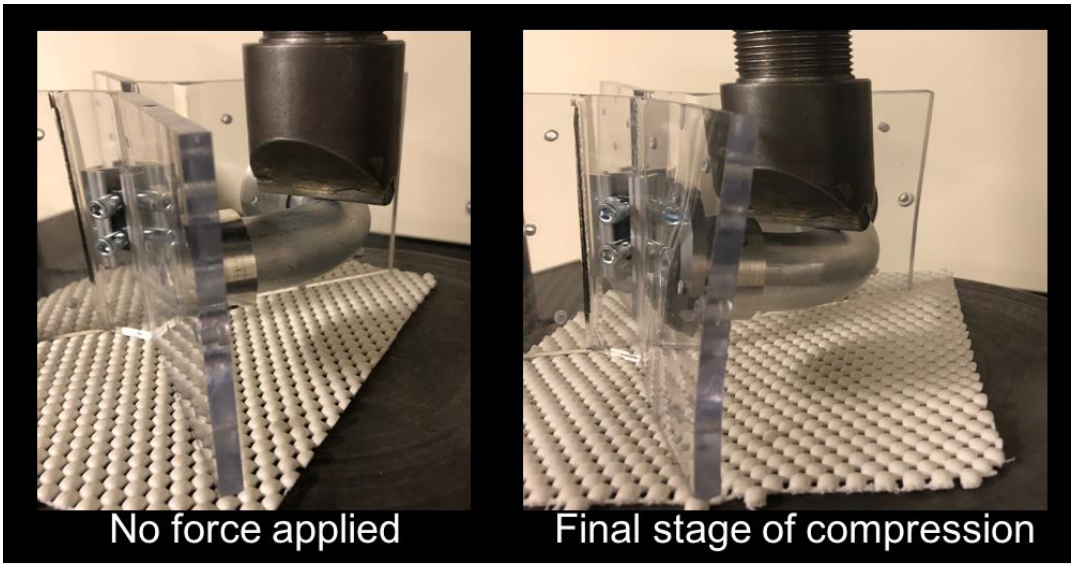

Figure 2: Setup and final stage of compression of the handle test.

The testing system itself did not fail. There was no material failure which is great for our results. The assembly slipped out from the Instron at 550 lbs. The data that was collected can be seen in Figure 3. The peak is where the testing sample slipped out from the Instron.

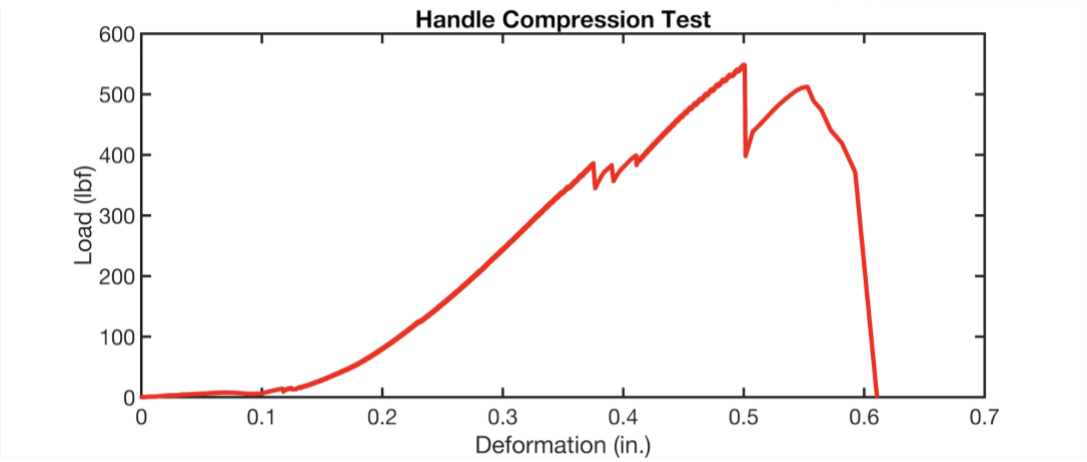

Figure 3: Load versus deformation of the handle testing sample.

From this compression test, we are highly confident in the strength of our toy design. The polycarbonate cubes and the tube and flange handles are all incredibly strong and can withstand a lot of applied force. No child would be able to apply such a force, so it would be safe in a hospital.

In order to further prove the strength of our toy, we did a simplified mathematical model of the system. Using a spring-mass-damper system, we modeled the force and deformation that the toy would experience when being dropped from certain heights. The spring constant was obtained from the cube compression test (the slope of the initial force vs. deformation line) and the damping constant was assumed to be incredibly large due to the system settling very quickly and not oscillating. From this simplified mathematical model, we were able to find the polycarbonate of the toy (which would break first due to aluminum being a stronger material) would break from being dropped from a height of around 99 feet. While this value is an estimation, it confirms our confidence in our toy design and the safety of it being introduced to the hospital. If any of the inside components break, they can be replaced. Yet knowing the outside components could survive a high drop is a confidence boost.

3. User testing

After completing the redesign, we took the toy to the Horizons K8 school for a final time. Our goal was to show them the final product and get their final feedback. In order to receive more qualitative feedback from the kids we compiled a list of questions to ask them. The results of that are shown below in Figure 4.

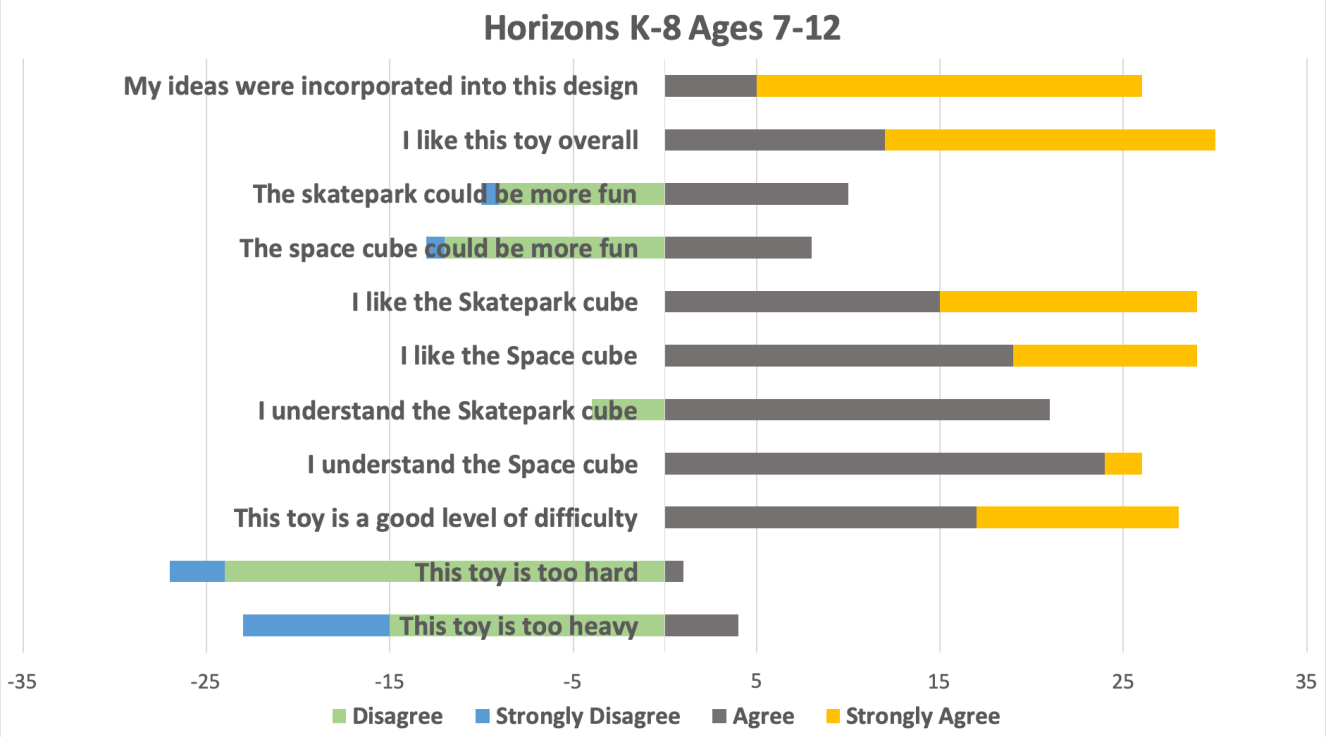

Figure 4: Results from children years 3-4 and 5-6 at Horizons K8 school in Boulder.

The most important questions from this list were "My ideas were incorporated into this design", "This toy is too heavy", and "This toy is too hard." Our goal was to take the feedback we received from our last time visiting the kids and incorporate it into the final product. As shown above, all of the kids felt that we had taken their ideas into consideration. The main suggestions from the kids from the previous round of testing were to add color, add more 3D elements, decrease the weight, and make it easier to hold. The kids almost all did not think that the toy was too heavy. This is a huge improvement from last time. The other key element was the difficulty of the toy. Since this toy is going into a hospital environment and is meant to be engaging for a long period of time. This means that the toy cannot be too easy and boring but also shouldn't be too difficult and therefore frustrating. Almost all of the kids we talked to said it wasn't too hard and all of them agree that it is a good level of difficulty. The results of this questionnaire show that the kids like this toy significantly more than the previous design.