

Container Chaos: The Impact of a Casual Game on Learning and Behavior

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Abstract—This paper explores the impact that playing a casual game can have on a player's learning and subsequent behavior. A casual mobile game, Container Chaos, was created to teach undergraduate students about the carbon footprint of various disposable beverage containers. Learning was tested with a short quiz, and behavior was tested by observing which beverage containers players choose when offered a drink and a snack. The game was tested multiple times, under a variety of different circumstances. Findings of these tests indicate that, with extended play over time, players can learn new information and sometimes even change their behavior as a result. This has implications for how other casual games can be used to teach concepts and possibly modify behavior.

Keywords—Behavior, carbon footprint, casual games, environmental impact, material sciences.

I. INTRODUCTION

CASUAL games are everywhere. People play them while standing on line at a store, waiting for a bus or train, and again when they get on that bus or train. Although casual games do not require the level of involvement that console games do, people tend to play them a lot. In fact, a 2019 study found that, worldwide, people spend more time playing casual games than other games [1]. With all that play time, players are certainly learning something, even if it is only how to do better in the game. This begs the question: Can a casual game teach players something that is useful outside of the game? Can playing a casual game lead to changes in behavior outside of the game?

Sustainable materials play a central part in our future economy in that, by carefully selecting the most environmentally friendly and energy efficient materials, we can reduce our energy consumption and increase sustainability of our lifestyle [2]. Helping people to understand the environmental impacts of materials we use in our daily lives is crucial to their making environmentally sound choices. However, this is not a trivial task as it involves educating consumers as well as the next generation of engineers who will be designing our future products. Engineers need incentive to learn to develop innovative materials solutions that reduce the environmental impacts of their products [3]. Consumers need incentive to make environmentally sound choices, which can drive product innovations in directions that

are not easy to foresee [4]. Yet, learning about the environment by simply acquiring information is not effective in changing people's opinions, attitudes, or behaviors toward the environment [5], [6]. Active learning, which has students apply higher-level cognitive processes, is needed instead [7]. Increasingly, this is being provided by cyberlearning tools [8], which include simple simulations and games that give students additional means to interact with the information [9].

To help both engineering and non-engineering students to understand sustainability issues, we developed a set of web-based learning activities and tools to be used in an introductory-level college course. A key piece of this is Container Chaos, a fast-paced casual game where instant recognition of pro-environmental choices leads to higher scores. The goal of this game is to be fun enough that people will want to play it over and over again. The theory is that, through repeated play (which translates to practice), players will come to recognize sustainable choices of beverage containers in their own lives.

Container Chaos went through several iterations to enhance both the learning potential and the fun factor of the game. It was then tested multiple times, in a variety of settings, to determine whether the players learned something from the game, and whether that experience would change the players' behavior in the real world. This paper describes that process and what we discovered.

II. RELATED WORK

In recent years, there has been a renewed focus in education on the need to relate learning to real-world experiences [10], [11]. It is well understood that showing students the relevance of their learning and relating education to real life increases success in learning engineering and other STEM fields [12], [13]. Socio-scientific topics, such as sustainability, are particularly good for engaging students in this way [14], [15].

Immersive, complex games and simulations have been shown to increase engagement and enhance learning [16]. Yet learning may also be achieved with simple simulations and games, which give students additional means to interact with the information [9]. Although many of these learning games are extremely complex and involved, casual games are also being explored for their learning potential. For example, casual games have recently been used in a learning context to get students to recall and use their biology lessons [17]. Another casual game increases museum-goers' engagement with the exhibits by giving players a gamified goal that requires them to ask questions [18]. There is even some evidence that casual games can affect behavior. The creators

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of Power Explorer found that playing a game over a sustained period can make teenagers more aware of the environment and even lower their energy use in the household [19]. Yet, in all of these cases, the games are simply reinforcing knowledge that has been learned previously. We wanted to test whether students could learn new (and unexpected) information from playing a game, or whether playing the game could change their behavior in the real world.

III. BACK STORY

Despite the public focus on recycling, the quantities of municipal solid waste produced by consumers have continued to steadily increase. This is primarily due to waste in the container and packaging categories [20]. Beverage containers, which can be made from different materials and thus have different environmental footprints, are a visible and iconic part of the municipal waste stream. Materials substitution, weight reduction and better container design can all help to reduce the environmental impact of the beverage industry.

When teaching students about sustainability, it is important that they learn to understand the numerous factors that make one choice more or less sustainable than another. Common perception holds that cardboard is better than polystyrene foam (commonly known as Styrofoam), and paper is better than plastic. This has led to a series of product bans [21], [22]. However, this is a long-standing scientific debate. Life Cycle Analyses, which are studies that look at various impacts of these containers across their entire life span, have come to differing conclusions [23]-[25]. Yet, it is possible to focus on climate change impacts and argue that polystyrene containers are less harmful to use than paper containers. In fact, when looking at CO₂ alone, Styrofoam containers have the least environmental impact and glass containers have the most. For many students, this is very unexpected. Helping students to understand the measurable effects of their consumer choices should lead to more informed decision-making.

A. Enviropedia

To help both engineering and non-engineering students to understand sustainability issues, we developed a set of web-based learning activities and tools that we call Enviropedia. This system supplements the students' understanding of sustainability by providing a learning environment focused on the impact of beverage container choices. Fig. 1 shows the login page for Enviropedia.

In addition to the Container Chaos game, Enviropedia provides access to a wiki that student teams use for compiling their findings, and a carbon-footprint calculator for estimating the environmental impact of new containers. Overall, Enviropedia increases awareness of the impact that simple choices have on the environment and reinforces recognition of what good choices are. At this level, Enviropedia is appropriate for general science courses.

B. Environmental Impact

Of course, the best way to help the environment is to make and use fewer beverage containers altogether. Understanding

this will hopefully lead more students to choose re-usable containers and work toward reducing their use of disposables overall. However, as disposable beverage containers will continue to be used, the next best option is to consider how the materials used in these containers impacts the environment. This is particularly important for future material scientists, who will be inventing the next generation of beverage containers.

Initially, we chose to make both the game and the calculator focus on the carbon footprint associated with various beverage containers and their accessories (e.g. straws, sleeves, and lids). The carbon footprint for a beverage container is the amount of carbon dioxide (CO₂) that is emitted when fossil fuels are burned during the manufacture and transport of that object. This number is significant because CO₂ is the leading greenhouse gas contributing to global climate change. It is also a number that is easily calculated given the chemical composition of the fuel and the quantity that is consumed. Table I shows these carbon footprints (CO₂ output), measured in grams, which were collected from the SimaPro databases [26].



Fig. 1 Enviropedia front end

TABLE I
CARBON FOOTPRINT OF BEVERAGE CONTAINERS AND ACCESSORIES

Container type	Size (fluid oz)	weight (g)	Carbon footprint (g CO ₂ output)
Small Styrofoam	8	2.5	6.3
Medium Styrofoam	12	4.7	11.8
Large Styrofoam	16	9.1	22.8
Small Paper	6	8.2	40.8
Medium Paper	12	11.4	57.2
Large Paper	16	16.1	80.4
Small Plastic	12	6.72	16.8
Medium Plastic	16	9.76	24.4
Large Plastic	30	17.84	44.6
Aluminium Can (large)	15	15.9	65.4
Aluminum can (small)	8.4	9	37
Glass bottle	9.5	184	356.9
Cardboard Sleeve	n/a	6.6	33.2
Polystyrene Lid	n/a	3.9	9.8
Straw	n/a	2	4

Looking at the numbers alone, the results can be non-intuitive. For example, the carbon footprint of a 16-ounce Styrofoam cup is 71.6% less than that of the same size paper cup. And a glass bottle that holds just a little more than half of those 16 ounces has a carbon footprint more than 15 times

greater. The reason these are non-intuitive is that popular culture teaches us that paper is better than Styrofoam because it decomposes more quickly in the landfills. And glass is considered better because it can be recycled. The lesson here is that when we say something is “better”, we need to be precise in explaining why that is so. The impact on the waste stream is independent of the carbon footprint.

IV. CONTAINER CHAOS

Container Chaos was designed to reinforce knowledge

about the impact that manufacturing and transporting various materials has on the environment. In this game, instant recognition of pro-environmental choices leads to higher scores. Container Chaos was developed using Adobe Flash, and therefore can be played on any device that supports the Flash Player. It is embedded in a webpage that explains the point system and rules and provides a link back to the other Enviropedia resources. Fig. 2 shows what the players see in their web browser while playing the game.



Fig. 2 Original version of Container Chaos on the web, during gameplay

The first version of Container Chaos was similar in gameplay to the old Space Invaders arcade game, in that the goal is to eliminate the things falling from the sky before they hit the ground. Points are earned for each container that is eliminated, as indicated in the legend on the left side of the screen. As in the arcade game, the frequency with which the containers appear, and the speed at which they fall, increases as the player accumulates more points. Unlike Space Invaders, letting a container hit the ground in Container Chaos does not end the game. Instead, it adds to the carbon footprint of the container to the pollution levels. The game ends when pollution levels hit the maximum.

When the containers are falling thick and fast, focusing on the higher-ranked containers will earn the player more points and give the player more time to earn points (because the containers hitting the ground contribute less to the pollution levels). By playing the game multiple times, players can increase their final game scores by recognizing which containers contribute more pollution.

A. Pilot Test

Enviropedia - and Container Chaos - were tested with 111 students in four one-credit undergraduate freshman seminars

and one three-credit Sociology course. Students in these courses were not expected to have prior knowledge of chemical engineering or materials science. Throughout the semester they were asked to play Container Chaos, use the carbon footprint calculator to estimate impact of their container, and make updates to a wiki page.

Although we did not collect specific data regarding the use of Container Chaos, we did collect a brief pre- and post-test, at the beginning and end of the semester regarding students' understanding of carbon footprints (learning). In an end-of-semester survey we also asked how many times the students had played Container Chaos. Results are summarized in Table II.

TABLE II
LEARNING AND ENGAGEMENT WITH ENVIROPEDIA

How many times did you play the game "Container Chaos"?	edits	words	comments	photos	learning
Never played it	1.0	31.0	1.0	0.0	-
Only one time	1.7	149.7	0.3	1.7	+0.5
A few times	2.9	289.3	0.5	1.8	+0.7
More than five times	5.0	345.0	2.0	1.0	-

We found that the number of times that students played the game correlated closely with their overall engagement in the course, measured in terms of the average number of edits they made to the wiki, the number of words they wrote in their entries, and the numbers of comments that they left. It was interesting to see that learning (measured as the difference between pre- and post-test scores) increased for students with average levels of engagement, but stayed constant for students who were either minimally engaged or very engaged. It became clear to us that we needed to conduct a more rigorous experiment. We also needed to make Container Chaos more accessible (running on mobile devices) and more fun to play.



Fig. 3 Snapshot of mobile version of Container Chaos during gameplay



Fig. 4 Instructions for the educational version of Container Chaos

B. Mobile Game

Container Chaos was re-written in Javascript to run in a web browser on a smart phone. Modeled after Fruit Ninja, the game now gives players 60 seconds to collect as many points as possible. Points are earned by slashing beverage containers without hitting a Styrofoam cup. As before, the number of

points collected is determined by the carbon footprint of the containers that are slashed. Therefore, higher scores can be accumulated by focusing on the containers with the highest carbon footprint. Fig. 3 shows a screen shot of the gameplay.

Because of the limited screen size, we needed to explain the objectives before the game started. We decided to test two different ways of doing this. First, we created an educational version that has an explicit educational objective. In this, a legend showing the carbon footprint is shown before the game starts (Fig. 4).

Second, we created a "stealth" version where the educational objective is hidden. Here, the information is disguised as being all about the game. The "Loading" screen, which was unnecessary, gives players some time to digest the fact that Styrofoam has the smallest carbon footprint and glass has the largest (Fig. 5).



Fig. 5 Instructions for the stealth version of Container Chaos

V. EXPERIMENT

The purpose of our study is to discover what effects playing a casual game could have on the player. We developed the following hypotheses:

- H1. Playing Container Chaos will affect learning, by teaching players about the carbon footprints of various disposable beverage containers.
- H2. Playing Container Chaos will affect behavior, by causing players to choose beverage containers that have lower carbon footprints.
- H3. Players of Container Chaos will learn more from a "stealth" game, where educational objectives are not apparent, than from an explicitly educational game.

A. Experimental Method

To test the hypotheses, we needed to do three things:

1. Have the subjects play the game. They were asked to play the educational version, the stealth version, or a control (a mobile game about the environment that had no information about carbon footprints or beverage containers).
2. Have the subjects take a quick quiz. Sometimes this was given both as a pre- and post-test. Other times it was only given at the end. Fig. 6 shows the quiz.
3. Serve refreshments, including a salty snack and a beverage that needs to be poured into a cup. Cups that are

offered are all similar in size and color (Fig. 7). An equal number of each type is made available; after the experiment is over (and the subjects have gone) we count the cups to see how many of each type remain.

Carbon Footprint Quiz

Rank each of the following beverage container materials based on their carbon footprint*. You may assume that all of these containers hold the same volume of liquid. Rankings should range from 1 (for the lowest carbon footprint) to 5 (the highest carbon footprint).

_____ Aluminum can

_____ Glass bottle

_____ Paper cup

_____ Plastic cup

_____ Styrofoam cup

Fig. 6 Carbon footprint quiz



Fig. 7 Cups offered for taking refreshment

The university's Internal Review Board (IRB) determined that because no identifying information was being collected, this study did not constitute human subjects research, and therefore did not require IRB approval.

B. First Test

The first test was conducted at a freshman event at the university. Students were told that they would be testing out different environmental games for mobile devices. Students were randomly put into three different groups to play three different games: educational Container Chaos, stealth Container Chaos, and a control game. Each group was sent to a different room to do this. After playing for about 15 minutes, they were asked to fill out a software usability survey based on Brooke's SUS [27] and the Carbon Footprint Quiz (printed on the back). They were then offered refreshments and told they could leave.

Unfortunately, the event was not well attended. A total of 23 students participated; putting 8 or fewer in each group, and so no meaningful conclusions could be drawn. In the control group, no one realized that Styrofoam has the smallest carbon footprint, and consistently ranked it as the worst. Approximately half of the people who played Container Chaos answered parts of the quiz correctly, indicating that Styrofoam has the smallest carbon footprint and glass has the largest. There appeared to be no real difference between the stealth

and educational versions of the game. The results with the behavior were more disappointing. No one in the control group took a Styrofoam cup. Among the other groups, very few took a Styrofoam cup. We decided that we needed to test a larger group.

C. Second Test

The second test was conducted during Opening Weekend at the university. Over 400 freshmen participated. They were divided into groups of 20, which were randomly given one of the three games to play (educational Container Chaos, stealth Container Chaos, and the control game). Each person was given a card that showed the URL of the game that they were to play. After about 5-10 minutes of play, they were sent to the Watering Station where they handed in their card, got a drink, and filled out the Carbon Footprint Quiz.

Managing this testing session proved to be challenging. Several groups would come to the watering station at the same time, and so it was difficult to tell who was taking what cup. Overall, many more paper and plastic cups were taken than Styrofoam, though we did overhear some conversations about the choice ("The game says that Styrofoam is better. But that cannot be right."). Some of the quizzes filled out by students who had played Container Chaos were suspiciously accurate (with the actual grams of carbon given), which led us to suspect that students were taking out their phones and copying the answers. In the end, we decided that players needed more time to digest the information. We also needed to work with a more organized setting to keep better track of the cups and prevent them from copying down answers.

D. Third Test

For the third test, we asked several university professors to offer extra credit to students who would play Container Chaos and achieve a score of 1,000,000 or more. The theory was that in trying to achieve that goal, students would play the game more often and would therefore learn more from it. This time we dispensed with the comparison of educational and stealth games, and just gave them the educational version.

We then came to the last day of class with quizzes, snacks and beverages. Out of nearly 200 students who were asked to do this, about one tenth achieved the goal. But because we gave the quiz to all of the students (and not just those who did well), results were mixed. Again, no one took a Styrofoam cup.

As a control, we gave the quiz and refreshments to two sections of classes that did not play Container Chaos at all. As in the first test, no one realized that Styrofoam had the smallest carbon footprint and that glass had the highest. Furthermore, no one took a Styrofoam cup. This appeared to confirm that there is a clear (and reliable) cultural bias against Styrofoam.

E. Fourth Test

The fourth test took place in one author's classes. Students were given a quiz and refreshments at the beginning of the semester, to serve as a baseline. As expected, students appeared to think that paper was "best" and Styrofoam was

"worst". Also, no one took a Styrofoam cup.

Students were then told that they could earn extra credit for playing Container Chaos over the semester. Once a week, they could submit a snapshot of their final score. Students who did this every week would receive the most extra credit; students who played less received less. By the end of the semester, two thirds of the class had played the game at least once; half played more than once; but only 3 people played every week.

On the final day of class, students were once again given a quiz and refreshments. This time, 40% got the rankings perfectly, and 20% at least realized that Styrofoam had the smallest footprint and glass had the largest. Most remarkably of all, half of the cups taken were Styrofoam.

VI. DISCUSSION

It is clear, from the pre-tests and control groups, that most students believe that paper is good and Styrofoam (and plastic in general) is bad. That was reflected both in the quiz answers and their choice of cups.

Because the Styrofoam cup featured prominently in the game, the majority of people who played either the educational or stealth version of Container Chaos guessed that it had the lowest footprint (1), although some listed it as having the highest (5). Also, because glass bottles were also featured prominently, many got that one right as well. However, only a few people seemed to realize that paper has a greater carbon footprint than plastic.

It appears that people can learn something new from playing a casual game. Repeated play appears to increase the effectiveness of this learning. At the same time, it seems that players do not pay a lot of attention to information given at the beginning of the game, and so more explicit information and/or reminders throughout the game might improve the effect.

Results from the fourth test suggest that playing casual games can indeed change behavior. However, it appears that sustained play is needed for this to happen. It might also be easier to change behavior if it does not go against the player's pre-conceived notions.

We could not prove or disprove the hypothesis regarding stealth education. Further investigation is needed.

VII. CONCLUSION

Overall, our experiments demonstrate that players can, in fact, learn new and unexpected information from playing a casual game. Playing a casual game can even result in a change in behavior. However, for both of these things to happen, players seem to need to engage with the game regularly over a sustained period of time. Also, it is not known whether this learning and behavior change will persist over time.

Focusing the lesson on the carbon footprint of beverage containers produced mixed results. On the one hand, the game teaches people something that is unexpected and perhaps even counter-intuitive. This was reinforced by our control groups, who consistently demonstrated that without our instruction, people would choose containers with a high carbon footprint.

Yet we also discovered that this was a detriment: even with the instruction, subjects were reluctant to choose beverage containers that they had been told (by society) were "bad". Only with repeated play over a sustained period of time did some of them change their behavior.

We have considered that our results might be stronger if the lessons being learned were more neutral, or something that players typically did not already have an opinion on.

Although the idea of "stealth" learning has merit, we were unable to draw any conclusions about whether or not hiding the learning objectives makes the game more enjoyable, thereby leading to greater learning. It certainly deserves to be studied further.

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