

Polish



Group 3A

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Current Problems.

The Users...

Product Level

- Over **4.7 billion** plastic toothbrushes are produced worldwide every year and **99%** of these brushes are not biodegradable.
- These polymers are often over moulded and joined with the bristles using **permanent manufacturing and fastening techniques**. This allows for cheap manufacturing and consistent reliable use, but a disaster for recycling.
- However, alternatives have entered the market using bamboo and plant-based polymers like "The Humble Co" plant based and bamboo toothbrushes [3]. However, the recycling process is just as difficult as with typical polymer designs as these plant-based alternatives are still not designed for disassembly & are often not recycled correctly.

Packaging & End of Life

- A market-level movement has yet to be led towards creating **plant-based, fully recyclable packaging**, not just among the toothbrush market but FMCG in general.
- Although recyclable, most of the plastic packaging is not directed down the correct path of recycling.
- Although some take-back services are beginning to come to the limelight such as **Terra-Cycle** [4], it is not the mainstream option as there is simply no incentive.
- **200 million toothbrushes in the UK alone are disposed of into landfill** & every single one of these is still in existence; either in a landfill or floating somewhere in the ocean [1].

System

- A holistic systemic approach to making businesses sustainable needs to be the core focus of these companies.
- The **consumer is quite often not engaged with the end of life process** associated with their product, which impacts the sustainability of the whole system.

4.7 Billion
99% non-biodegradable

200 Million
brushes into landfill in UK
every year...

Global toothbrush value increase
over 6 years from 2020 to 2026...

\$5 Billion

\$7.5 Billion

With **67 million people in the UK** today and over **40 million of those between the age of 18-65**, most healthy, fortunate humans are users of a toothbrush. This means the scale of the current problem is vast, but also means the possibility for change through innovation is also vast.

However, based on previous ethnographic outreach and surveys in previous research, the following common pain points were highlighted.

Consumer Pain Points

- ↳ Using a worn out old toothbrush for far longer than expected.
- ↳ Most affordable toothbrushes having the shortest life-span.
- ↳ Not enough sustainable options within the marketplace currently.
- ↳ Insufficient end-of-life instructions for the consumer, often unclear.
- ↳ Price of replacing a whole toothbrush every 3 months, especially with a family.

Resulting Insights

- Improve the system of an oral care company as a whole. Taking a holistic approach to identifying scope for improved sustainability.
- Introduce localised manufacturing and material sourcing. This could drastically improve the environmental metrics of a company, but also cement a sustainable USP, removing the need to ship from overseas.
- Companies should form a systematic approach to the end-of-life product lifecycle. By considering disassembly at the design stage, companies can save time and money at the point of recycling, and have all the relevant systems already in place for the consumer.
- Creating a diverse range of sustainable alternatives within the sustainable sector. Providing the consumer with varied choice with regards to age rating and firmness...

Future Scenario

10 year outlook

With increased awareness about energy consumption during production and delivery, consumers would want to shift to more localized systems where sourcing, manufacturing, and recycling is done in the same geographical area. With the consumer utilising a local supermarket to source, replace, and dispose of the toothbrush heads all in one place, this new system allows all materials to be separated and disposed of in a sustainable manner. A new method of shopping is in place whereby the consumer brings in their own packaging and containers, in line with government single use plastics regulations- this goes for toothbrushes. Brands are inclined to adhere to universal sizing regulations to allow cross-compatibility amongst toothbrush handles and heads to improve accessibility within the marketplace. Toothbrush heads are collected together for recycling, therefore allowing for full recyclability and processing, resulting in direct use back into the production line. This categorisation and company responsibility for their own recycling waste improves the current issue with contamination amongst recycling, but also ease of sorting and reuse.



Actions of the User

- Consumers no longer buy single-use toothbrushes in supermarkets unless absolutely essential.
- Consumers move from online shopping to buying local. Supermarkets become the core focus of the populations needs. From groceries to DIY supplies to healthcare products.
- There is an attitude shift away from cheap, acute products and more desire to make things last.
- Users have a broader choice of what they want locally, making 'restrictive choice' a redundant excuse for buying from online platforms.

Actions of the Company

- Responsible for the complete end of life management of all their products. **No longer the responsibility of local recycling centres.** The companies will take responsibility for the collection and recycling of the products at their point of recycling.
- Companies localise their manufacturing to limit the milage travelled by each product but also to make the supply chain easier to manage.
- Companies review their whole product life cycle and process every year, and adapt to the changing needs of the world. Innovation becomes an internal focus point amongst employees and is integrated & implemented into their strategy.

Technological Advancements

Materials

Advances in material technology have allowed '**plant-based**' polymers to be predominantly starch. In 2022, the oral care brand 'The Humble Co' use a ratio of 35% Starch to 65% in their plant-based toothbrushes. In the future, they will have solved the issue of starch-heavy plastics being too porous and breaking down, allowing to increase the starch content from 35% to 70%, making this one of the most sustainable polymers on the market.

Furthermore, **Nylon recycling** has been the core focus of major oral care market leaders and is now able to be sterilised after use and melted down and recycled directly back into the toothbrush bristle manufacturing process.

Full Recyclability

Starch-based polymers are now able to be **fully composted at home** in the organic waste. Furthermore, with mostly **mono-material designs**, this improvement allows for a pure, easy recycling process.

Nylon is now fully recyclable and able to be used again directly in toothbrush bristles.

Helping the User

Shops have optimised customer interactions allow for a seamless interaction between the customer returning the old bristles and collecting the new ones.

Manufacturing and transport costs have been reduced creating a cheaper, more affordable product for the consumer that still maintains its performance and futuristic aesthetics. Companies marketing strategies focus on their 'sustainable practices', providing incentive of the consumer to use these new products.

Now

70%

2027

35%

The starch content within 'Bio-plastics' increase over the next 5 years according to 'The Humble Co predictions.'

Polypropylene

Starch

Our System.

To tackle the previously mentioned problems and to increase the sustainability of the toothbrush industry, a hyperlocalised closed loop system is designed. In this system, the toothbrush, made of 3 monomaterials, are either fully recycled back into the same product, composted, or fully recycled into new products, depending on the material in this system. Two key objectives are achieved:

Initial Virgin Nylon & PET collected

It isn't possible to recycle the nylon/ PET back into the toothbrush heads. They will be sent to an advanced third party recyclers who have a better technology to recycle the materials into other products. This does take it off the closed loop but still remains an open circular loop

Open Circular Loop

Removed Contaminants

Melted
Polymer extrusion is the process carried out to make long thin reels of nylon. These reels are cut at specific lengths in order to then be attached to the toothbrush head

Extruded Into Reels

Bristles attached to head

Rounded to relevant hardness
Smooth bristles provide a comfortable brushing experience. Thus, the bristles are softened and rounded by machines present at the factory

Safety Check
All parts of the brush go through a thorough safety check to ensure they are safe for the user as it is a personal health product.

Injection Moulded
PET is one of the most recycled form of plastic and is simply injection moulded back into the shape of the head it originally

Injection Moulded

Pellets Formed

Starch & Virgin Polymer Collected
With advanced composting systems at home, the handle would just degrade in the backyard and turn into soil along with other food waste in the house.
This, in the larger scheme of things, closes the loop as starch on soil too...

Stacked

Sanitized
It is assumed that technology to sanitize and recycle nylon bristles will exist so that they can be taken back to the same form, be hygienic, and are still able to remove plaque

Composts Naturally

Goes to Backyard

Disposed with Organic Waste

Handle Dispensed
After purchasing the handle for the first time, the user is expected to re-use it for a few years until it starts to wear out...

Transported

Dispenser Loaded

Separation/ Identification
At this stage, the material goes through filters (e.g colour) and also quality. After certain number of recycles, the polymer cannot be made into a head anymore, and *this is placed separately*

Used until worn out

Plant-Based Handle

Sterilising

Washed

Manufacturer separates bristles from head

Head dispensed

Rejected Parts

Cannot be recycled by manufacturer

Separation/ Identification

Goes back to the manufacturer

Old heads collected in shop hopper
With a hopper within the store collecting up the nylon/ PET heads it becomes easier for the manufacturer to find value and recycle the materials. This step is vital as it makes sure that the materials don't leave the loop and are further taken back into production as raw materials

Sent to third party recycler

Melted

Nylon Bristles

Polymer Head

Granulation

Melted

Sterilising

Separation/ Identification

Separation/ Identification

Goes back to the manufacturer

Plant-Based Handle

Used until worn out

Disposed with Organic Waste

Goes to Backyard

Composts Naturally

Pellets Formed

Injection Moulded

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Extruded Into Reels

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Product and Packaging Design.

The design offers a compromise between high quality oral care and a stripped back toothbrush removing unnecessary elements in order to allow for easier disassembly and fewer materials to consider at end of life.

It was deemed that the product would have to compete with the top performing brands on a performance level in order to gain enough demand to be able to start making significant positive environmental impact.

Bristle Rounding

Rounding the bristles of toothbrushes is an important process. It ensures that brushing is comfortable on the gums. Whilst many alternative solutions were considered for how to trim and attach toothbrush bristles, it was decided that the bristles would be inserted in groups into a blob of nylon which would then itself be inserted into the head before the head had cooled to a solid state. Bristles would then be more easily removed without individual ones being lost in the process. The bristles are to be dulled using rotating abrasive disks along the factory line.



Head.
Material: Polypropylene
Mass 2g
End of Life Recycled
Price £0.50

PET is the most recycled polymer and the infrastructure already exists to efficiently do this. It is foodsafe and can be easily injection moulded.

Handle
Material: Bioplastic
Mass 12g
End of Life Composted
Price £4

This plant based polymer is injection moulded. With higher starch content in the future, this handle will offer a far lower embodied energy than even current bioplastics. Injection moulding allows for the details in the handle to be included during moulding.

Bristles
Material: Nylon
Mass 0.9g
End of Life Recycled

Nylon cleans better and lasts longer than any other alternative. Through user research we determined that quality of brushing was not something users wanted to compromise on so we have nylon to encourage more users to follow our sustainable journey.

Removal

Two holes in the handle allow for pins to be pushed through in order to snap the head out from the handle. Users are encouraged to follow this process in store where pins are provided on the dispenser. However, the process is still possible at home using a safety pin or sim card pin.

Hardness

Polish aims to provide no compromise on quality of oral care and therefore offers three hardnesses of bristles for the specific comfort of the user. All heads are disposed of in the same container by the user to minimize hassle. Once returned to the manufacturing plant, the bristles are stripped from the head before the polypropylene heads are sorted by colour so that they can be recycled.



Infrastructure.

Implementation

The infrastructure is produced and distributed by Polish who are also responsible for maintenance which would occur on delivery and collection if needed. The stores receive a percentage split of the money that Polish receive. Polish are responsible for collection and delivery of bristles head to and back from their manufacturing facilities.

Spring loaded, push to dispense

Manufactured from copper because of its anti-microbial properties (8). Once pressed, the dispenser releases one head. The system registers the number of new heads selected and once payment has gone through, allows any of the buttons to be pressed releasing only up to the paid for quantity.

Packaging of storage containers

Storage containers are made from acrylic with cork stoppers at the open end. The diameter matches with the design for the coloured dispensers as well as the disposal lid.

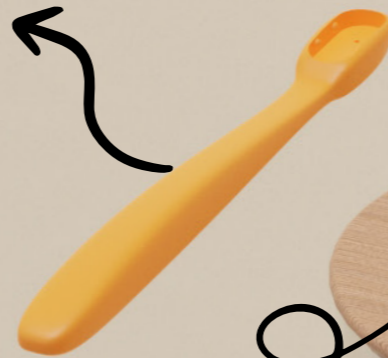
Two hoops are screwed into the wall which hold the containers and the dispensers in place as shown by the sketch on the right.

Polish provide the store with 3 spare empty containers and lids on initial setup and only on request after that with a small fee. Collection and delivery happen at the same time and the store are expected to return all excess containers.



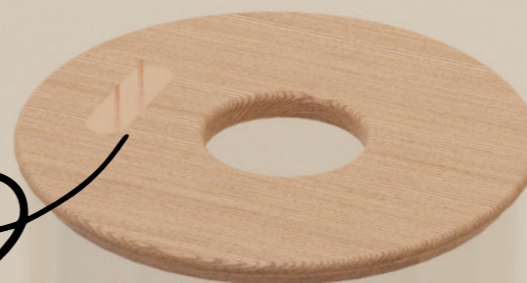
Absence of handle packaging

Within the context of our vision for the future where stores aim to almost entirely eliminate packaging and the responsibility is on the consumer to transport their products home in their own containers. We expect the handles to be displayed by the stores in whatever manner they deem fit with advice to wash at home as one might do with fresh fruit before eating. Handles are delivered to the store in the same reusable containers that the bristles are stored in.



Removal pins

The removal pins are embedded within a lid provided to the supermarket by Polish. The pins are made from copper because of its antimicrobial properties (8). The employees of the store are expected to sanitize the surface with a similar frequency to how they would with other areas with high frequency contact such as touch screens.



Storage of new heads

The storage containers filled with new heads arrive to the supermarket and are transferred over to the dispensers. Before they are placed on top, the dispensers are sterilized with foodsafe surface sanitizer. The used containers can then be used to collect used toothbrush heads.



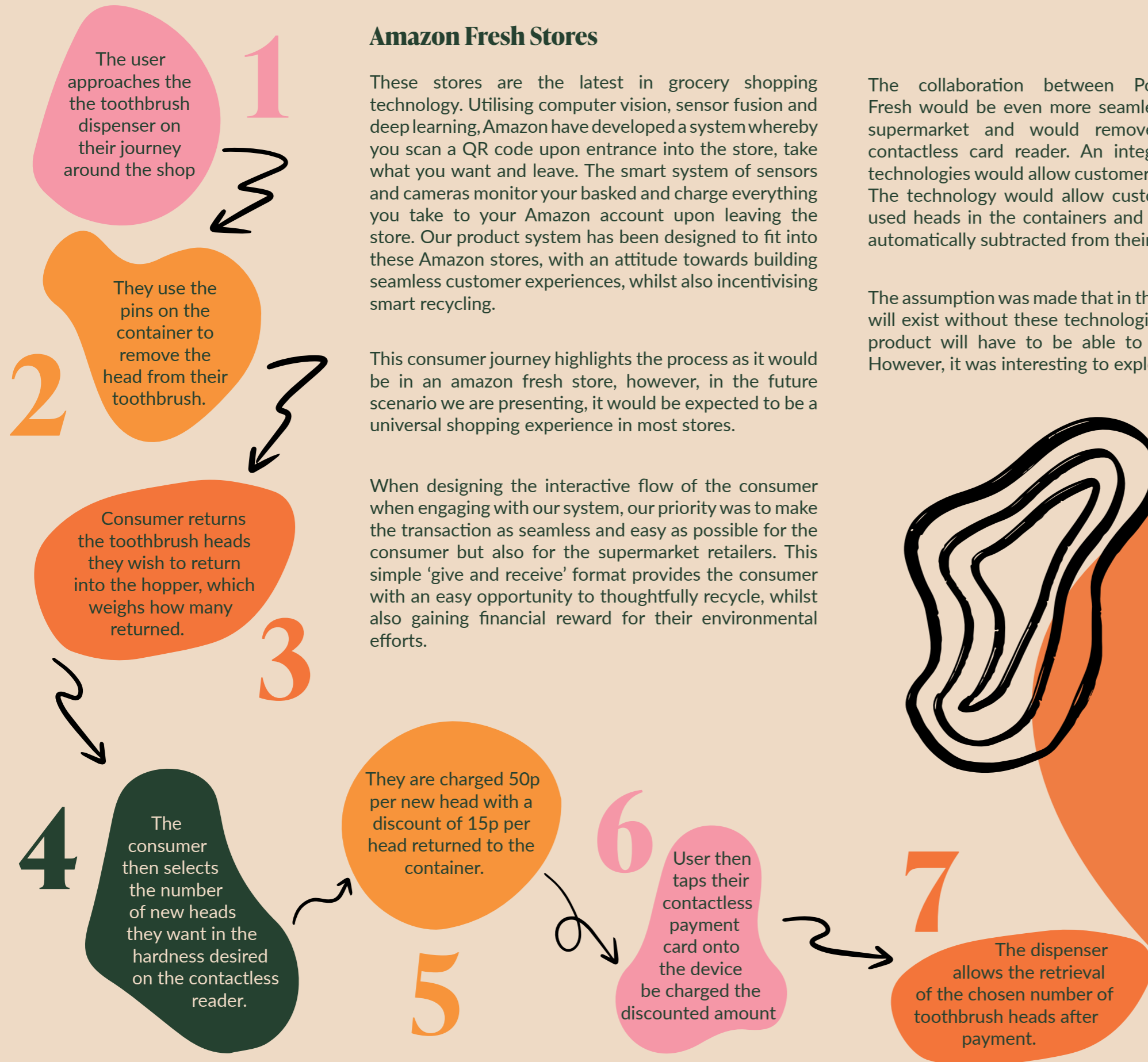
Contactless card reader

The scales underneath the container detect the number of used heads added and load 15p to the contactless card reader for each. Once the user has finished loading their used heads into the container and selected the number of new heads they wish to receive they can tap their credit card or phone against the reader to pay the discounted price or receive cash back. This is the same technology that is already used to incentivise customers to return reusable cups at sports matches.



User Interaction and Amazon Fresh

Mapping the Interaction:



Amazon Fresh Stores

These stores are the latest in grocery shopping technology. Utilising computer vision, sensor fusion and deep learning, Amazon have developed a system whereby you scan a QR code upon entrance into the store, take what you want and leave. The smart system of sensors and cameras monitor your basket and charge everything you take to your Amazon account upon leaving the store. Our product system has been designed to fit into these Amazon stores, with an attitude towards building seamless customer experiences, whilst also incentivising smart recycling.

This consumer journey highlights the process as it would be in an Amazon Fresh store, however, in the future scenario we are presenting, it would be expected to be a universal shopping experience in most stores.

When designing the interactive flow of the consumer when engaging with our system, our priority was to make the transaction as seamless and easy as possible for the consumer but also for the supermarket retailers. This simple 'give and receive' format provides the consumer with an easy opportunity to thoughtfully recycle, whilst also gaining financial reward for their environmental efforts.

The collaboration between Polish and Amazon Fresh would be even more seamless than in a regular supermarket and would remove the need for a contactless card reader. An integration of Amazon's technologies would allow customers to seamlessly shop. The technology would allow customers to place their used heads in the containers and the money could be automatically subtracted from their shop total.

The assumption was made that in the future, many shops will exist without these technologies and therefore our product will have to be able to function elsewhere. However, it was interesting to explore the possibility.

Benefits:

Seamless User Experience with whilst user remains incentivized to recycle because of financial incentive.

Fewer costs for Polish associated with infrastructure and maintenance since the technology already exists with Amazon Fresh.

Amazon have a strong sustainability agenda especially with regards to sustainable sourcing.

This in turn brings a more sustainably aware customer group who may align themselves with the values of Polish.

amazon fresh

Journey Mapping.

User Journey

The following flowchart shows typical steps a user of this brand/system of reusable toothbrush would follow. The journey would be unique for the first time, when the user has nothing to refill/drop off. Although, this changes when heads are changed every three months, and handles are dropped off once they wear out

User makes a grocery list

Drives/walks to grocery store

Composts used handle

Buys a new toothbrush handle

Collects brush head

Drops off used head

Goes back home, Uses for three months

With this system, the user collects new heads while they're out for grocery shopping at the supermarket. This local system removes extra transport required to deliver just one item at their doorstep.

With future advancements, users will be able to just dump their handle with their organic waste so that it gets composted naturally. They would have to do it when it feels worn down, at their convenience

To incentivise the user, if heads are returned, the new ones can be bought at a discounted price. The dispenser is intuitive and does not require a high maintenance staff

Due to its ergonomic design, the brushes can be used by most people in the teens and adult demographic. This means that one grocery trip can get heads for the entire family at the same time.

An important assumption in this journey is that the user understands reusability and doesn't leave the system after just a few repetitions. This wouldn't offset the sustainability effort.

As suggested by dentists, the bristles of a nylon toothbrush should be changed every three months as they start to harden, lose their specific shape, and overall, do not remove as much plaque. Thus, the handle is reused by the user every three months

User Experience

With mapping a possible generic user's experience with the system, it becomes easier to understand individual places where it performs better than the existing one. The aims of the system should be firstly, to maintain high satisfaction levels and secondly, to incentivize the user to become a returning customer as without customers, no matter the credibility of the system, the loop might never be completely closed.

	Before leaving	Getting new handle	Disposing used heads	Getting new heads	Usage (brushing)
					Satisfaction Sustainability Efforts
Thinking / Feeling	"I should check if the brush heads needs to be replaced. It has been a long time." "My son's handle seems to have gotten old, I'll just go ahead and put that in my backyard with my other food waste"	"I hope the dispensers are somewhere in the oral care aisle." "There seem to be some new handle in the dispenser. I'll get that for my son, Luckily, the normal head would still fit in!"	"Cool, I've given four used brushheads. This collection of heads seems like an interesting idea." "Oh, theres data about the collection as well! Good to know that I'm being more sustainable than before!"	"Okay, this dispenser seems easy to work out, just press here?" "Yeah," "Great, I even get a discount for returning the old ones, this system is surely cheaper than buying brushes everytime haha."	"This is good, the brush feels just like another quality toothbrush" "I was really worried considering some of these brands are just all say but nothing good in the product,"
Cost at each stage	Whilst making the list for shopping, every user has an expected cost for an item. Here, the user has a high expected cost as they have to buy a handle and four brush heads.	The first purchase is the handle. With this system, different styles would have different costs and depending on the need of the user, they might chose to buy a certain kind.	The disposal system is completely free of charge.	With returned brushes, the cost for new ones is much lower, therefore, the running cost for utilizing this toothbrush system is very less.	With the design and bristles being similar to competitors, the other utilization costs such as water, stay the same, irrespective of companies and brands.
Notes	<ul style="list-style-type: none"> - Grocery trips are quite often for families, thus, missing buying the brush in one won't affect much. - Home disposal of handles makes it really easy for users. 	<ul style="list-style-type: none"> - Should aim for an "ideal world" system where all brands have a common mechanism to insert a brush head. - The user can just put the handle in their bag, doesn't need packaging. 	<ul style="list-style-type: none"> - It's good when users are aware of why the system is in place. Displaying facts about their involvement invokes pathos. - System needs to be with other oral care products, 	<ul style="list-style-type: none"> - As heads aren't disposed at home, there needs to be a monetary incentive for them to dispose them at a supermarket. - User needs to realize that its not only better sustainably but financially too. 	<ul style="list-style-type: none"> - The main idea with this product is to keep satisfaction at the highest at all points, which is achieved. - User's Sustainability efforts may fluctuate, but the product should take care of itself.

Environmental Impact.

To assess the environmental impact of Polish, an Eco-Audit was carried out using CES Edu-Pack. The two separate journeys of the head and handle were analysed.

Materials

Head 2.79 MJ (84.8%)
 Head 0.127Kg (77.3%)
 Handle 3.6 MJ (65.9%)
 Handle 0.16Kg (52.8%)

Manufacturing

Head 0.484 MJ (14.8%)
 Head 0.0363 Kg (22.1%)
 Handle 1.82MJ (33.3%)
 Handle 0.136Kg (46.2%)

Eco-Audit Summary

Transport

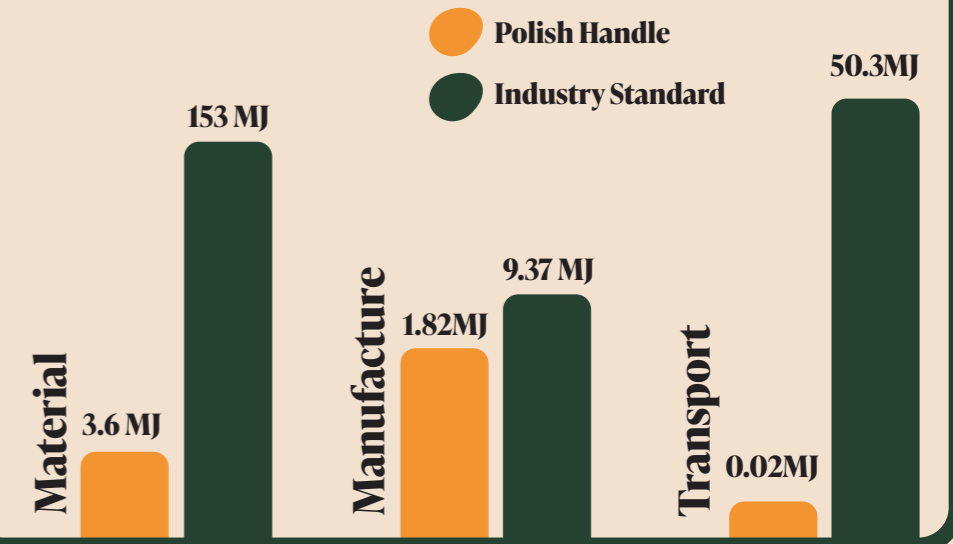
Head 0.00738 MJ (0.2%)
 Head 0.00053Kg (0.3%)
 Handle 0.02MJ (0.4%)
 Handle 0.0014Kg (0.5%)

End of Life

Head 2.7 MJ (%)
 Head 0.121Kg (%)
 Handle 0MJ (0%)
 Handle 0Kg (0%)

Adding this remanufacturing stage saves around 63% of energy and CO₂

The embodied energy of our toothbrush handle was compared to the environmental assessment of the typical polymer toothbrush in today's market. The results are highlighted below:



Analysis of Comparison

Over every stage of the lifecycle, our new design champions over the traditional manual toothbrush competitors. However, despite both the industry standard and our design both having 0MJ end of life potential, our handle biodegrades into the soil with the standard toothbrush either ending up in the oceans or wholly underground for decades.

The results above show **ONE lifecycle** of the industry standard toothbrush. However, the figures shown above by our design are representative of **EIGHT lifecycles** of a traditional toothbrush as this new handle is designed for use for 2 years, with the traditional brush only have a life of 3 months before becoming redundant.

Furthermore, the difference in transport environmental impact is vast. The difference in embodied energy from manufacturing locally as opposed to overseas in China is staggering. With a **2'500 times** greater embodied energy from the shipping of the product from overseas.

The handle has NO end of life potential as the desired outcome is full bio-degradation in the consumers home compost.

Innovation & Feasibility.



Why?

- Our solution completely removes the need for packaging.
- Utilises a complete closed system within all system elements of the product.
- Encourages the supermarket to become the recycling hub of a product, making recycling more feasible for consumers the local nature of shops attract daily visits from customers.
- Our solution encourages the users to recycle using financial incentive and reward.
- Polish uses a high concentration of starch to PET, allowing for faster biodegradation and breakdown after use. Furthermore, this biodegradation process does not need industrial facilities, just the consumers backyard.
- The user has complete control of bristle firmness and are not restricted to just one firmness.
- Fits a gap in the market that balances its sustainable agenda with high quality oral care.

How?

- Rather than establishing a new payment and ordering system on it's own, Polish utilises already well-established resources such as Amazon Fresh. This acts as both the advertising, the ordering, the payment and recycling hub for the product.
- The Polish consumer and stake-holder (supermarket) interaction has been optimised and made as seamless as possible to minimise maintenance for the supermarkets and increase desirability to stock the product in stores.
- Through the environmental analysis, Polish has proven to be more sustainable than traditional manual toothbrushes in all areas of the products life-cycle.
- Polish does however rely on a governmental shift towards supporting localised manufacturing within the UK, as one of the key sustainable USP's is the minimised milage undertaken by the product from manufacture to consumer.
- Polish also relies on future improvements in all areas of the recycling process, specifically within recycling Nylon back into oral-care products. Polish is also dependant on technological improvements in bio-plastics through increasing the starch content within these starch-polymers.

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If all these technological and societal challenges of the near future are met, Polish is set to be a market-leading, innovative toothbrush setting the path for the future of oral-care.