4-24-2023

Redesign a PET Bottle: Creating Possibilities for Future Recycling

Shen Liu
sl7987@rit.edu

RIT

Redesign a PET bottle: Creating possibilities for future recycling.

by

Shen Liu

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Fine Art in Industrial Design

School of Design
College of Art and Design

Rochester Institute of Technology
Rochester, NY
April 24th, 2023

Thesis Committee

Prof. Alex Lobos – Chief Advisor, Graduate Director

Prof. Lorraine Justice – Associate Advisor

Redesign a PET bottle: Creating possibilities for future recycling.

Shen Liu

Keywords: Sustainable product design, Customer behavior, Origami, Circular economy

Abstract

Plastic packaging for food and beverages is one of the popular materials that change people's behavior and exacerbates the waste caused by the linear economy. Since the 1970s, people are trying to reduce plastic packaging pollution through a variety of sustainable designs. However, sustainable design's effectiveness is insufficient as one of the keys to the circular economy. This has led to a credit crunch in sustainable design.

This article explores ways to connect sustainable living to millennial behavior and make more millennials recycle polyethylene terephthalate (PET) bottles. Through online research, interviews, and quantitative surveys, millennials' use of disposable plastic bottles has been analyzed and according to the requirements of millennials, redesigning PET bottles for a potential recycling scheme is feasible.

As a case study, I evaluated the difficulties faced by millennials in recycling PET bottles and their potential expectations for recycling systems. My design includes a visually appealing, compressible PET bottle with a delicate appearance. It helps consumers save four-fifths of their

storage space during recycling. That means consumers can easily carry it around until they are ready to recycle. This change is more likely to improve the storage efficiency of bottles and the possibility of bottle recycling. In addition, designing a brand is an important step in building customer trust in sustainable design, helping to connect consumers with their sustainable lifestyle and the products they use.

1. Introduction:

Most consumers question the need for recycling because they see that recyclable materials are still being landfilled or being used inefficiently (Drmaxlib, 2020). The reasons for this result are complicated. Among the many reasons, is that consumers do not make the connection between sustainable living and the products they use (Lobos, 2017). Facing the current complicated recycling information and standards, consumers are frustrated because supporting recycling takes much time, This indirectly leads to anxiety when using and choosing plastic products. Therefore, when redesigning PET bottles, we need to pay attention to the storage of PET bottles. We can get a new PET bottle that supports anatural customer experience with the cycle of crush, conserve, and recycle.

Materials, Technology, and Policies

Most bottle manufacturers use PET as the bottle body and High-density polyethylene (HDPE) as the bottle cap. This combination prevents leaks from occurring in the lowest cost and most

effective manner. However, as people become more recycling conscious, bottle caps are considered part of recycling (AG, 2021). To reduce recycling and disposal costs, I chose to use only PET as a solution for producing plastic bottles.

The blow molding process is primarily used to manufacture plastic bottles. Due to the limitation of experimental conditions, I chose the vacuum blister process and 3D printing for the process. I used 0.02 inch polyethylene terephthalate glycol (PETG), Polylactic acid (PLA), and Thermoplastic polyurethane(TPU) as materials to check the feasibility of the concept.

Additionally, I questioned the necessity of the existence of the safety ring on the bottle cap. According to the regulations of Food and Drug Administration (FDA) in TITLE 21--FOOD AND DRUGS, tamper-proof packaging of drugs is to improve the safety of over-the-counter drug packaging (CFR Code of Federal Regulations Title 21, Volume 4 2023). In other words, the new anti-tampering standard will expand beverage packaging options.

2. Initial Research

Since the early 1950s, plastic bottles have gradually replaced glass bottles. Plastic bottles are favored by manufacturers due to their material characteristics: lightweight, low damage, and low cost. With the increasing demand for environmental protection. Manufacturers have begun advertising PET, a 100% recyclable plastic and people tried many ways to recycle PET bottles. These include the New York bottle bill with a five-cent bonus. Plus the PET water bottle which lost 52% of its weight. Asimple visualization of household recycling launching in 2020 (DW Planet A, 2021) is in Figure 1.

Figure 1– Simplified visual image of household recycling launched in 2020

However, inefficient PET recycling and reuse have made people question the necessity of recycling. This project seeks to connect consumers, sustainable living, and products as restoring the reputation of sustainable design for understanding what is consumer demand for recycling and the potential for plastic bottles in the future, I conducted a quantity research. I received 49 responses. Ninety-eight percent of participants were between the ages of 18-34. Based on online data, I obtained four pieces of information on consumer sustainable living (Figure 2) that impacted my project.

1. Millennials want to contribute to environmental protection through recycling, and they also want efficient recycling and saving their time.

2. The shape and packaging of designed PET bottles are affected by the liquid in the bottle.

3. Single-use plastic puts an additional psychological burden on customers. Some customers reuse the bottles as temporary containers.

4. Mobile devices and social media are the primary means by which customers receive recycled information.

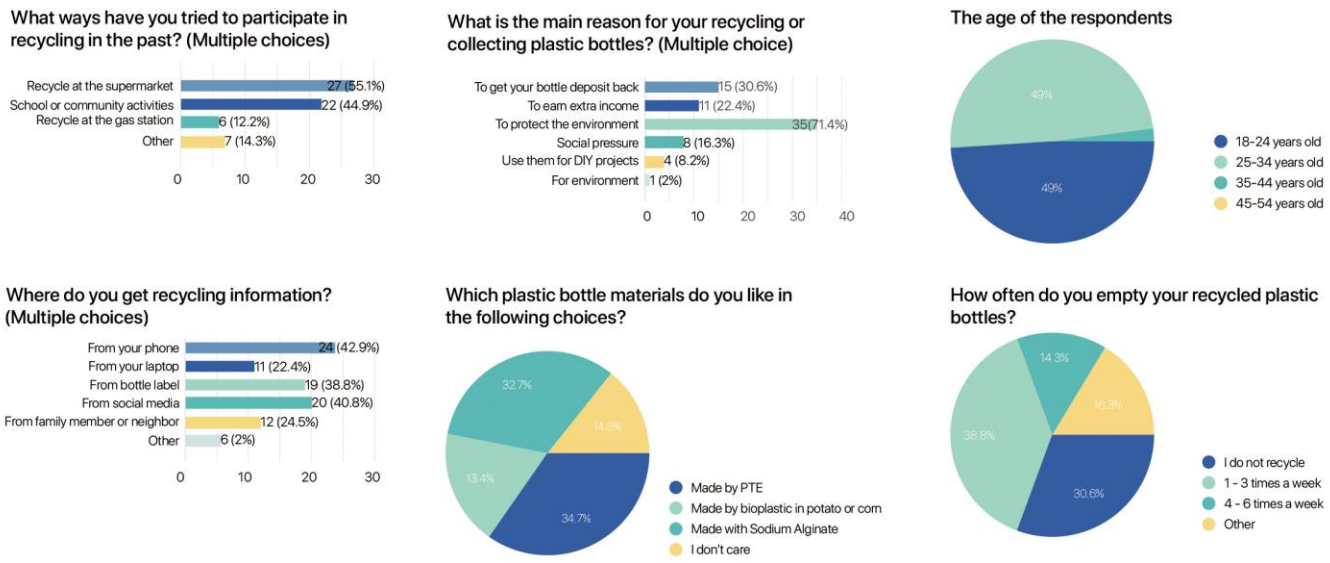

Figure 2- Quantity research results

3. Problem Statement

How can we inspire more millennials to recycle PET bottles? This concept attempts to link consumers' sustainable living and the products they use, thereby offering a new possibility for future recycling of PET bottles.

4. Project Overview:

I chose to redesign PET bottles for Millennials aged 20-38 and used V-shaped design thinking as my methodology (Figure 3). The PET bottle concept designs were iterated three times (Figure 4). They occurred in 4-1 preliminary conception, concept refinement, and the prototype of the final concept. After completing each survey and before starting the next, I designed a prototype that incorporates information from previous surveys.

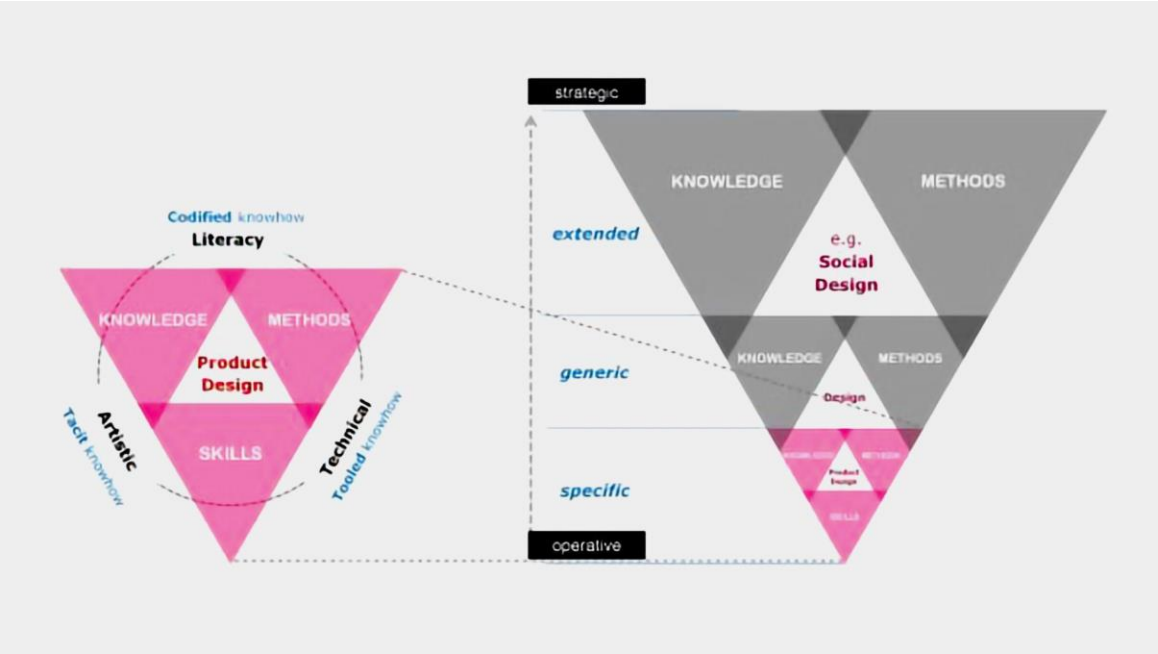

Figure 3- V shaped design thinking

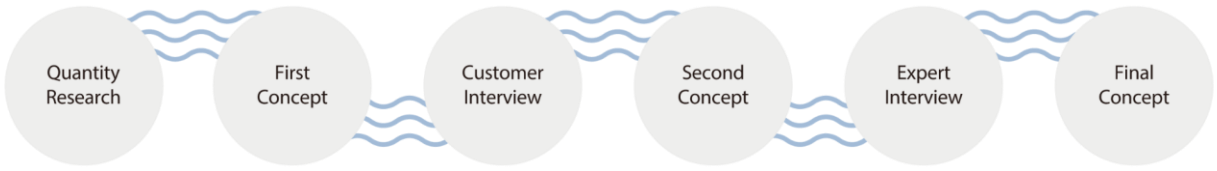

Figure 4- Project Planning process

4-1 Preliminary conception.

Millennials are eager to get a PET bottle that encourages efficient recycling. According to the early quantitative research that I did for this projct, storage space and transportation costs are among the potential reasons why customers are reluctant to recycle PET bottles. If compaction can be realized, it will not only save the customer's storage space but also improve the conveying and crushing efficiency of today's recycling. I started my work from three aspects: 4-1-a. Analysis of the compression mode of existing PET bottles. 4-1-b. Initial conception. 4-1-c. Exploration of prototype-making technology.

4-1-a. Analysis of the compression mode of existing PET bottles.

The current PET bottle compression methods are mainly divided into horizontal and vertical compression recovery methods (Figure 5), of which vertical compression is the least difficult and saves the least space. The difficulty of vertical compression is moderate, there are certain requirements for the customer's physical fitness hand strength, and the space-saving effect is in place after the compression, so I focused on vertical compression.

Figure 5– Horizontal & vertical compression

After more than 30 attempts at vertical compression, I discovered that it took 4 times to compress a 500ml PET bottle into a perfectly shaped "pie" (Figure 6 &7). In addition, PET bottles do not break or leak during compression.

Figure 6– Vertical Compression attempt

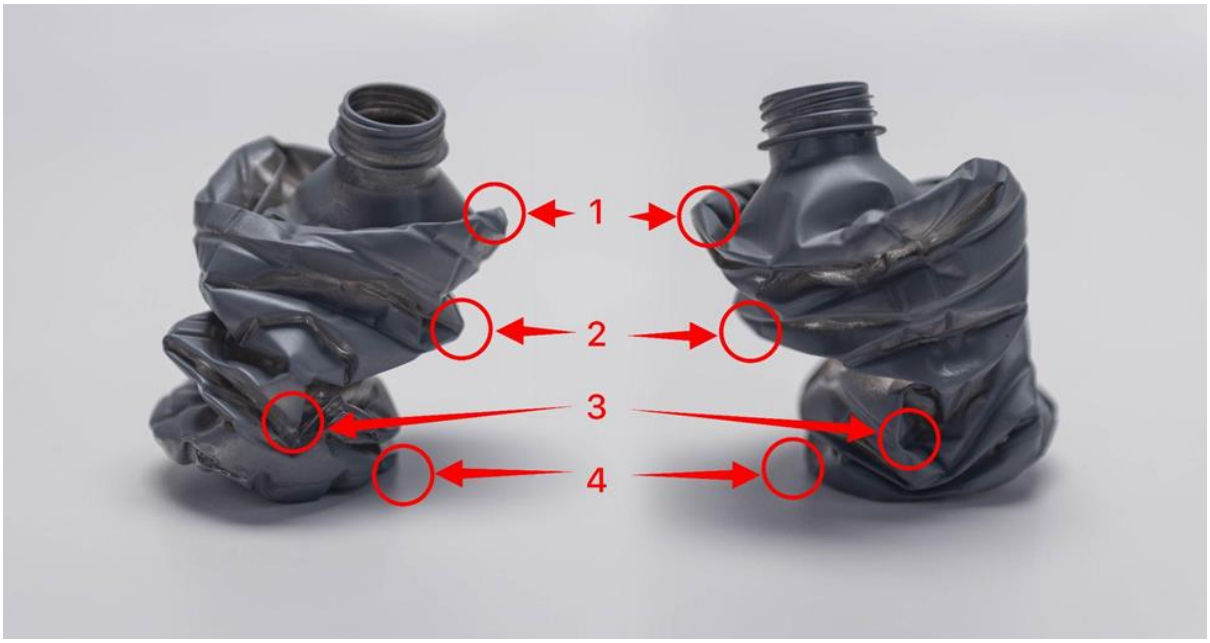

Figure 7– Perfectly shaped "pie"

4-1-b. Initial conception.

How to understand efficient recycling is a key goal of the early concept of this project, and based on quantity research analysis, consumers may be interested in a space-saving storage method. Therefore early concepts for this project are based on the following categories: origami arts, secondary creations of PET bottles, and the Costco recycling system.

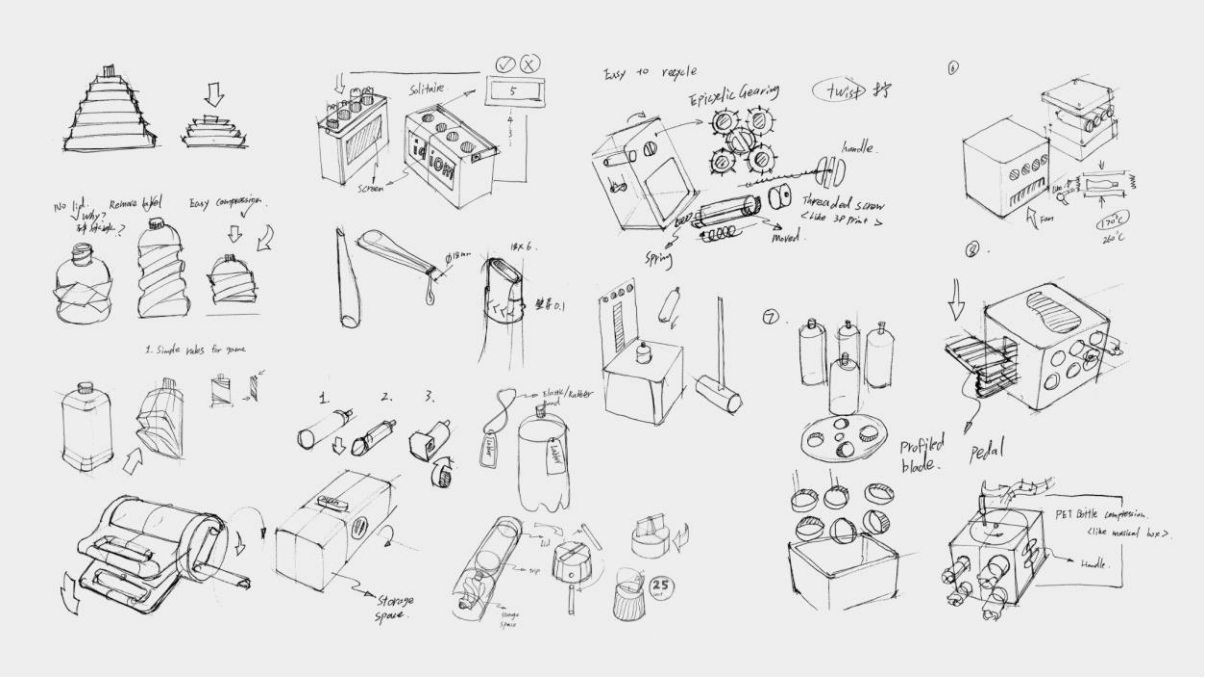

Figure 8– Early concepts

4-1-c. Exploration of prototype-making Technology.

I drew inspiration from the art of paper folding and experimented with a set of six patterns, and two concepts for future recycling. To provide interviewees with the most visual proof of concept

and objective test data, I used CAD models and 3D printing techniques to reduce test errors (Figures 9 &10).

Figure 9– Paper Prototype & Recycling Conceptual Map

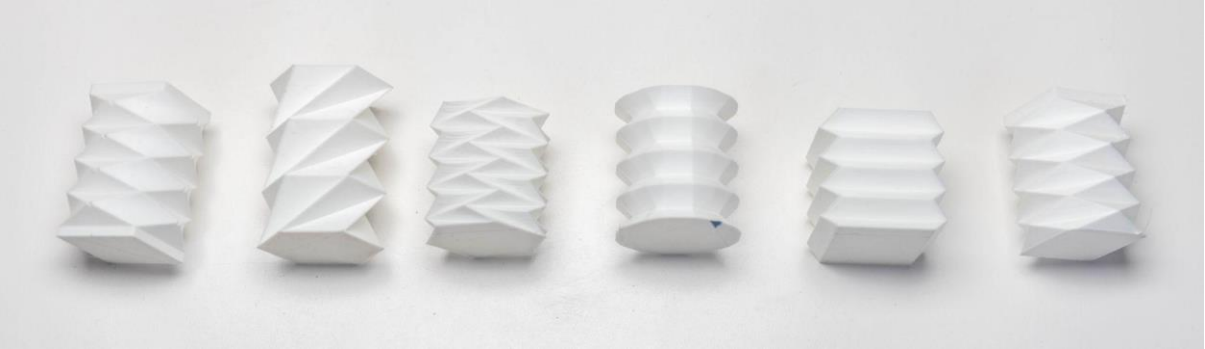

Figure 10– Photos of First concepts & 6 test prototypes

4-2 Concept refinement.

I conducted in-person interviews and prototype testing with eight millennial interviewees from different fields and backgrounds. The interviewees were asked to provide objective evaluations as consumers of the prototype and two sets of recycling concepts, and their opinions on the future recycling system were solicited.

Figure 11- Customer interview images

During the first round of interviews, the eight interviewees provided some suggestions, the most prominent of which were:

1. Increase the recycling value of PET bottles to promote recycling.

2. Establish my own brand to further strengthen the connection between consumers, sustainable living, and the product.

3. Abandoning the concept of DIY PET bottles, the research focus is on redesigning easily compressible PET bottles to save as much space as possible.

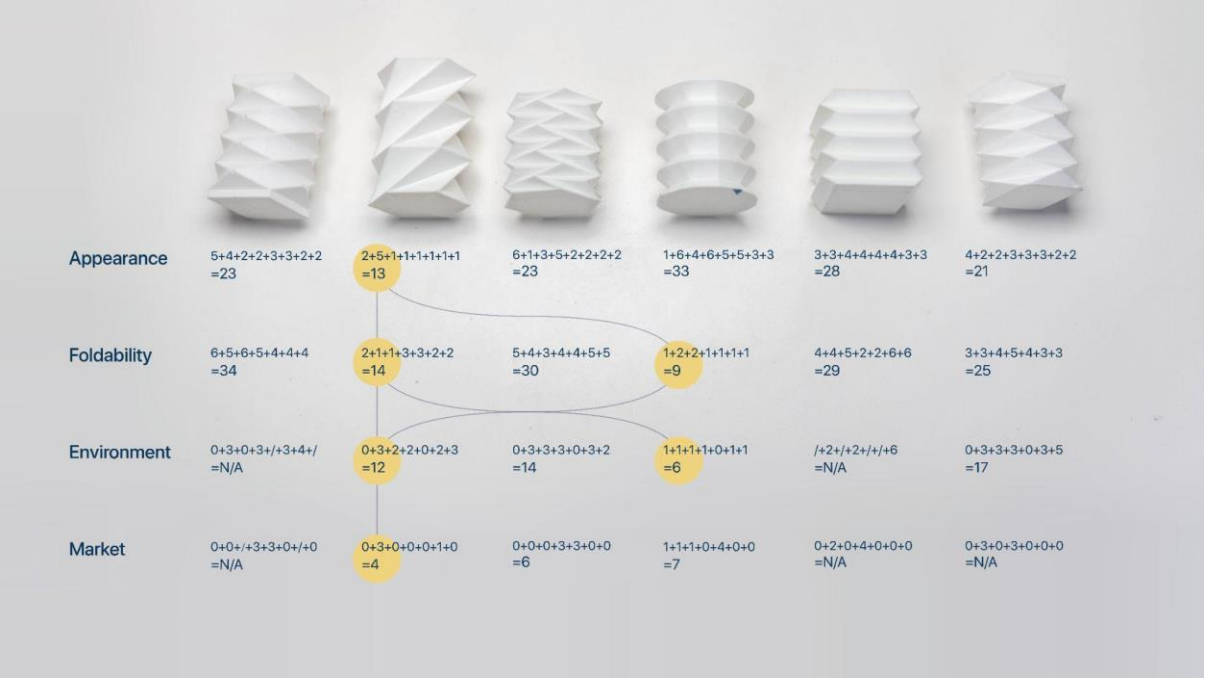

Figure 12- Statistical Chart of the results of six test prototypes.

Figure 13- Second prototype

Based on the information from the first interview, I developed a new concept (Figure 13). The result of the second iteration was a more concrete PET bottle proposal. A TPU prototype, made through 3D printing, can provide interviewees with a more direct user experience. Therefore, I planned a second interview with four experts, including professional designers from the packaging or industrial fields, experienced UX/UI designers, professors, and specialists. After comparing the new solution with existing PET bottles, I hoped to provide modification suggestions for this concept, especially in terms of later manufacturing and promotion.

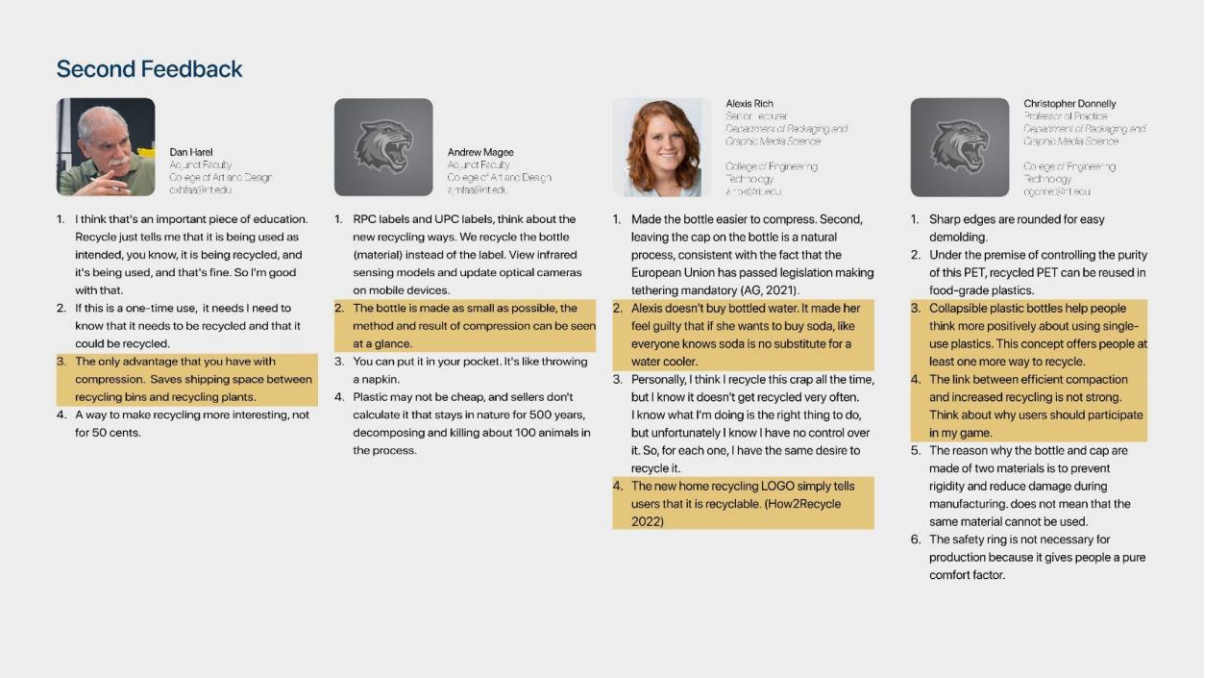

Figure 14- Summary of the second interview

In the second interview, the four experts showed great interest in the second concept and suggested emphasizing its easy compressibility. It is worth noting that the cap would naturally return to its original position because to prevent the bottle from rebounding after compression. This solved the problem of bottle cap recycling (AG, 2021). However, they noted that consumers

may not intuitively realize the sustainable benefits, as concept 2 emphasizes storage space savings and transportation efficiency. Therefore, they suggested that I attach clear recycling labels and repeat slogans on the bottle to remind consumers and connect their sustainable lifestyle with the products they use.

4-3 The prototype of the final concept

Figure 15- Final design photoshoot

After three iterations, the PET bottles were identified with effective compression and marking. According to the materials I selected and the origami art I quoted, I decided to use POGAMI to build the brand effect of this project. As an effective brand marketing solution, POGAMI promotes a sustainable lifestyle of "Crush, Conserve, and Recycle". On the other hand, it establishes a connection between discarding millennials' PET bottles and discarding paper towels. After using the product, it is temporarily stored in the pocket and discarded at the right time.

Figure 16- POGAMI Brand building

POGAMI's ultimate goal is to realize the PET plastic packaging cycle in the food industry which means new plastics can be used in urgently needed medical, industrial, and other areas (Figure 17).

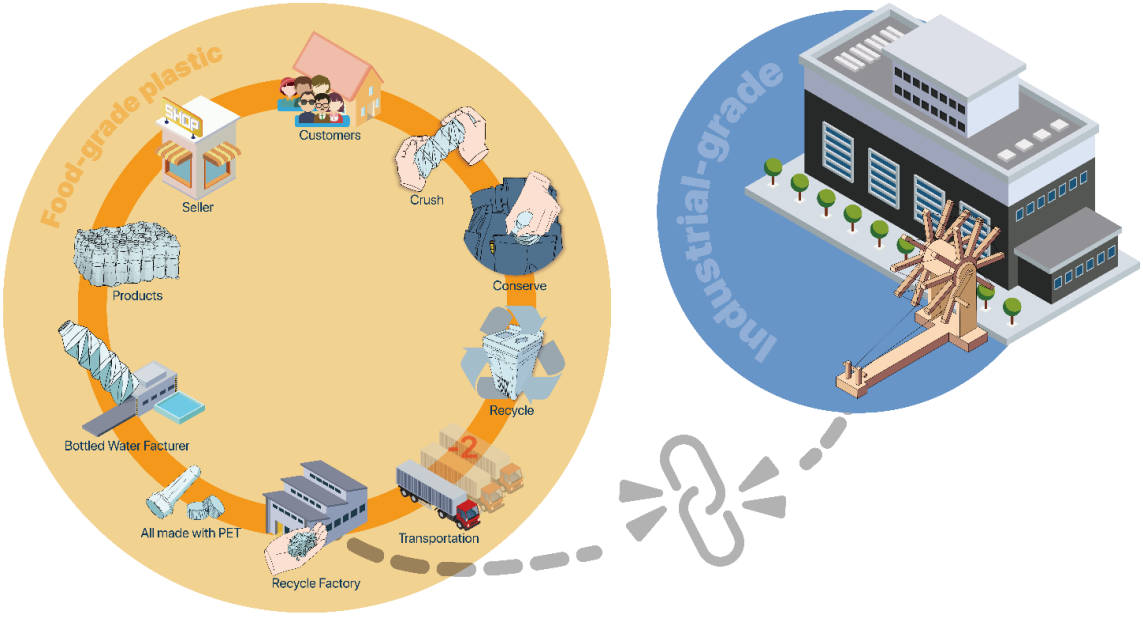

Figure 17- POGAMI's goal of circular economy

Conclusions

Overall, the main insights were collected during the testing. The compressed bottles (POGAMI) were considered useful. POGAMI cannot directly solve the problem of plastic recycling, but it creates new opportunities for sustainable life and achieves a circular economy for food packaging plastics by influencing the usage habits of customers. The final design addresses three main customer needs: saving space, reducing recycling guilt, and improving sustainable lifestyles.

A large part of this project is interviews. From the public to the experts, I have collected a lot of raw information from the viewpoint of appearance, usability, production, etc. Emphasis on

technological development and people's sustainable lifestyles. There is great potential for solutions that can support the recycling of plastics in food packaging. At the same time, it has a positive impact on the industry.

The next step for this project is to explore ways to improve sustainable creditworthiness. In this case, I will further develop the feasibility of recycling plastics in food packaging and seek cooperation with physical companies. Implement a sustainable lifestyle of “Crush, Conserve, and Recycle”.

References

AG, P. S. G. (2021, June 1). Packsys Global: "tethered" beverage container closures. petnology.com. Retrieved April 10, 2023, from https://www.petnology.com/online/news-detail/packsys-tethered-beverage-container-closures

Amazonas, M., Fisher, G., & Zhang, W. (2018). *Research Shows Which PET Water Bottle Design Attributes Impact Recycling*. Plastic Technologies, Inc. Retrieved December 3, 2022, from https://www.plastictechnologies.com/wp-content/uploads/2018/07/Research-Shows-Which-PET-Water-Bottle-Design-Attributes-Impact-Recycling.pdf

Angel Water, I. (2022, June 14). *The life cycle of a plastic water bottle*. Angel Water. Retrieved December 3, 2022, from https://angelwater.com/blog/life-cycle-plastic-water-bottle/

Center for Drug Evaluation and Research. (1992, May 21). CPG Sec. 450.500 Tamper-Resistant Packaging Requirements for Certain Over-the-Counter Human Drug Products. U.S. Food and Drug Administration. Retrieved February 26, 2023, from https://www.fda.gov/regulatory-information/search-fda-guidance-documents/cpg-

sec-450500-tamper-resistant-packaging-requirements-certain-over-counter-human-drug-products

Code of Federal Regulations. (2023, January 17). CFR - Code of Federal Regulations Title 21, Volume 4. accessdata.fda.gov. Retrieved April 10, 2023, from https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=211.132

Drmaxlib. (2020, December 28). *Recycling Is like a Band -Aid*. CLEAR. Retrieved December 3, 2022, from https://civiclaboratory.nl/

DW Planet A, D. W. P. A. (2021, February 5). *Is bioplastic the „better" plastic?* YouTube. Retrieved December 3, 2022, from https://www.youtube.com/watch?v=-_eGOyAiNIQ&list=LL&index=10

How2Recycle. (2022, July 28). How2Recycle. Retrieved February 26, 2023, from https://how2recycle.info/

Leong, B. D., & Lee, B. Y. H. (2014). *LEARNING the UNLEARNED: Product Design for Sustainability*. The Hong Kong Polytechnic University School of Design. Retrieved December 3, 2022, from https://www.sd.polyu.edu.hk/en/assets/files/Research/01-AL/LEARNINGtheUNLEARNED2014.pdf

Lobos, A. (2017). Mending broken promises in sustainable design. Routledge Handbook of Sustainable Product Design, 145–159. https://doi.org/10.4324/9781315693309-13

Polyportis, A., Mugge, R., & Magniera, L. (2022, November). *Consumer acceptance of products made from recycled materials: A scoping review*. Resources, Conservation and Recycling. Retrieved December 3, 2022, from https://www.sciencedirect.com/science/article/pii/S092134492200369X

Staff, R. T. (2015, October 20). *Weight of water bottles decreases, while recycled content increases*. Recycling Today. Retrieved December 3, 2022, from https://www.recyclingtoday.com/article/water-bottle-weight-decreases-recycled-content-increases/

TEDtalksDirector. (2019, August 16). *Origami robots that reshape and transform themselves | Jamie Paik*. YouTube. Retrieved December 3, 2022, from https://www.youtube.com/watch?v=DTIjvPLkJgo