AMS SolePower Station Improvement - The EnerCycle Machine

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SEEDS Program AMS SolePower Station Improvement - The EnerCycle Machine

Final Report

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Objective

The University of British Columbia (UBC) recognizes the importance of meeting today's needs without compromising the needs of future generations. This led to the goal of "creating a vibrant and sustainable community of faculty, staff, students and residents". In order to build a strong culture of sustainability at UBC, the Alma Mater Society (AMS) desires to increase student, faculty, and staff involvement and attention.

Last year, a team of mechanical engineering students collaborated with SEEDS to design and install a charging station called the SEEDS solePower Station, an area where students can produce their own electricity for charging their electronics. This project aims to improve and sustain user engagement of this SEEDS SolePower Station by adding a component that attracts users.

Despite the charging station's technical qualities and its location by an entrance to the AMS Student Nest (Nest), the device failed to attract users to it since its installation. Students would notice the device, but fail to use it for more than a moment, if at all, due to its lack of engaging features. This year, SEEDS presented our design team with the opportunity to design and implement an enhancement to the charging station with the main intentions of increasing its social impact and promoting sustainability. By increasing the charging station's appeal, more people will approach it, potentially engage with it, and think deeply about the ideas around sustainable transportation.

The proposed solution is a Goldberg Machine, much like the one exhibited outside of Science World, but on a smaller scale. It incorporates the theme of energy usage and sustainability with respect to three major transit options: biking, bussing, and driving a passenger vehicle.

Design and Testing

Designed Solution

The solution will be a Rube Goldberg Machine called "The EnerCycle" that promotes sustainable thinking with respect to the energy consumption of different modes of transportation. The final design operates on a cycle that continuously runs as long as energy is supplied to the system (Figure 1). When it is assembled with the previously built SEEDS "SolePower Station" (Figure 2), the EnerCycle continuously runs as long as a user is pedaling.

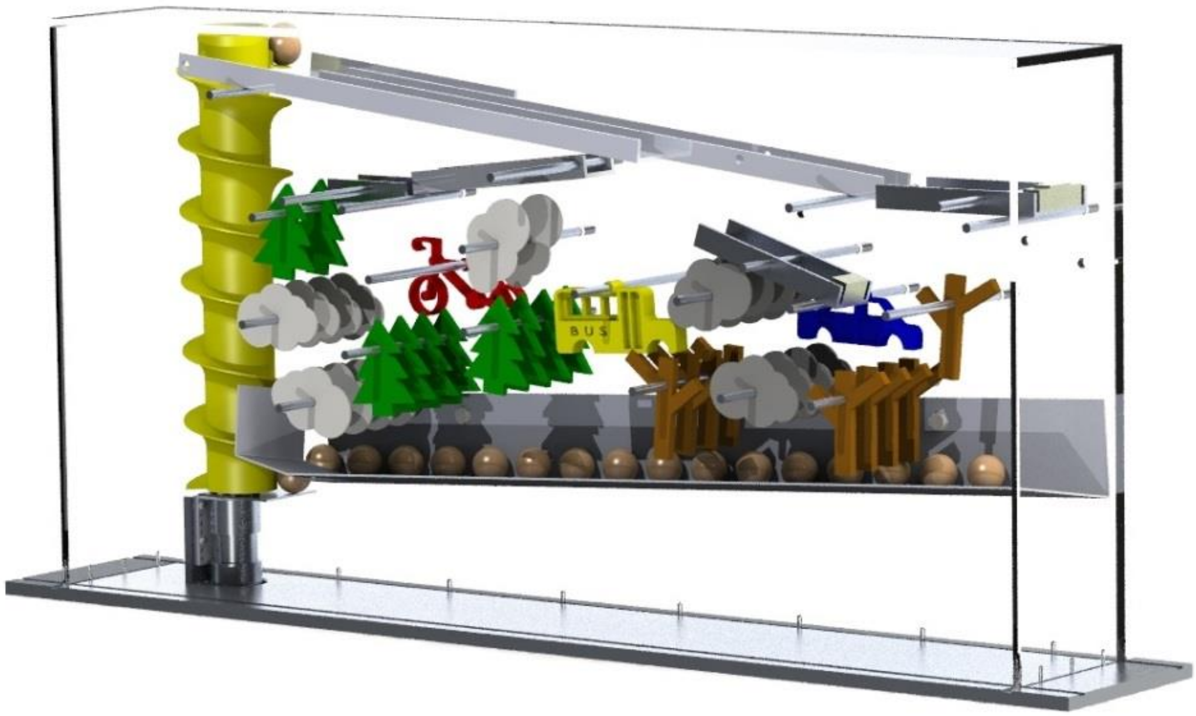

Figure 1: "The EnerCycle" Goldberg Machine

Figure 1 is a rendering of the design. The enclosure is made of transparent plastic, with the inner items being 3-D printed from a biodegradable plastic that have various color options. The EnerCycle runs 1-inch diameter balls through a cycle with several different paths. Each ball represents a unit of energy and the different paths represent different modes of transportation that each require different quantities of energy to operate. Initially, all the balls are collected in the ramp at the bottom of the system, awaiting to enter the feeder. The Archimedes' screw starts turning when energy is supplied by pedaling (or other means), which allows the balls to systematically enter the feeder and be carried up to the top of the ball sorter by the Archimedes' screw. Each ball is randomly sorter into one of three paths and eventually enter a self-tipping basket: the 1-ball basket, the 2-ball basket, or the 4-ball basket. A basket remains stationary until it is occupied by the maximum number of balls it can carry. For example, the 2-ball basket remains stationary until it is filled with 2 balls. When a basket reaches its maximum occupancy, it tips and allows all the balls it is carrying to fall into a Plinko board-like assembly. The balls go through the assembly until they are eventually collected into the ramp and the cycle restarts. If the energy supply to the EnerCycle is cut at any point, the EnerCycle halts operation until energy is supplied again.

Figure 2: Integration of The EnerCycle onto the SolePower Station

Verification Test Results

To verify the performance of The EnerCycle, we performed three different tests that tested potential failure modes:

- An Archimedes' screw test – this test is used to verify that the Archimedes' screw can properly perform its function of carrying balls up from the ramp to the ball sorter
- A self-tipping basket test – this test is used to verify that each of the self-tipping baskets can perform their function of carrying balls until they are full, at which point they would tip
- A noise level test – this test is used to verify that the sound level of the EnerCycle is not high enough to disturb people in the device's surrounding area. This test is necessary because the client specifically stated that the device does not disturb anyone that may be working or studying in the surrounding area of the device.

Results – Archimedes' Screw Test

In this test, we fed one ball into the feeder at a time and powered the Archimedes' screw. We observed the screw lift the ball to the top of the ball sorter during each trial and recorded any issues that occurred as the ball was being lifted up. Once the ball was lifted as high as it would go, we stopped the screw, checked the condition of the device (motor, screw, etc.) and repeated the test. We performed this test for 10 trials.

After the first several trials, we found that the Archimedes' screw could not lift the balls because it experienced some warping. To alleviate this issue, we reprinted the screw using a different 3D printing orientation and repeated the test. Using the newly-printed screw, the balls were able to consistently be lifted up to the top without any interruption.

Results – Self-Tipping Basket Test

In this test, we continuously fed 20 balls into the ball sorter and observed if each of the self-tipping baskets were tipped by the correct number of balls. Initially, we found that the balls often did not land inside the baskets due to overshoot. To alleviate this issue, we redesigned the baskets by changing their dimensions, which eliminated most of the overshoot. The test was repeated using the newly-designed baskets and we found that although there were still rare instances of overshoot, the baskets were only tipping when they were full, which was how they were designed to tip.

Results - Noise Level Test

In this test, we used the "Sound Meter" application on one of our phones to test the environmental noise in the new Student Union Building surrounding the EnerCycle. We found that people located within a meter from the device can hear the device, but the sound level is only about 20 decibels, which is about equivalent to whispering in a quiet library. People located beyond a meter from the device can barely hear the device and anyone beyond 5 meters from the device could not hear the device at all. Thus, the EnerCycle meets the client-specified requirement that the device not disturb people in the surrounding area.

Validation Test Results

We were unable to perform any tests to validate the EnerCycle's ability to satisfy the objective of increasing the SolePower Station's social impact and promoting sustainability due to the Sustainability Center, where the SolePower Station will be located, still being under construction at the time this document was written.

Conclusions

At this time, we are unable to concretely conclude if the EnerCycle satisfies the primary objectives of increasing the SolePower Station's social impact and promoting sustainability. However, based on our verification test results, the EnerCycle will operate without interruption and can act as a means of entertainment for users sitting at the SolePower Station. A validation test will need to be performed to determine if the EnerCycle increases the appeal of the SolePower Station and gets users thinking about sustainability.

Recommendations

We have several recommendations for improving the EnerCycle:

- Add game elements that promote friendly competition
- Add more variety to the colors and aesthetic items within the structure
- Add threaded holes to the top of the front and back plates to allow the use of fasteners for holding the pieces together instead of glue
- Add hinges to the side walls to allow easy access to the components inside the structure for easy maintenance
- Add a clamping mechanism to the EnerCycle to better secure it to the SolePower Station's table
- Perform a validation test to assess long-term user engagement and promotion of sustainability.

Our main recommendation is to perform to assess the EnerCycle's influence on long-term user engagement and promotion of sustainability using a validation test. The results of this validation test would help determine if the EnerCycle meets the main objectives of the project. We suggest using a validation test that involves counting the number of people approaching and observing the SolePower Pedal Station. To obtain the number of users, the device should be observed in 1 hour intervals at 10:00am, 12:00pm, 2:00pm, 4:00pm, and 6:00pm on a weekday at the new sustainability center in UBC's new student union building. People who use the pedal station would be counted as +1 and people who approach the pedal station and observe it for longer than 5 seconds would be counted as +0.5. The total number of who approached and observed the pedal station during testing can then be used as an empirical measurement of the EnerCycle's influence on user engagement. To test how well it promotes sustainability, observers should be randomly approached and asked if they took way any kind of messages from observing the EnerCycle.