A Design Approach for Extending Product Longevity

by

Kaelan Harrison

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Combating the challenges faced by
modern product obsolescence

Approved by

Jerrod Windham, Chair, Professor, Industrial Design
Joyce Thomas, Co-chair, Professor, Industrial Design
Rusty Lay, Professor, Industrial Design

Abstract

This guideline proposes to extend the longevity of products by helping the designer consider authentic human behavior when designing new products. This includes designing products that provide true human satisfaction while minimizing the environmental impact associated with the product's life. Designing for emotional durability using empathic modelling helps to promote human satisfaction, while the modularization of components and the user's right to repair provide longer lasting products. The Okala Practitioner is used to provide the designer with means as to how much the product impacts the environment. Within this guideline is the Golden Pyramid evaluation tool which is intended to allow the designer to gauge where their concepts place in terms of human satisfaction, environmental impact, and longevity. This tool can be used with any design concept and existing product.

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products have on the environment. I would like to thank Beth Topping, a professor in the English department at Georgia State University, for reading through the entirety of this thesis and making sure the grammar and formatting was correct. Lastly, I would like to thank all the people interviewed in the implementation section that provided me with information and critique regarding the concepts being developed.

Dedication

This thesis is dedicated to my parents, Wes and Donna Harrison, who provided me with inspiration and support throughout the time spent writing this thesis. Without them I would not have had the encouragement, financially and emotionally, to continue to strive forward. They pushed me continuously to be the best I could be in the entirety of my time at Auburn and raised me to be the open-minded person I am today. I love and thank them tremendously for this.

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1 Introduction

1990s: Earth's waste more than tripled in the previous two decades, with same increase in plastic production. 2000s: More waste was recorded on Earth in the prior decade than in the last 40 years previously. 2018: We produce 300 million tons of waste a year, which is nearly equivalent to the entire human population weight (Jambeck, 2018).

The world is filled with products that tend to often unused rather than be utilized to their full potential. When addressing sustainability for the 21st century, designers should consider creating products that can be used and useful for the entirety of product lifetimes. During the early industrial revolution, products were built with durability, without intention of planned obsolescence which is a 'modern' invention and conscious decision by manufacturers to make products less durable, forcing consumers to constantly replace products and ensuring new sales (Hirsh, 2021).

Sustainability is an extremely broad topic and refers to many different environmentally conscious decisions. This thesis will describe sustainability in the sense of product longevity through human satisfaction while minimizing the environmental impact of unused and discarded products.

1.1 Problem Statement

Product obsolescence is damaging to our planet as well as damaging to the human mind. It has influenced American society to be more materialistic because of the perpetual desire to get the next model. Humans are continually disappointed by their current possessions because there will always be another, better product awaiting them. Humans tend to desire aesthetics much more than they did 100 years ago, which causes designers to spend more time thinking about them instead of the products durability, functionality, and usability. Functionality and usability have become expected, and users now desire products that truly satisfy them in other ways than its ability to do the intended task.

1.2 Need for Study

Designers have a stronger influence on society than ever before. They have ability to create products that make tasks simpler and increase efficiency, overall making life better for people. Business owners should look further than only the profitability and strive to create timeless products that users engage with over longer periods instead of making products that quickly turn obsolete to ensure profit for the companies who produce them.

Unused or broken products that are meant to go obsolete over a short period and discarded are exponentially creating harmful waste. Making products go obsolete in a brief time allows for increased profit from sales, which tempts the business and financial mindset. Consumers often prefer to buy the newer model of the product instead of repairing it themselves if a part fails. As culture demands more skill

specialization, causing a shift away from people being the jack-of-all-trades, the average person is no longer equipped to repair products themselves. Along with this, the cost of labor has increased, and people's time has decreased. The consumer often would rather order a new product rather than to spend the time and money getting it repaired. These are mindsets that cause discarding products to become a more and more unsustainable practice.

1.3 Purpose of Study

Research shows that designers can have a role in changing the industry for a positive impact. This study is undertaken to encourage the designer to create products that are both emotionally and physically durable with the goal of reducing product obsolescence and increasing sustainability. The purpose of this study is to provide designers with information and a guideline to develop long-lasting, sustainable products that deeply satisfy user needs.

1.4 Assumptions

- The authors cited in this paper have expertise in the fields that they have written about.
- The reader is familiar with traditional industrial design processes and methods.
- Designing products meant for obsolescence harms the environment by creating excessive waste that ends up in landfills.

- Some companies purposely encourage consumers to develop a mindset to want/desire/need the next product, and to discard 'old' products.

1.5 Scope and Limits

The scope of this thesis is to provide designers a new evaluation tool, a business/product paradigm, The Golden Pyramid, that is divided into three desired goals: minimize negative environmental impact of manufactured products, prolong longevity of product usage, and help the user reach satisfaction with their products. This pyramid can help a designer gauge the areas of sustainability they are improving in. It can be used with products developed using any set of design guidelines. It is a healthy way of reflecting upon the work done and sensing what areas need improvement. What limits this paradigm is the fact that the three goals are dependent upon each other and each influence whether all can be achieved. For example, if one has minimized a product's environmental impact and reached human satisfaction, then the product might not be as physically durable. Or, if the product is physically durable and is safe for the environment, the user may be dissatisfied with its functionality, usability, or aesthetic qualities. The designer will also be using their best judgment and honest opinion to evaluate their product appropriately.

1.6 Anticipated Outcome

The Golden Pyramid proposed in this thesis incorporates the scope of three goals of environmental impact, product longevity, and human satisfaction towards creating a way for designers to gauge where their product meets these expectations.

The guidelines of this thesis are intended to change the way the designer thinks during the entirety of the design process. Over the next decades, society will see that designers have a significant role in changing the destructive environmental course that is currently in motion. Using the proposed guideline, the designer will be encouraged to think empathically towards both the user and the environment towards creating long-lasting products that benefit the designer, user, and the environment. The designer will be prompted to discover new information and user preferences over the course of a product's lifetime, things that help the user to feel an emotional connection to the product because of how well it fits into their specific environment and needs. This shift of focus is mandatory for making incremental changes to the product industry for future generations. Previously, 'time, quality, cost' was a focus of business during the product development phase, which ignores product lifetime.

A way to prolong product lifetime is to analyze what ideals consumers truly long for by finding what qualities in products extend the emotional durability. This includes breaking down the features of the desired product and finding which ones create a connection between the user and product. Along with emotional durability, giving the user the ability to disassemble and repair the product themselves is intended to help prolong the product lifetime instead of needing a repairman or in worst case scenario, replacing the entire product. This thesis not only provides the designers with design considerations to help lengthen the lifetime of their product, but also it explains how to approach sustainable design methodology.

1.7 Definitions of Terms

Authenticity – refers to when a designer is true to the user research and puts effort into meeting the dependencies of the user and product.

Componentization - items working together to form a single functioning item. Since each part is separate, it is often possible to upgrade, change or repair one component while leaving the main system operational.

Dissatisfier - have to do with a person's relationship to the context or environment in which she or he performs the job (Gawel, 1997).

Dependency – human dependency suggests an abnormal degree of reliance on something that is psychologically or physically habit-forming. Product dependency refers to anything that a product, part of a product, project, user, or partner relies on.

Emotional Durability - A term coined by Jonathan Chapman (2005) that combines the durability and longevity of products with their emotional significance to the user.

Golden Pyramid – A comparative product tool/guideline based around human satisfaction, product longevity, and minimal environmental impact.

Modules – each of a set of standardized parts or independent units that can be used to construct a more complex structure, such as an item of furniture or a building.

Naturalistic Materialism - refers to human interests and values that are based on reason, scientific investigation and experience (Walker, 2014, p.8).

Reflexive Evaluation – At the end of an evaluation, once you have reported the findings, go back to the data collection tools you use and consider what changes you would make in hindsight (Kallos, 2022).

Satisfier - describes a person's relationship with what she or he does, many related to the tasks being performed (Gawel, 1997).

Sustained Narrative - describes the ability to adapt a product over the course of its life. It may include features that change according to the day or be useful in multiple scenarios.

2 Human Satisfaction, Longevity, and Environmental Impact

This chapter includes a review of information relating to emotional durability, component modularization, minimizing environmental impact, and human satisfaction. These points are substantial to the future of design and are significant factors in expanding the longevity of product lifetime. Sustainability is a broad topic, but one way that designers can make sustainable choices is by extending product longevity. This ensures that products are produced with good conscience to be utilized for the entirety of their life.

Emotional durability is included to give the designer an example as to how to design with empathy and authenticity towards the user's needs (see the product case studies 3.1 Volkswagen Beetle and 3.2 Tamagotchi). Emotionally durable design is the combination of creating truly satisfying products by making the consumer dependent on them in a positive way. Empathizing with the user is the first step in creating longer lasting products. Another cause of the termination of a product is due to the difficulties of disassembly and repair. Many products are made with the intention to not allow the product to be taken apart so that the consumer is forced to spend more on a new product or a professional to fix their product. One way to ensure that each part of the

product performs to its potential is modularizing (refer to Quip in 3.4). By modularizing parts of a product into components, the user can replace one component without disposing of the entire product.

Understanding the research and applying the proposed guideline in this thesis will allow the environmentally conscious designer to proceed with positive impacts and scale out where their product falls under these areas in relation to existing products. One positive goal should be for the product to not leave behind a negative footprint ecologically. The product should be utilized to its full capacity while also being environmentally friendly, and these design considerations are needed for the designer to reach a product with true human satisfaction. They will not all be able to be met due to constraints in the industry, but there can always be improvement.

2.1 Human Satisfaction - Emotional Durability

Emotional Durability is a term coined by Jonathan Chapman (2005) that combines the durability and longevity of products with their emotional significance to the user. This is an approach to creating empathy and connectivity with products that are usually discarded due to naturalistic materialism and product obsolescence.

2.1.1 Naturalistic Materialism

"Naturalistic Materialism is related to forms of modern secular humanism in which human interests and values are based on reason, scientific investigation and experience" (Walker, 2014, p.8). Human values are constantly shifting and transforming. The Information Age began around 1970 and is how our society is currently classified (Toffler, 1980). Before the Information Age, faith in a higher power was the basis for

human life; however, an increase in information due to the growth of technology encouraged a materialized society to be shaped. Human evolution is increasing incrementally due to new-found experiences that are occurring exponentially. With this constant redevelopment of cultural ideals, traditional sources of value have been discarded with nothing to replace them (Chapman, 2005; Walker, 2014). Considering humanity has replaced long-standing ideals with materialism, businesses found they could sell more products by manipulation. Products could be produced at less cost and with a decreased lifetime because consumers will not hesitate to go purchase the most recent model. This growing materialism resulted in the business scheme of planned obsolescence which increases profit margins.

2.1.2 Product Obsolescence

Increased profit margins mean there is now a need for rapid production. With this increase of manufacturing, multiple variations of products could be made making it tougher for consumers to know if they have the product that addresses their desires the most. Before the user has had time to become adapted to a product, the replacement has already been manufactured to buy at a low cost. “In a marketplace of relentless product obsolescence, the notion of consumer satisfaction will remain a utopia until product values diversify to incorporate factors beyond technical modernity” (Chapman, 2005, p.17). Our desires are being controlled by the industry to expand the market based on disappointment and dissatisfaction. This approach allows for users to have the feeling of limited progress. This has been termed *undercover/staged* marketing because it feeds on slightly ‘improved’ versions of basically the same product arousing the

feelings of desire, cravings, and status (Walker, 2014). Reducing product obsolescence entails eliminating design approaches that promote designer superficiality, consumer utopias, and technical modernity (Chapman, 2005). Product obsolescence is separated into two different terms: relative and absolute obsolescence (see Figure 2.1).

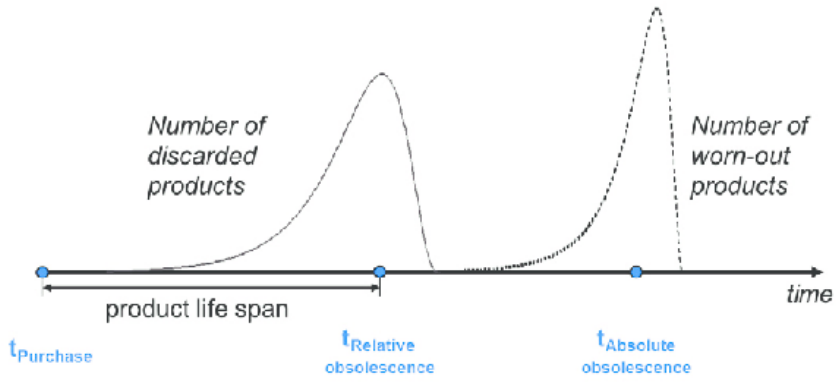


Figure 2.1 Relative and Absolute Obsolescence

Relative Obsolescence refers to when the user discards the product due to decrease in functionality or reduced aesthetic appeal. This could be in terms of battery life, durability, or modernization of production. If a newer product costs the same or less than the cost to repair, then the user feels obligated to buy the updated product. Absolute Obsolescence refers to when the product is physically worn out. This means the product has reached its intended lifetime and cannot be used anymore (Fels, Falk, & Schmitt, 2016). As one can see, consumers are drawn to thinking their products have reached their end of life much before even the intended lifespan has been covered. This is due to the exponential number of products being produced more rapidly each year. Products are discarded before their intended lifespan end as well as much before they are physically worn out.

2.1.3 Designer Superficiality

Designer superficiality is the tendency of product designers to ignore product value in favor of encouraging consumer spending on new and/or updated products. A business mindset based on monetary value tends to encourage the designer to create products with a shorter lifespan. “Cosmetic approaches to design engender wasteful cycles of desire and frustration within consumers by delivering only short-lived glimpses of progress” (Chapman, 2005, p.16). Chapman uses the metaphor *cosmetic approaches* (tactics fashion companies use to manipulate women into buying the most recent cosmetic or fashion product) to explain how some products are being marketed. When conceptualizing, this approach prompts designers to create products that deliver a false narrative to the user. The moment that advertising and promises made by manufacturers fail to meet expectations of the consumer, they begin to desire the newer model. Designers need to refrain from aesthetic perfection which creates an endless cycle of the user craving fulfillment (Walker, 2014).

2.1.3.1 Consumer Utopias

Business models try to advertise perfection. They aspire to optimize the amount of attention brought upon their product. This can create an assumption that the entirety of truth will not be included within the advertisement. False advertising allows for the idea of a *consumer utopia* to arise. A consumer utopia refers to the psychological state in which consumers feel as though life will only be ideal after getting the ‘next product’. No matter the amount of effort manufacturers put in, the world will never fulfill the material desires of humanity. Advertising a perfect world is not being authentic.

Without authenticity, a product does not provide an adequate emotional connection due to immediate disappointment. Designers ought to make products that avoid the excessive, distracting superficiality of the marketplace and that have congruency with meaning (Chapman, 2005; Walker, 2014).

2.1.4 Maslow's Hierarchy of Needs

To create products with authenticity, designers should consider all factors of human needs. Abraham Maslow's pyramid is a five-stage model expressing the all the basic needs of human development (see Figure 2.2).

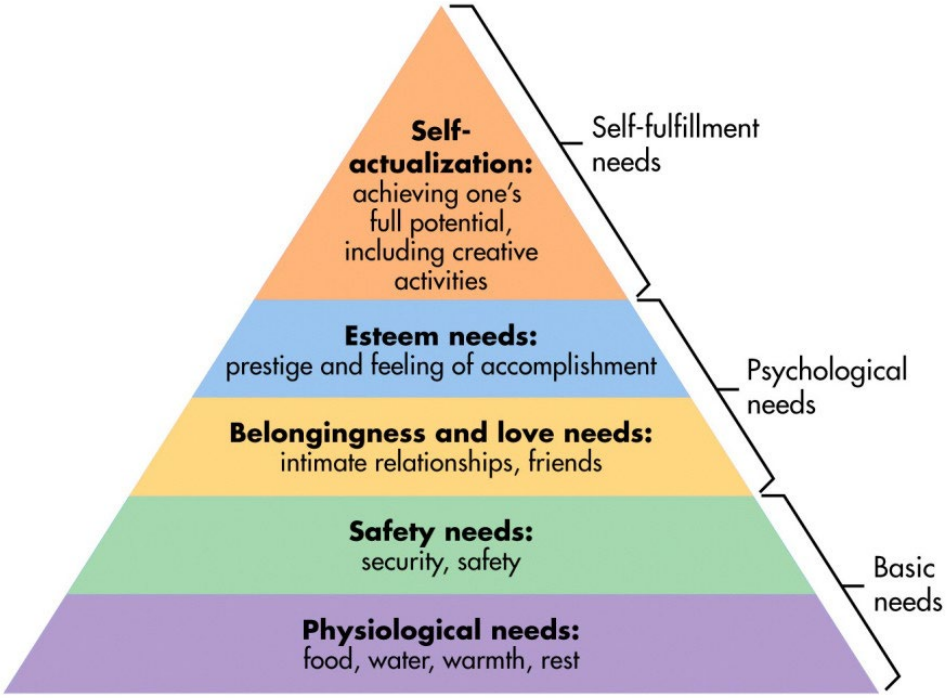


Figure 2.2 Maslow's Hierarchy of Needs

The bottom four are deficiency (D) needs which are divided into basic needs and psychological needs, and the top layer is being/growth (B) needs (Maslow, 1943).

2.1.4.1 Deficiency Needs

Deficiency needs are rooted within human biology. Basic needs are composed of our physiological needs, which can be detrimental if not acquired. These are associated with our senses and physical needs to survive. Once these have been met, humans desire routine and comfort. Safety needs fulfill monetary and communal needs obligatory to society.

Deficiency needs also acquire psychological needs after basic needs have been steadied. Love and belongingness needs are acquired through a spouse, friendship, family, and community, while esteem needs are met through accomplishment and contentment (Hjelle and Ziegler, 1981; McLeod, 2020). Maslow classified these as deficiency needs, expressing that they give humanity less motivation to continue amassing them, contrary to being needs.

2.1.4.2 Being Needs

Being needs promote growth. They are the top layer of Maslow's pyramid, representing human self-actualization. These needs support motivation within one's psychology to continue pursuing them. They create personality and confidence within oneself through the ability to seek personal growth and further experience (Maslow, 1943; Chapman, 2005; McLeod, 2020; Hjelle and Ziegler, 1981). Designers should strive to meet the user's deficiency needs first to fulfill the authenticity of the design; however, when considering the longevity of a product, they should design it to promote the growth of the user to fulfill self-actualization. This will promote emotionality and attachment to the product, giving it the potential to fulfill its lifetime.

2.1.5 Kano Model

The Kano Model is also important when considering the aspect of emotional durability. This model was developed by Noriaki Kano et al. (1984) to express three attributes: Threshold (Basics), Performance (Satisfiers), and Excitement (Delighters) (See Figure 2.3).

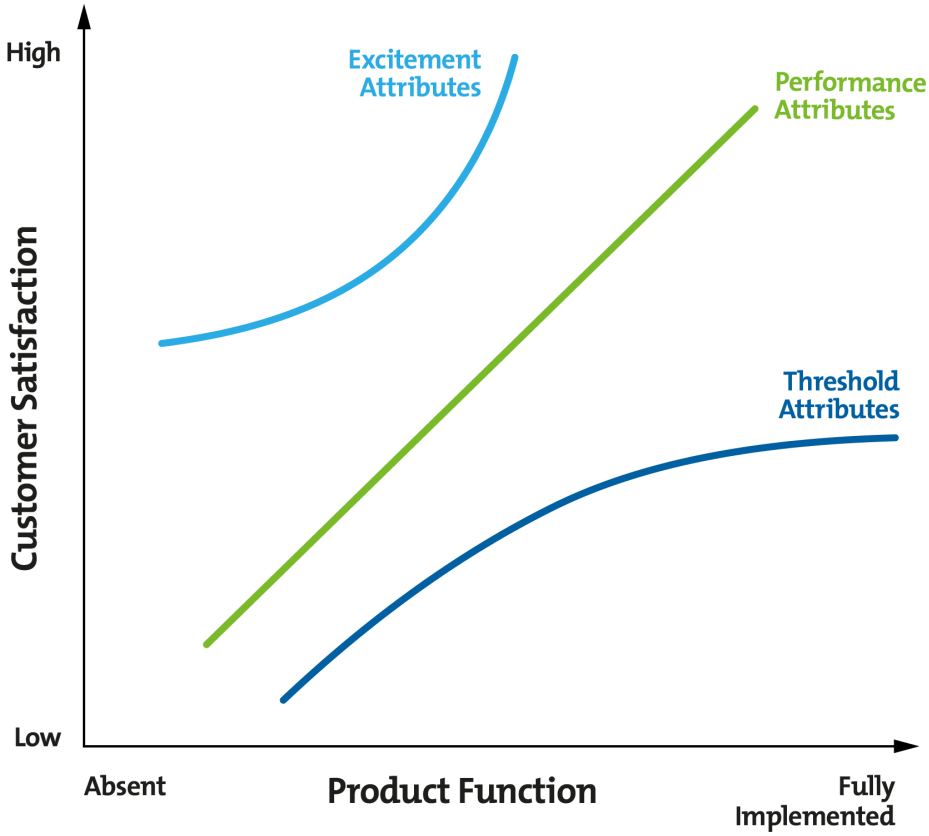


Figure 2.3 Kano Satisfaction Model (Kano, 1984)

Diagram reproduced with permission from the Japanese Society for Quality Control. Original reference: "Noriaki KANO, Nobuhiko SERAKU, Fumio TAKAHASHI, and Shin-ichi TSUJI Attractive Quality and Must-Be Quality, Journal of the Japanese Society for Quality Control, Vol. 14, No. 2, pp. 147-156, 1984."

Threshold (Basic) attributes are the absolute minimum requirements. They are expected by the consumer and do not implement user satisfaction due to the commonalities associated with them.

Performance (satisfiers) attributes are not required but are based around quality standards that are expected by the user. These support increased satisfaction while the consumer is using the product.

Excitement (delighters) attributes have been increasingly implemented in modern design. These delight the user, continuing their will to use the product over its lifetime. Excitement attributes are not desired by the user until they unfold (Kano et al., 1984).

2.1.6 Pleasure-Based Approaches

Patrick Jordan (2000) created his own hierarchy chart relating to Maslow's hierarchy through formulating a class system of product attribute importance. His structure regards functionality and usability as expected qualities (See Figure 2.4).

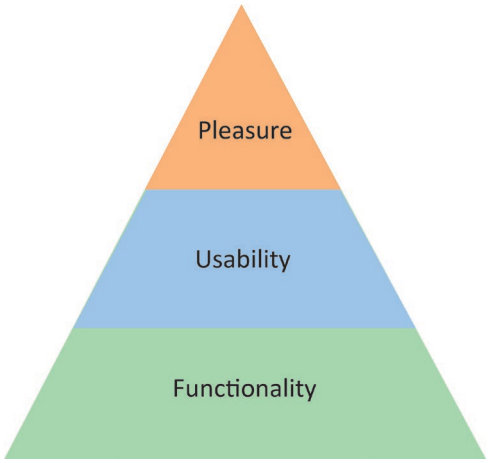


Figure 2.4 Jordan's Hierarchy of Pleasure

2.1.6.1 Functionality and Usability

The functionality and usability of a product has slowly evolved from being the main source of satisfaction for users to becoming an expectation for them. Considering the Kano Model (See Figure 2.1.4), these attributes can easily cause dissatisfaction if the product does not perform to expectation. Usability is reliant on functionality, but functionality does not always compute to usability. Product usability is ever growing as a requirement expected by the user. In the Kano Model, if the performance attributes result in only ease of use and satisfaction, this only maintains the median of satisfactory accounts. Usability is necessary to give opportunity for pleasurable products because it ensures efficiency (Jordan, 2000; Kano, 1984).

2.1.6.2 Pleasure

Human factors design is centered around emotional needs and functional needs. Utilizing empathic/pleasurable design approaches ensure that the user has engagement with and develops relationships with the product. The four pleasure-based approaches pursue physio-, socio-, psycho-, and ideo-pleasures (Jordan, 2000).

- ***Physio-pleasure*** is related to bodily senses. This interaction is through touch and smell creating tactile and olfactory pleasurable experiences.
- ***Socio-pleasure*** is reached through interaction and experiences sustaining a narrative within the user and prolonging engagement.
- ***Psycho-pleasure*** forms through emotional connections and relations. These cognitive reactions occur internally allowing for the experience to be more efficient and accessible.

- ***Ideo-pleasure*** pertains to the user's values. The way a product embodies a significant cultural or environmental stance can cause users to embellish them. Ideo-pleasure creates durability through connection (Chapman, 2005; 2008; Jordan, 2000).

2.1.7 Emotionally Durable Design Traits

Chapman suggests that after considering the needs and attributes of the consumer, designers should employ emotionally durable design traits to ensure fulfilling these user needs. "New product genres will emerge, offering alternatives to the wasteful mode of technocentric design, expanding our experience of daily life, rather than stifling it through endless cycles of desire and disappointment" (Chapman, 2005, p.17). Emotional design is measured by a product's authenticity, dependency, sustained narrative, and feasibility.

2.1.7.1 Authenticity and Dependency

Products should always deliver what is promised. A product that does not perform the way it was advertised causes discontentment within the user. Having an authentic and dependable design means straying away from materialistic relations and thinking towards a synergistic relationship between the user and product. Authenticity refers to when a designer is true to the user research and puts effort into meeting the dependencies of the user and product. What parts/features does the product depend on? "Dependency is frequently spoken of as an abnormal degree of reliance on something that is psychologically or physically habit-forming" (Chapman, 2005, p. 71) When designed for dependencies, the product should engage the user consistently over

the course of its lifetime. The same as humans rely on product engagement to fulfill their lives, the product also relies on our engagement to fulfill theirs. When a product is designed with an authentic aim, the consumer can trust that the product is going to meet their needs steadily.

Dependencies can be split into two categories: product and user dependencies. Product dependencies refer to the features a product must contain to be suitable to its environment as well as exceed expectations of the user. Without these, the product seizes to suit the atmosphere intended. and fails to have continued use over the course of its lifetime. User dependencies are generalized attributes that the user is dependent upon to continue thriving in the lifestyle they support. These make the product exceed expectations past functionality and provide superior benefits. These features encourage the user to engage with the product due to the ease of use and excitement that it provides (as referred to in the Kano Model, page 27).

2.1.7.2 Sustaining the Narrative

According to Chapman (2005), in order to sustain the narrative of a product, it must surpass expectations by unfolding its features at a consistent pace. The narrative of a product seems to adapt over the course of its life. It may include features that change according to the day or be useful in multiple scenarios. The user should have the narrative of the product unfold throughout its lifetime creating the opportunity for multiple experiences to develop. The Tamagotchi, created by WiZ and Bandai in 1996, was a tiny virtual pet device allowing the user to take care of and experience a pet without having a physical animal (See Case Study 1.2). This product exhibits cherish

ability due to its capacity to keep the user's attention over the course of the 'pet's' lifetime. These attributes are recommended to gauge the dependency of the product (Chapman, 2005; 2008).

2.1.7.3 Feasibility

Feasibility is defined as the state or degree of being easily or conveniently done (Simpson, 1989). A designer must maintain feasibility within the current parameters of the manufacturers. This limits what the designer can do when conceptualizing because manufacturing plays a large roll in sustainable decision making. Feasible concepts are products that are easy to assemble with the industrialized machinery. The more difficult the product is to manufacture the less environmentally friendly it is. Using feasible conceptualization can result in products that provide effective flow in manufacturing and ultimately are more sustainable (Chapman, 2005; 2008).

2.1.8 Empathic Modelling

"Empathic modelling is the method whereby an individual, using various props and scenarios, is able to simulate the deterioration of physical and perceptual abilities in everyday scenarios" (Nicolle & Maguire, 2019, p.2). This strategy is important for emotional durability because the designer must transition their thought process to match the user's. Many times, this approach is used for people with disabilities, so that the designer can formulate design strategies based around the parameters of the disability. Architects in 1982 were used as participants in one application to find the requirements needed for people with poor eyesight (Poulson, Ashby, & Richardson, 1998). Although known for helping consumers with disabilities, empathic modelling can

be used for any design brief. Designers can use tools to restrict them from their normal capabilities to better replicate a scenario appropriate to the consumer. For instance, if the user target is a woman with children, then modelling out different scenarios surrounding instances related to parenthood could help the designer create a product better suited for their environment.

2.1.9 Mass Customization

Mass customization is an approach for the designer to deliver products and services that fully meet the consumer's desires (Tseng et al., 1996). It is the idea of making a product be 'cosmetic' by giving the user the ability to help 'design' the product. Nike ID is a strong proponent of this method because it gives the consumer the ability to completely customize their tennis shoes. Whether it's changing the color of the sole, Nike swoosh, or shoestrings, or stitching the user's initials into the side of the shoe, the user can have input as to what the shoe looks like. This is a fantastic approach to emotional durability because the consumer creates an attachment to the pair of shoes through creative desirability.

2.2 Longevity

2.2.1 Component Modularization

"Modularized components are items working together to form a single functioning item. Since each part is separate, it is often possible to upgrade, change or repair one component while leaving the main system operational" (McGee, 2020, p. 1). This an important aspect for designers to consider because it allows for the main system to be utilized for a longer period. The user can buy a new component and replace it, in contrast to having to buy an entirely new product or model. This is sustainable because each component can live to its potential. It also allows for the designer or company maintain the current modules, while also ideating new modules for future use. The product is now adaptable to future generations (McGee, 2020).

2.2.2 Typology for Unsustainable Practices

Walker (2006) suggests that for component modularization to be of benefit, designers must first create an *aesthetic typology* for unsustainable practices. This study and classification incorporate analyzing products that are environmentally harmful by first dissecting the internal components to identify the damaging elements. In developing their typology for unsustainable practices, evaluating *socially responsible* products, and comparing them to the irresponsibility of others, Walker suggests designers consider these questions pertaining to these aspects of the product:

- *Need*: What components are needed to build this product?
- *Suitability*: How could this product be more culturally appropriate?
- *Relative Affordability*: Are the modifications affordable?

- *Advancement*: How would these advance further sustainable practices?
- *Usability*: Is this product adaptable across its lifetime?
- *Local Control*: Can this product be manufactured locally?
- *Empowerment*: Does this product empower society to participate in change?
- *Dependency*: What parts/features does this product depend on?

These questions enable the designer to step outside of personal design bias and create a solution appropriate for the user as well as the environment. Through evaluating a product within this methodology, designers can examine the role of each component plays to increase the longevity of the product's lifetime.

2.2.3 Component Categories

Walker (2006) tells us that products are divided into two main components that each influence the user's experience. *Dominant components* make up the functionality (internals) of the product. These components are usually hidden or covered by the *subordinate components,* which provide ergonomic interfaces for the user and make up the outer shell, presenting the product aesthetically. The product would not be usable without the dominant components, suggesting that these are the more significant variables. If these elements were brought more to the forefront, the user might have a greater sense of utility from the object. It could be viewed more as a construction of multiple modules instead of a single result. The (external) subordinate components are often used to cover or mask the dominant components with the intention to cause the user to crave buying the product instantly, resulting in less knowledge and information

about the (internal) dominant components grasped by the user (Walker, 2006). The use of subordinate components providing aesthetic qualities to products expands the quantity of production. For example, if three different models of cars had three different styling and coloring concepts, then nine total variations of cars have been produced, although the dominant components for manufacturing have not been changed.

"The design of subordinate components is a primary concern for industrial design and act as an enclosure, or façade, to the functionality of the product" (Walker, 2006, p.156). Walker is inferring that the enclosure masks consumers from the actual durability and usability of the product, and that design needs to shift away from this concealment. A product should encourage knowledge of its functionality to the user when they are using it.

2.2.4 Satisfier v. Dissatisfier

In the early 1980s, designing for human factors was often not included in design criteria (Walker, 2006). Products were to be appreciated based on the usability and utility of the object, making those factors the satisfying elements of the production. By the early 1990s, good human factors and ergonomics were expected by the user. Purchasers in the 21st Century now anticipate products to be easy to use, and if they are not, people become dissatisfied with them. With good functionality and usability becoming an expectation of users, their product satisfaction has become more influenced by stylization of the subordinate components incorporated into design (Jordan, 2000).

2.2.5 Exposure and Enclosure

Separating and understanding the dominant and subordinate components allow for the designer to see which elements need to be exposed more. When all a product's functional, prominent components are enclosed, the consumer has no means to understanding how the product actually works. Looking towards exposure of the dominant components, Stuart Walker creates *ensemble designs* which are concepts that are created from typically discarded components, giving them a renewed life. Figure 2.5 shows one example, the Ad HOV Torch.

Figure 2.5 Ad HOV Torch – (Walker, 2006)

These designs may interest structural engineers but are not aesthetically pleasing to most consumers. The point of this example is to expose to the consumer the

components needed for the functionality of this product. These components can be modularized and easily replaced, ultimately expanding the lifetime of the product. Instead of being aesthetically pleased by the outer styling, the user is interested by the circuitry and usability of each element. By progressively conceptualizing products that display functionality instead of resolving their concept through stylized drawings and exposing the dominant components, the consumer has a Do-It-Yourself sense, allowing for emotionality and connection to the entirety of the product (Walker, 2006).

2.2.6 Mass Customization

Another existing approach that design companies take to increase connectivity to their products is making them mass customizable. “Mass customization is the process of delivering market goods and services that are modified to satisfy a specific customer's needs” (Dollarhide, 2020). Mass customized products allow for the consumer to participate within the design process.

2.2.7 Mass Customization v. Mass Production

In an industrialized world filled with mass produced products, mass customization has the potential to increase labor and cost of production. Although in some respects it does, it has a substantial impact on reducing the number of product stock keeping units (SKUs) released. When considering these manufacturing methods, designers should inspect how the lifetime of the product is affected through the cycle of production, use, and end-of-life (Bruno et al., 2013).

2.2.7.1 Production

Mass customized products are built around modularization (Ulrich, 2004). Unlike products made through mass production, mass customized items can be modularized from multiple suppliers and assembled near the consumer for timely shipment. Various manufacturing methods are required for all parts to be assembled (Berman, 2002). This manufacturing choice ultimately is less sustainable at the factory source compared to mass produced objects. However, mass produced articles are distributed through multiple wholesale and retail sources before getting to the end user, while, mass customized objects, which are made for an individual, allow for the product to be distributed directly to the customer (Berman, 2002).

2.2.7.2 Use

Mass customizable products better satisfy the user's desires and needs compared to those mass produced (Berman, 2002). They develop a harmony between the consumer and producer, providing the ultimate benefit of having a product *self-designed*. When considering the usage of a personalized item, one would expect that the product lifetime increases due to the emotionally durable qualities of the customization. This relates to the hierarchy of needs by allowing the user to have an influence of how the product is used. If a product has a variety of uses, then it enables more space for user/product connection.

2.3 Environmental Impact

This last section of research includes minimizing negative environmental impact while creating more sustainable products that promote human satisfaction. This section is the most important because it represents the overarching goal of this thesis. Designers need to shift from only thinking about time, cost, and quality and instead consider the lifetime of the product.

2.3.1 Time, Cost, Quality

Before the Information Age, people were concerned with far less from a product. Industrial manufacturers were concerned with producing low cost, quality products that could be made quickly. This is considered an old paradigm because it is only centered around the beginning of the product's lifetime and the initial transaction from manufacturer to user (Vargo & Lusch, 2006; Wolfson & Tavor, 2018), (Vanegas, DuBose, & Pearce, 1996). Although 'time, quality, cost' will always continue to be important in business, manufacturers and designers should also consider the effects of the product over the course of its lifetime. This will ensure that the product is sustainable in terms of its usage and end-of-life.

2.3.2 A Shift in Business Paradigm

A new paradigm (refer to 2.1.2) is needed to allow society to think beyond this materialistic viewpoint in industry (see Figure 2.6).

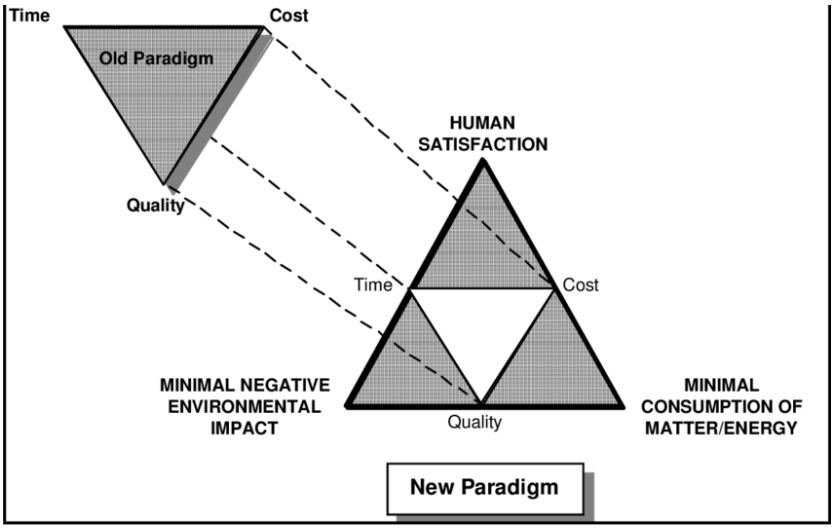


Figure 2.6 Transition to a New Paradigm (Vanegas et al, 1996)

Figure 2.7 shows a paradigm shift between the current *time, cost, quality* spectrum that has been used in business to frame the development of their product. The image shows a new paradigm that expresses the needs of society further than just the initial manufacturing time, expense, and condition of a product. This new paradigm consists of the social, environmental, and economic needs that business should shift their attention to. The social (human satisfaction) point consists of the user's needs, preferences, culture, population, politics, equity, and quality of life. The environmental aspect influences business to consider the full lifetime of the product in the design state, while the economic needs consist of a change in the disruption of exchanges of matter and energy within our biosphere due to product manufacturing and use (Vanegas, et al. 1996).

2.3.3 Okala Practitioner (Product Lifetime)

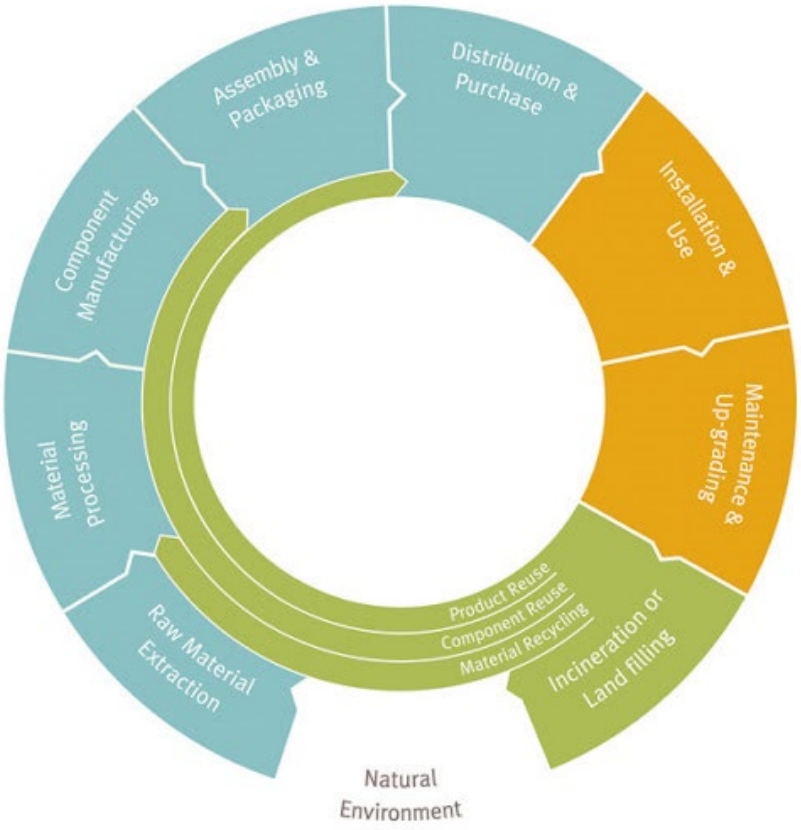


Figure 2.7 Okala Product Life-Cycle Wheel (White, Pierre & Belletire, 2013.)

The Okala Practitioner, an education product available from IDSA, seeks to incorporate sustainable design practices into daily design habits. This chart shows the entire cycle of the product's development, sale, usage, and end-of life. Okala suggests that designers should consider how their product will affect the environment and user across its lifetime. Most product producers deal with three of the blue elements shown in the Okala Wheel (Figure 2.8) – component manufacturing, assembly and packaging, and distribution and purchase. Businesses tend to halt there when considering the

lifetime of the product. They are more concerned with the initial sale of the product than how the product is used and discarded afterwards.

2.3.4 Okala Practitioner (Design Strategy Wheel)

To implement positive environmental impacts throughout the product's lifetime cycle, one can use the Okala Strategy Wheel to ensure that each stage of the product's life is met with environmentally friendly decision making (see Figure 2.8).

Figure 2.8 Okala Design Strategy Wheel (White, Pierre & Belletire, 2013)

This wheel is composed of eight different strategy categories that propose environmentally friendly solutions designers can incorporate into the design process. Each category has a series of solutions that the designer can run through to make sure

they are implementing each strategy. The Okala Practitioner (White, Pierre & Belletire, 2013) describes this list as follows:

1. **Innovation**
    - Rethink how to provide the benefit
    - Design flexibility for technological change
    - Provide product as service
    - Serve needs provided by associated products
    - Share among multiple users
    - Mimic biological systems
    - Use living organisms in product system
    - Create opportunity for local supply chain
2. **Reduced Material Impacts**
    - Avoid materials that damage human or ecological health
    - Avoid materials that deplete natural resources
    - Minimize quantity of materials
    - Use recycled or reclaimed materials
    - Use renewable resources
    - Use materials from reliable certifiers
    - Use waste byproducts
3. **Manufacturing Innovation**
    - Minimize manufacturing waste
    - Design for production quality control

- Minimize energy use in production
- Use carbon neutral or renewable energy sources
- Minimize number of production steps
- Minimize number of components/materials
- Seek to eliminate toxic emissions

4. **Reduced Distribution Impacts**
    - Reduce product and packaging weight
    - Reduce product and packaging volume
    - Develop reusable packaging systems
    - Use lowest impact transport system
    - Source or use local materials or production
5. **Reduced Behavior and Use Impacts**
    - Design to encourage low-consumption user behavior
    - Reduce energy consumption during use
    - Reduce material consumption during use
    - Reduce water and consumption during use
    - Seek to eliminate toxic emissions during use
    - Design for carbon-neutral or renewable energy
6. **System Longevity**
    - Build in user's desire to care for product long-term
    - Design for take-back programs
    - Design for durability

- Design for maintenance and easy repair
- Design for re-use and exchange of products (upgrades)
- Design for second life with different function
- Create a timeless aesthetic

7. **Transitional Systems**
    - Design upgradeable products
    - Design for second life with different function
    - Design for reuse of components
8. **Optimized End of Life**
    - Integrate methods for used product collection
    - Design for fast manual or automated disassembly
    - Design for recycling business model
    - Use recyclable non-toxic materials
    - Provide ability to biodegrade
    - Design for safe disposal

2.4 Conclusion

This literature review has considered sustainability as the overarching goal with understanding how to create longevity in product usage by consumers. Making products last includes more than material choices and environmentally friendly decisions. Longevity includes making products fit into their environment and user type to their full lifetime potential. Consumers are quick to discard products when they tend to

disappoint after a short period. Designers need to strive to make products that satisfy the user beyond anything they have experienced when using another product in the product's category.

Chapman explains emotional durability as when a user feels a connection with the product. To do this, designers must dig deep to find the true needs of the user and be authentic towards these needs when developing the product. Users need a product that not only is functional and usable, but one that can adapt over the years to age gracefully and satisfy the user over a longer period. The next chapter is a series of case studies where creating products for longevity were successful. These examples will help describe the existing products that have initiated theories of longevity and human satisfaction.

3 Case Studies

Products from Volkswagen, WiZ and Bandai, MCC, and Quip have been investigated to understand which elements of their designs have been influenced by emotionally durable, human satisfaction, and product longevity design methods. These case studies are examples that support this project's research, and each one represents a piece of how the guideline was created in Chapter 4.

The Volkswagen Beetle and the Tamagotchi were created with the intention to reach user needs and be emotionally durable to the consumer. They both contain opposing and significant features that invoke a connection with the user. The Smart Car and the Quip toothbrush were created through modularized components, allowing for the user to discard and replace specified parts helping prolong the product's lifetime. All four of these products have different roles in providing examples as to how the following guidelines could be implemented.

3.1 Volkswagen Beetle (Volkswagen & Porsche) – Emotional Durability

Figure 3.1 Volkswagen Beetle (Pinterest, 2020)

The Volkswagen Beetle was created in 1938 by Volkswagen and Ferdinand Porsche. This car was the symbol of unification in a town called Wolfsburg during the tumultuous period of the Great Depression. Considering a small number of people owned a motorized vehicle at the time, this car was made to be affordable to the 'common man'. Hitler christened Wolfsburg as "The Town of Strength through Joy Car," giving a sense of establishment to the society of Germany. At a time when only the wealthy owned vehicles, the Beetle was a classy but inexpensive option that allowed the low to middle class to have a significantly increased range of motion. This car was an initiator of the industrial revolution given that towns could now be built around motorization, generating *Lebensraum* or living space. People could travel further

distances with ease, allowing for suburbs to form around cities. Volkswagen, meaning the 'People's Car', was advertised to suggest freedom, democracy, and love (Hiott, 2012). The stark history of the period when it was designed and the way it brought people together helped to make it a timeless design. The symbol of unification it provided allowed for people to create emotional ties with the car. Instead of designing for the upper class, Volkswagen built the Beetle around low cost and durability, both physically and emotionally. The car aged gracefully over the 20th Century and now has a gargantuan fan base (refer to section 2.1.7 Emotionally Durable Design Traits). The Beetle is the longest running and most manufactured car of a single platform ever made. Volkswagen created a product that excelled in human satisfaction. The narrative of the product continues to unfold, and the car aged gracefully over a century. This is a great example of how culture can be prioritized, and emotional durability can be implemented.

3.2 Tamagotchi (WiZ & Bandai) – Emotional Durability

Figure 3.2 Tamagotchi (Bandai, 2022)

Shifting product categories, the Tamagotchi is a small egg-shaped computer created in 1996 by WiZ and Bandai. Containing only three buttons and being compact enough for any pocket or purse, the Tamagotchi was a virtualized pet that required the user to maintain its life regularly. The design is meant to be unambiguous and sustain a narrative (refer to 2.1.7.2). The narrative of the product unfolds at a steady rate. Each

day the consumer can be entertained with an original task, based on the needs of the pet over the course of its life. The user can also sync their pet to another user's, allowing them to have a friendship or even get married. These ongoing features allow for the consumer to grow an emotional relationship with the pet and ultimately to the product. The owner becomes dependent (refer to 2.1.7.1) to the product, which encourages them to use it until the product's end-of-life (Chapman, 2008).

3.3 Smart Car - Modularizing Components

Figure 3.3 Smart Car (Squatriglia, 2011)

The Smart Car was a crossover concept developed by MCC, a merger of two companies: Mercedes and SMH in 1998. This car represents a large-scale example of component modularization. Typical car companies require over 200 different suppliers, while the Smart Car only uses 25. These suppliers are responsible for manufacturing individual modules such as the cockpit, car doors, and rear axle. These large components are sent to the final MCC plant to be simply assembled. Only 20% value is added at the final assembly, reducing energy costs (Doran, 2003). This is sustainable because it allows for 'just-in-time' manufacturing, a process which minimizes inventory and increases efficiency by a timely provision of only the necessities required to produce the product (Ohno, 1930). Modularization of components leads to vertical and

horizontal integration by easing the difficulties of the supply chain. The Smart Car gives the user the ability to customize it, helping fulfill their emotional and physical needs to their full potential. This exposes the dominant, functional components instead of the outer styling associated with the majority of car manufacturers (refer to 2.2.3). Also, when a component starts to fail, it can be easily removed and replaced with a new component. This gives each of the components the ability to perform until the end-of-life.

3.4 Quip – Modularizing, Empathic, Servicing Case Study

Figure 3.4 Quip Tooth Brush System (Sim, 2021)

Quip was founded by Simon Evener and Bill May in 2012. They conceived the idea after hearing negative remarks from their dentist as he constantly considered using an electric toothbrush. The two industrial designers created the idea of componentizing the toothbrush head and body so that the body could be used for an extended life while the brushes could be replaced. The main problems they found with existing electric toothbrushes were the overly complex functionality, clunky grips, and the lack of service to cater to a modern lifestyle. Most people fail to change their toothbrush adequately, so they created replaceable brush heads and motors, purchasable through Quip's service, that can be disposed of when worn out (see Figure 3.2).

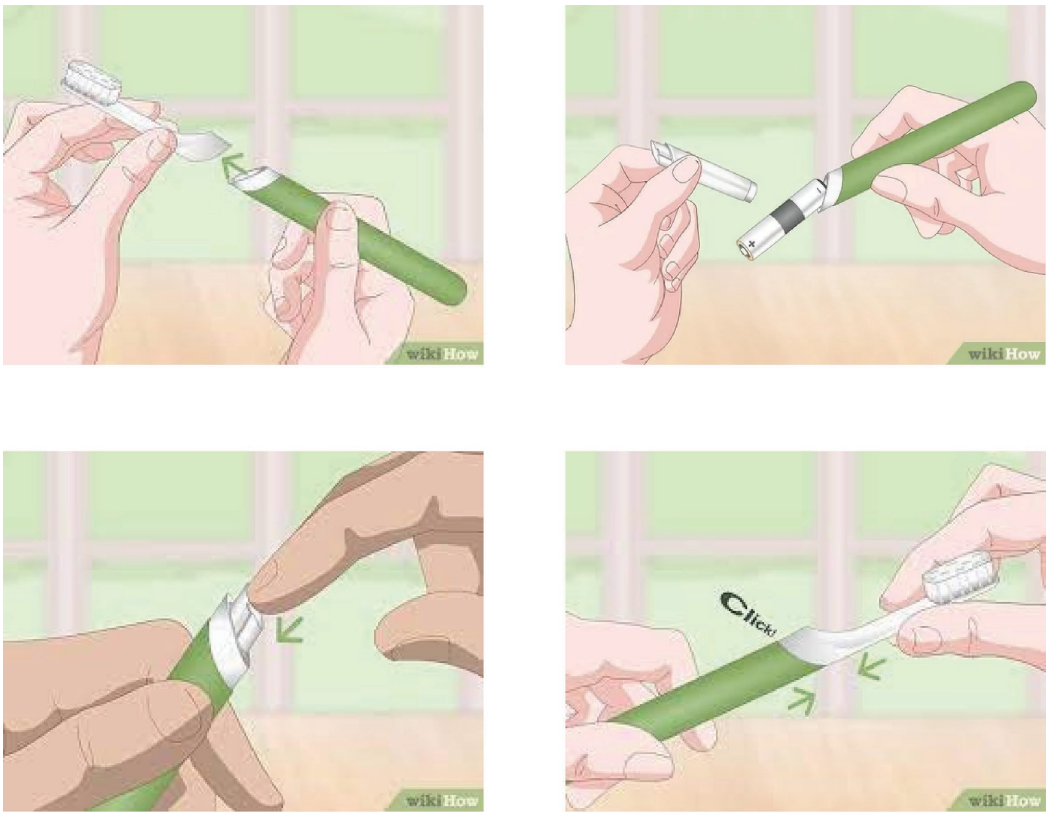


Figure 3.2 Quip Brush and Motor Replacement Sequence of Use (wikihow, 2021)

Enever and May used empathy in understanding the mindset of a dentist to create a device that makes brushing more enjoyable. The design team took a more authentic aim by excluding the marketing team until the design was finalized to ensure they were meeting the needs of their consumers (Evener & May, 2012).

3.5 Conclusion

Products influence a person's life well beyond the time of purchase. The case studies within this chapter exemplify products that have exceeded product longevity beyond original expectations because they provided human satisfaction, emotional durability, and used modularized componentry. The Tamagotchi and VW case studies

illustrate the human satisfaction and social needs element of Figure 2.6 through creation of products that people are dependent upon.

Smart Car and Quip case studies show that the still functioning components can continue to function after another component is disposed of which means fewer parts must be made. This helps meet the environmental needs of the planet. This part breaks down into a series of considerations including finding renewable resources as opposed to non-renewable resources. Designers should consider biodiversity, environmental disruption, and ecosystem resilience. This includes finding materials that can regenerate and do not create negative environmental impact. Many resources, such as minerals, take more time to regenerate than the amount of time it takes the industry to need more. Overuse not only puts the environment at risk, but also limits future manufacturers to these resources being acquired (Vanegas, et al., 1996).

Lastly, sustainability referring to economics is important for the designer to consider. “Economics is important to sustainability because of its broader meaning as a social science that explains the production, distribution, and consumption of goods and services. Economic gain has been the driver for much of the unsustainable development that has occurred in the past” (Vanegas, et al., 1996, p.4). The striving for monetary benefits can persuade designers and businesses to make a large volume of products instead of fewer quality products. This is unsustainable because of the overabundance of waste accumulating on the planet due to excessive amounts of products being produced and discarded.

4 The Golden Pyramid

This chapter details an approach to designing sustainable products that increase human satisfaction while decreasing environmental impact. This guideline is mixture of direct approaches as well as considerations to help designers increase user dependency on products they choose to own. The steps associated with this guideline are split into three design categories: analyzing the existing market, defining the intended product goals, and product development. These are presented linearly to show the direction in which to begin, but as the reader will see, the process is circular, particularly in the development phase. Figure 4.1 illustrates the steps in this guideline.

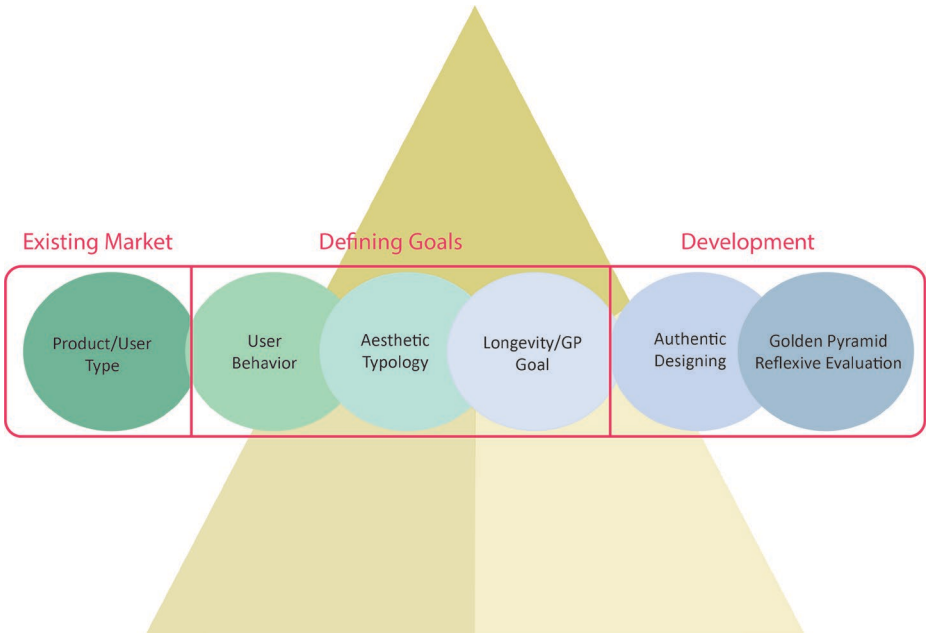


Figure 4.1 The Golden Pyramid

- Step 1: Product/User Type/Existing Market (refer to 4.1)
- Step 2: User Behavior (refer to 4.2)
- Step 3: Aesthetic Typology (refer to 4.3)
- Step 4: Longevity Goal (refer to 4.4)
- Step 5: Prototype with Authenticity (refer to 4.5)
- Step 6: Golden Pyramid Reflexive Evaluation (refer to 4.6)

4.0 Overview of The Golden Pyramid

Figure 4.2 The Golden Pyramid

The Golden Pyramid presents a triad which has overarching objectives for the designer to consider within their design process. Minimizing negative environmental impact throughout the product's lifetime including its end-of-life should be considered

crucial for all designers in every product they develop. It is the foundation of this approach.

This approach also recommends a guideline for extending product longevity which can also serve to reduce environmental impact. Human satisfaction is the goal of any designer, and it can be attained through exceeding the user's expectations by developing empathy with the user during the design process to create products that are used/useful across their lifetime.

4.0.1 Maximizing Human Satisfaction

Human satisfaction is at the top/center of the pyramid. It is what all designers are trying to attain in the products they develop. Many products can satisfy the user initially, but this tends to lessen over time. To achieve true product satisfaction for the consumer, the designer must first internalize the desires of the intended user. This includes empathically researching and modelling user behaviors until the designer gets a grasp at the difficulties and limitations of their lifestyle. The functionality and usability of the product comes first and foremost, but a product that genuinely satisfies consumer desires goes beyond what is expected. If a designer can maximize a product's human satisfaction potential, this ensures the user will extend its usage, ultimately allowing for the product to fulfill a life past relative obsolescence (refer to 2.1.2).

4.0.2 Extending Product Longevity

The right triad of the pyramid represents extending product longevity. Longevity is also a part of the Okala Strategy Wheel but is separated into its own leg of the pyramid because of its importance to this guideline. This is a sustainable action that

allows for designers to maximize product lifetimes and move away from designed obsolescence. Giving the user the right to disassemble and repair their product is way of implementing longevity into the product being produced. Modularization and componentizing allow for consumers to extend the product's material resources for a longer period, which reduces redundant manufacturing. This ultimately can lower overall energy usage and generates less waste by reducing the number of products being produced.

4.0.3 Minimize Negative Environmental Impact

The left triad suggests that designers should minimize use of environmentally harmful manufacturing methods in their creation of durable products. The reasoning for excluding 'Innovation' from the list of Okala strategies is due to the fact that this strategy is associated with rethinking how to provide the benefit, whether it be providing the product as a service or mimicking biological systems by using living organisms in the product system, the list of considerations does not necessarily relate to the topic of this thesis. This thesis relates to the lifetime of the product, and the remaining six strategies can facilitate existing products as well as future conceptualization. The six remaining strategies of sustainability in the Okala Strategy Wheel include:

- Reduced Material Impacts
- Manufacturing Innovation
- Reduced Distribution Impacts
- Reduced Behavior and Use Impacts

- Transitional Systems
- Optimized End-of-Life

The six strategies have a series of solutions designers can consider when conceptualizing (listed in 2.3.4).

4.0.4 The Golden Pyramid Evaluation Tool

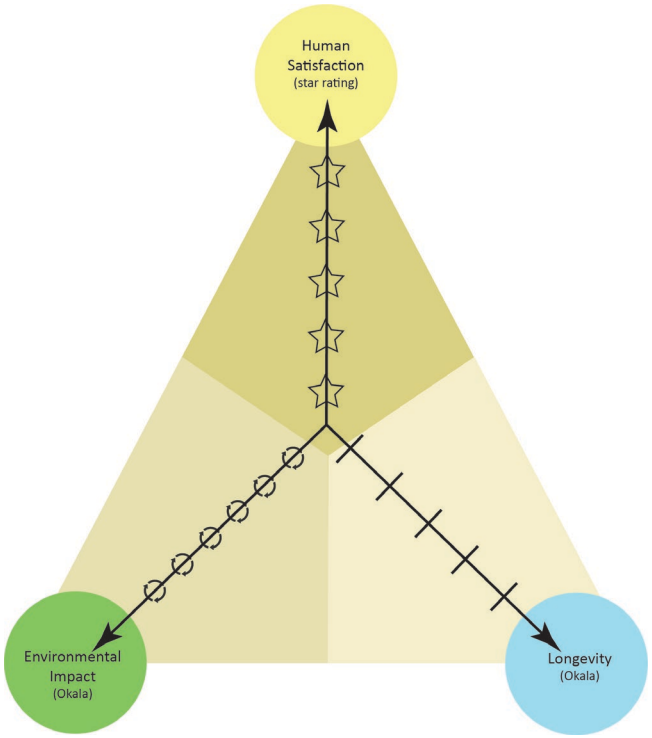


Figure 4.3 Golden Pyramid Evaluation Tool

The Golden Pyramid Evaluation Tool (Figure 4.3) is designed to help evaluate the existing markets and user groups as well as guide the designer to reflect on their work and gauge how their product meets these standards. Evaluating products/concepts on this pyramid can be subjective to the designer, and its main purpose is to influence the designer to put effort into meeting all intended considerations. Existing products can be more objectively evaluated based on research and reported consumer use experience.

However, evaluating conceptualizations are more subjective due to the designer's need to envision/imagine the future product usage. The subjectivity of this evaluation does not downplay the importance of this research since if the designer considers the strategies of each triad, the future product should improve within these standards relative to the existing industry. Results from analyzing products that exist or are being developed using the Golden Pyramid Evaluation Tool can vary significantly based on the designer's decisions. The scale has three legs that are composed of differing variables that have been identified through the research discussed in Chapter 2 – human satisfaction, product longevity, and minimizing environmental impact. More details about how this tool is used are shown below:

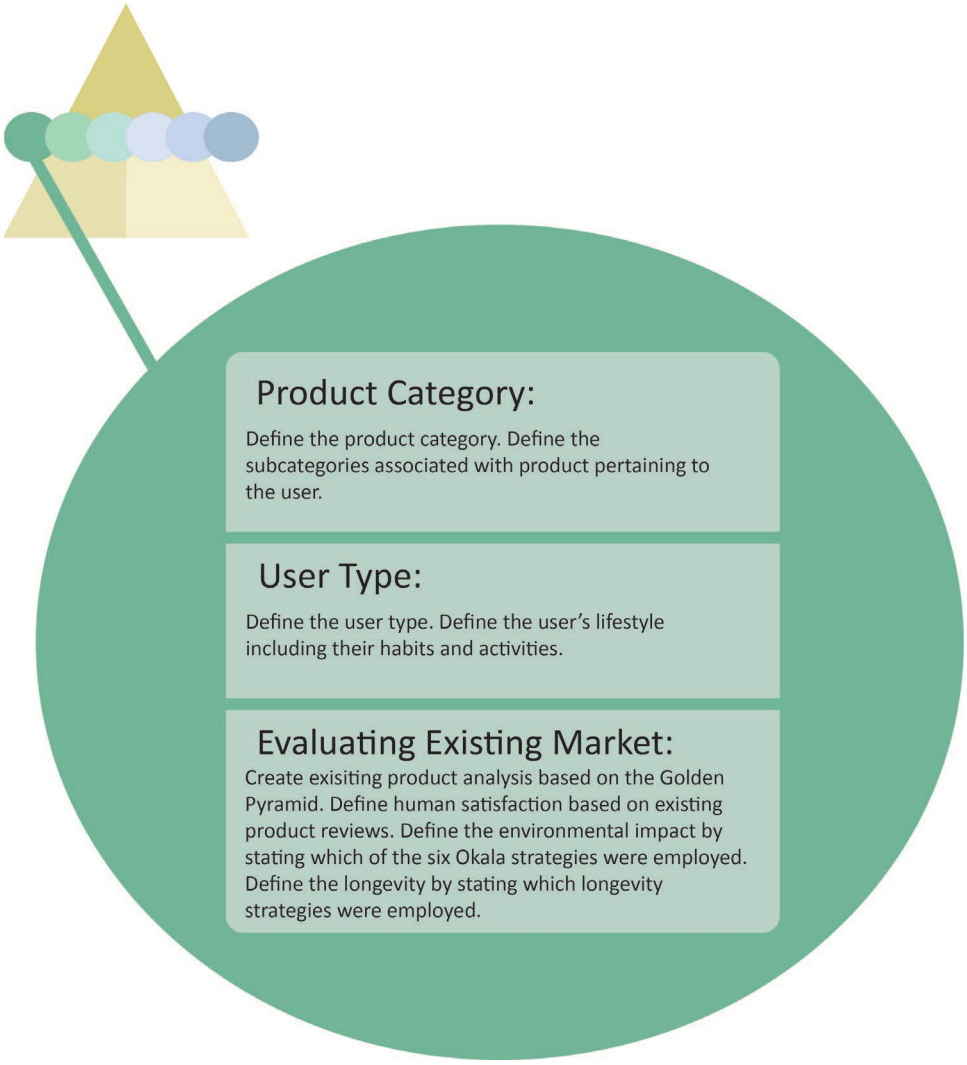
- **Human Satisfaction:** This leg has a scale of five stars that relate to the satisfaction goals. Using research gathered from professional and user reviews as well as information from the product/user groups in Step 2, the designer will evaluate existing products as well as the product under development based on how well the product meets each of the five satisfaction goals: 1) evokes positive emotions, 2) provides customer understanding, 3) engages the user consistently, 4) helps accomplish task at hand, and 5) exceeds user desires and expectations. For each of these goals attained, one star can be filled. This can be done by asking the user interview groups whether the existing product or future concept meets the satisfactory standards. The designer can the make a subjective evaluation based on this research and feedback.

- **Product Longevity:** This leg has a scale of five with each mark relating to elements of 'optimized product lifetime': 1) building in user's desire to care for product long term, 2) building in durability, 3) designing for maintenance and easy repair, 4) designing for upgrades, and 5) creating a timeless design or fashion. These five strategies can help define when the relative obsolescence is initiated and the designer can evaluate products on the scale, showing how many of the five were utilized.
- **Minimizing Environmental Impact**: This leg contains six loops. These six loops represent the remaining sustainable strategies on the Okala Strategy Wheel and illustrate how many of the six strategies are or will be used in the proposed solution(s). These strategies are 1) reduced material impacts, 2) manufacturing innovation, 3) reduced distribution impacts, 4) reduced behavior and use impacts, 5) transitional systems, and 6) optimized end-of-life.

4.0.5 Evaluation and Defining Goals

This approach asks the designer to evaluate their concepts referring to the Golden Pyramid to examine how closely they are meeting the objectives for each triad. The goal is to maximize the potential in all three categories. Some concepts may employ each of the six strategies on the Okala Strategy Wheel and minimize the environmental impact but fall short when satisfying the user or extending the product lifetime, or vice versa. These evaluations will direct the designer in a positive direction to address each leg of the triad. This will be discussed further within this chapter.

4.1 Step 1: Existing Product Landscape



4.1.1 Product Category

Initially, the designer should pinpoint what the product category is and research existing products within the category. What product category does the design brief call for? What subcategories of the product type are there?

4.1.2 User Type

This step involves defining the user. This is the most important aspect of Step One, considering the designer wants to understand the user and the existing market

before moving onto the product development. This should include finding/creating online forums pertaining to a similar user type, such as Facebook groups or Quora questionnaires, and surveying within, asking the questions shown below:

- What user types do the current products on the market attract?
- What habits and daily activities do the user types participate in?
- Which products does the user regularly use to maintain their lifestyle and why?
- What brands has the user type enjoyed the most? Why?

Observations and information can also be taken from the design interviews held in Step 2 of the guideline (see 4.2.3).

4.1.3 Evaluating Existing Market

The next step of the process will help the designer evaluating existing products within the market in terms of the three branches of the Golden Pyramid. Human Satisfaction rates products based by finding ratings/reviews/critiques of the top selling products on the market. Minimal Environmental Impact is measured by examining six categories of the Okala Strategy Wheel and finding which strategies were used. When determining longevity, the designer must understand the issues that cause a product to not reach their absolute obsolescence (refer to 2.1.2). This is measured by how many of the five strategies associated with the 'System Longevity' section of the Okala Strategy Wheel are considered. The designer should understand the basis of the Golden Pyramid, but they must know how to accurately utilize it. The first evaluation of this approach

includes comparing a variety of different existing products in the market, discovering where the most successful products land within each leg of the pyramid (see Figure 4.4).

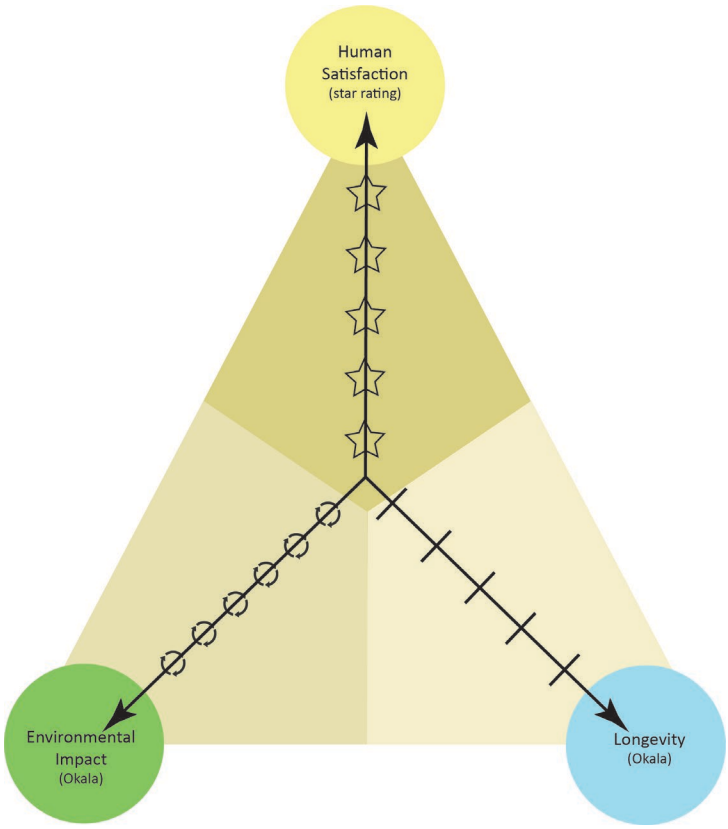


Figure 4.4 Average Existing Product Golden Pyramid Evaluation

Triad 1: Human satisfaction is evaluated using a scale of 5 stars, like the online product rating systems currently used in the product sales industry. The designer should research a variety of online reviews of existing products from multiple websites including professional and user critiques. The more research done, the better. This includes watching video reviews, reading online critiques, and capturing and analyzing the desires of the commentary under each review. To rate each existing product, the designer will determine, often subjectively, whether the product:

- Evokes positive emotions

- Provides customer understanding
- Engages the user consistently
- Helps accomplish the task at hand
- Exceeds the user desires and expectations

Each one of these five variables represent the five stars individually. The designer will then formulate an average (out of 5 stars), ranking how well these products meet the factors of human satisfaction.

Triad 2: Longevity is a measure of time that a product tends to last before it starts to become obsolete. This includes when the product begins to function worse, lose aesthetic appeal, or be surpassed by an improved product on the market. For existing product evaluation, the designer can use the 'System Longevity' section of the Okala Strategy Wheel. The five notches on the Golden Pyramid represent five suggestions in the 'optimized product lifetime' section. These strategies include:

- Building in the user's desire to care for the product long term
- Constructing for durability
- Designing for maintenance and ease-of-repair
- Designing for upgrades
- Creating a timeless look or fashion for modern society

The scale of five allows the designer to simply compare their concepts to current models.

Triad 3: Minimal environmental impact can be measured by reflecting on six of the remaining strategy categories that propose environmentally friendly solutions on

the Okala Eco-design Strategy Wheel (refer to Figure 2.8), excluding ‘innovation’ and ’system longevity’. Each category has a series of strategies that the designer can implement to create more sustainable and environmentally friendly products. If the product meets one suggestion in each of the six categories, it will likely minimize environmental impact. This will give an assessment as to what considerations previous designers have implemented in their designs. The six remaining Okala strategies include:

- Reduced Material Impacts
- Manufacturing Innovation
- Reduced Distribution Impacts
- Reduced Behavior and Use Impacts
- Transitional Systems
- Optimized End-of-Life

A way to evaluate existing products is shown below in Figure 4.5.

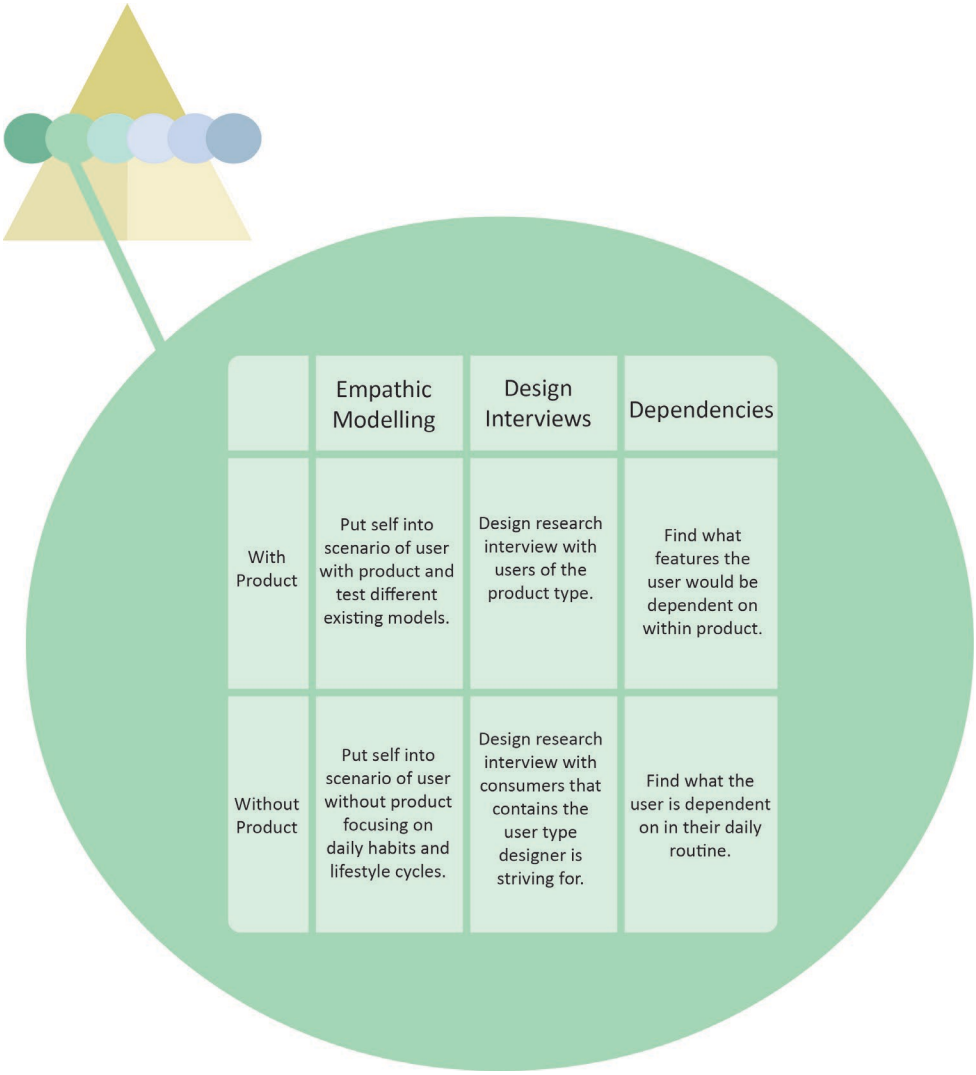
Figure 4.5 Existing Product Analysis Chart

This chart is a tool for the designer to rate existing products on the market and compare them with one another. The human satisfaction shows the results of professional and user critiques, analyzing whether the products meet the five human satisfaction goals listed in the tool (Figure 4.5) above.

The longevity section is where the designer should uncover what attributes contribute to the product's obsolescence. The designer can fill in the longevity leg on the Golden Pyramid by comparing the existing products to the five system longevity suggestions in the Okala Strategy Wheel.

The environmental impact is associated with reviewing six other strategies associated with the Okala Strategy Wheel and dissecting whether the designer considered each when conceptualizing. The designer circles each strategy category considered and fills in a loop starting from the center and moving outward on the Golden Pyramid.

4.2 Step 2: Research User Behavior With/Without Product



How does one design a product that the user truly longs for? Before sketching and prototyping, the designer needs to step back and empathize with the user to create a product that has potential for the user to grow an emotional connection with. This step involves empathic modelling, conducting design interviews, and finding product and user dependencies.

4.2.1 Empathic Modelling with Product

One form of empathic modelling allows the designer to put themselves in the shoes of the user and experience using a similar product. This includes engaging with a variety of different product models within the product category and analyzing what components and ergonomics promote the *ease-of-use* and efficiency of the product. For example, if the designer were designing a blender, then they could try making a smoothie with a variety of different blenders and sense what features stand out, the efficiency of use, and the ergonomic feeling each one delivers when using. This is valuable for the designer to experience existing products, because now they have an idea of what is successful and what is not.

4.2.2 Empathic Modelling without Product

Using the empathic modelling to experience life in ways others do is also significant because it helps the designer create scenarios that replicate the daily life of their user. This type of modelling includes simulating potential disabilities, human measurements, and daily habits of the consumer. These concerns all very likely could exclude usage of the specific product being designed. This type of modelling could include changing daily habits or activities to better imitate the desired user. For example, if one were designing for a mechanic, they could place themselves under a car or inside the hood. While doing this the designer could note the difficulties that mechanics experience daily such as minute tasks including the tight quarters, slippery hands from oils, and safety precautions. This is extremely important for the designer because it helps them empathize with the user by putting themselves in their shoes.

4.2.3 Design Interview Study with/without Product

This step also includes user interviews/studies which are a free-based discussion between the designer and five people individually or a group (the more the better) that have similarities to the user target. This step is important because this same group will be used to evaluate the product after the designer has generated their concepts. This will ensure that the user dependencies will be met.

The designer is encouraged to create two design interviews/studies of multiple different users – one group who are current users of the product category and a separate one with people of the defined user type. The goal is to help the designer have authenticity towards the user when designing. The designer should select people with a variety of cultures, beliefs, and opinions. This diversity of users will help the designer in connecting to a wider variety of consumers without falling back on stereotyping a persona.

Within these interviews the designer should ask the users to share their opinions on existing products of the product category and note what features and functions please them the most. This helps obtain multiple viewpoints as to the emotional durability of the product category and to the habits and desires of the user type.

4.2.4 Product Dependencies

After exploring usage of similar products and interviewing target users, the designer can compose a list of the product dependencies mainly referring to the features that engage the user and keep them consistently interested. Referring to 2.1.7.1, dependencies are the features that the user can rely on and 'depend' on when

using the product, which includes features that are psychologically and physically habit forming. Define which features and ergonomics are needed to make this product efficient for the user. What components could be eliminated? Creating this list helps the designer generate sustainable choices when conceptualizing through design for emotional durability. For example, two power tool brands could make the same tool, but one may be easier to use due to the button placement, drill bit attachments, and power consistency.

4.2.5 User Dependencies

The designer should also analyze what characteristics are associated with their user type that are not related to the product. What daily habits does this user depend on to maintain a life that fully meets their desired expectations? What features in other nonrelated products help the efficiency of the user's life? This is important for moving forward with the aesthetic typology. Finding user habitual lifestyle dependencies helps the designer conceptualize the suitability of the product to better fit the environment it will be intended to be used in. For example, user dependencies for a lawyer may be time-efficiency and organization. If a product lessens their ability to get from task to task or have a disorganized functionality, then it is worthless to this user type.

4.2.6 Research User Behavior Outcomes

The result of 4.2 is to create a list of product dependencies and user dependencies (see Figure 4.6).

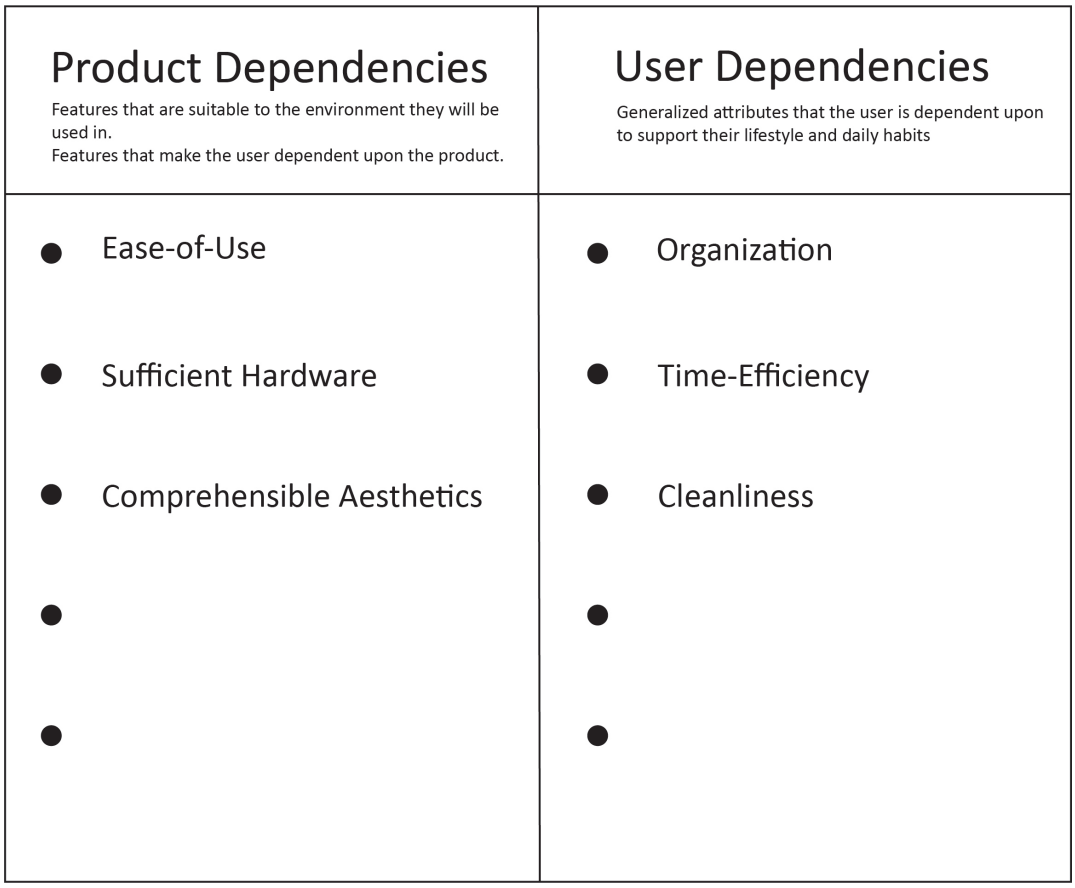
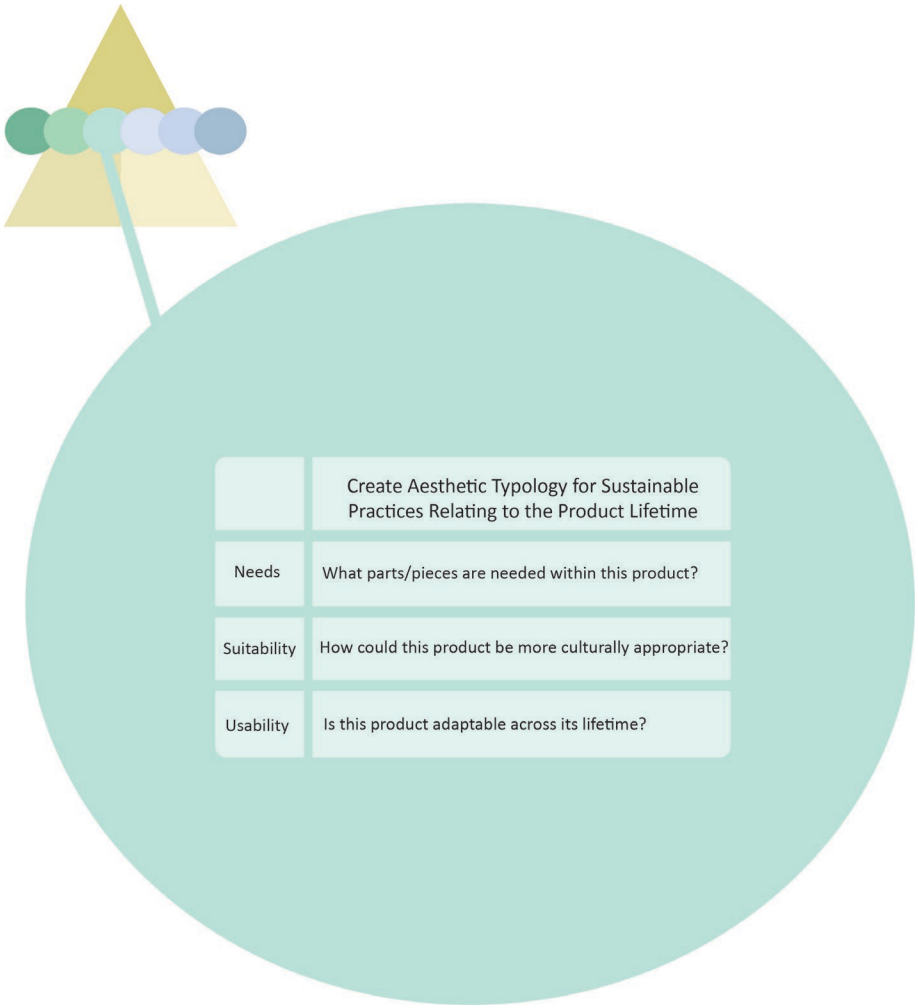


Figure 4.6 Product/User Dependency Chart

This list will help the designer keep track of the information acquired within Step 2. Moving forward with Step 3, the designer can create their aesthetic typology by referring to this list to make sure that each of the dependencies are met. This ensures that the product will exceed the user's desire and expectations when using. This list's purpose is to give the designer a general understanding of what attributes will support this product within the environment it is intended to be used. With these criteria the designer can determine more tangible product characteristics within the aesthetic typology in Step 3. The aesthetic typology will be the criteria that the designer can use moving forward with their design process.

4.3 Step 3: Create 'Aesthetic Typology' for Sustainable Solutions Relating to Product Lifetime



This part of the guideline is based on Stuart Walker's (2006) approach recommending the designer to evaluate existing products within the category and create an 'aesthetic typology' (refer to 2.2.2). An 'aesthetic typology' is a breakdown of a product by analyzing current product solutions to find sustainable methods of product development from material extraction to manufacturing. Only three points of Walker's typology are used within this guideline because they are crucial for product lifetime –

Needs, Suitability, Usability. Discovering unsustainable characteristics early in the process helps the designer to avoid these in the traditional design steps including sketching and prototyping. This typology list is related to the product and user dependencies found in Step 2. This typology takes the generalized dependencies found from empathic modelling and design interviews to create a firm list of criteria moving forward when the designer is conceptualizing. Creating this typology includes determining the following:

4.3.1 Product Needs/Requirements

What components are needed to manufacture this product? This can be done by disassembling existing products into their original parts before assembly. It can also be done by researching how the specific product functions and how previous manufacturers have assembled them. A term for this is DFA (Design for Assembly). “DFA is concerned with reducing the product’s assembly time, costs, and complexities by minimizing the number of individual parts, assembly steps, and potential for variability in build quality” (Siemens, 2022). This methodology can be useful to the designer when conceptualizing so that they only include the appropriate parts the product needs. When analyzing other existing products, the designer can find what aesthetic and functional features help prolong the lifetime and which do not.

4.3.2 Suitability for the User

How could this product be more culturally appropriate? Are the materials, ergonomics, and functionality suited for this user type and environment? What existing products seem to fit the best with their defined user group? After dissecting the user

and product dependencies (Step 2) based on characteristics gathered from empathic modelling and user interviews, the designer needs to step back and asses the cultural attributes within a product that support the user type as a whole. Observing, documenting, and understanding recurring user characteristics will help the designer create a product with features that better suit the user's lifestyle. Suitability is the features within the product that are culturally aware of the user's environment. With adequate cultural appropriateness, the product will feel as though it fits neatly within the intended environment.

4.3.3 Usability and Adaptability

Are the existing products adaptable over the full lifetime of the product? Can the product be modified or changed over the course of its life to make it used over a longer period? This research would include finding products that are used for a short time and analyzing what limits their adaptability. This analyzation also includes discovering what features help prolong the effectiveness, efficiency, and overall satisfaction of the user.

4.3.4 Organizing Information

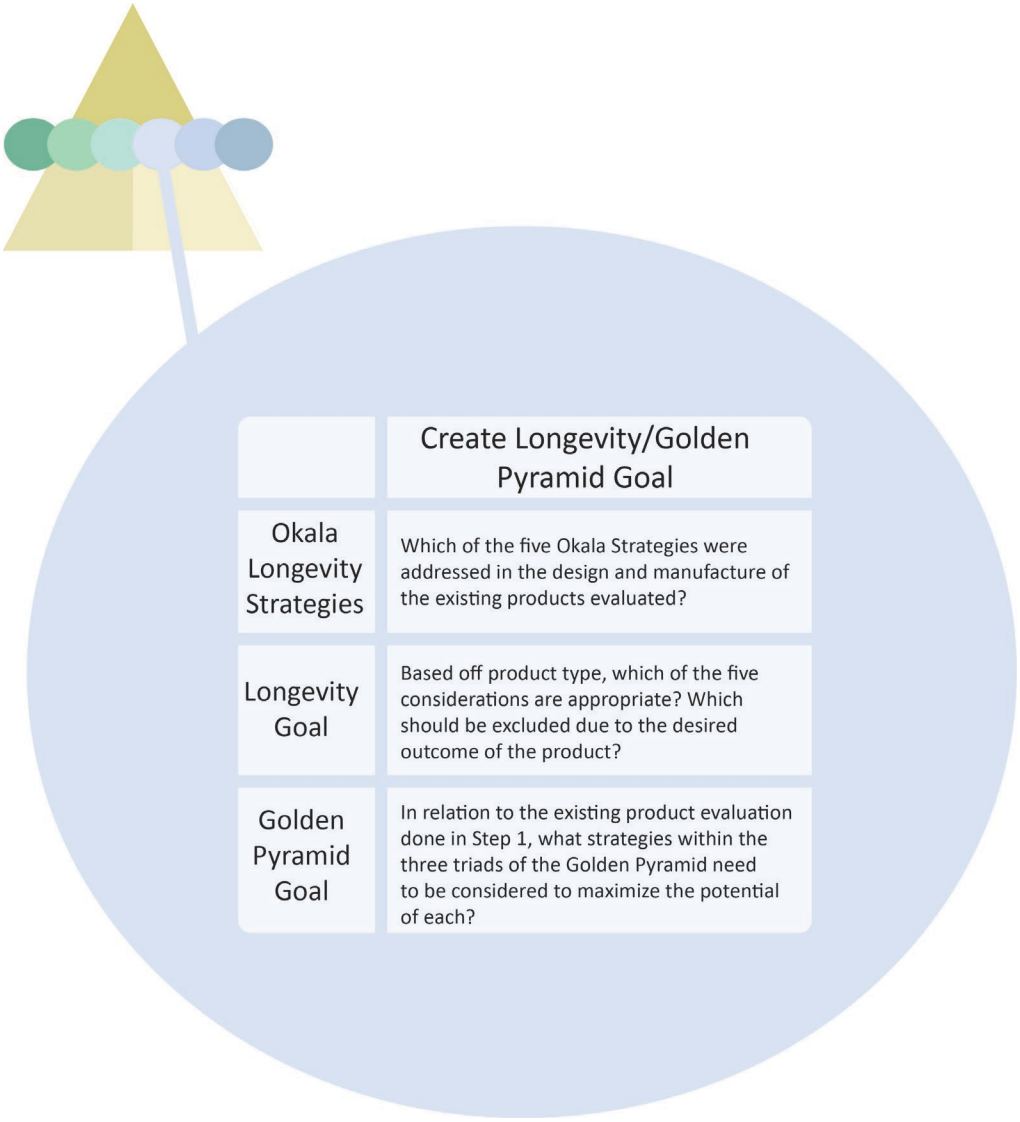
The designer can organize and synthesize this information in any form they please. Some examples could be creating a chart, graphic visualization, or mind map that strategically place the needs, suitability, and usability in an organized representation. See Figure 4.7 as one example of how this might be done.

Product Needs/ Requirements	Suitability for the User	Usability/Adaptability
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•

Figure 4.7 Needs, Suitability, Usability Chart

These typology categories are extremely necessary to consider when designing. This will allow the designer to go beyond the traditional design process with sustainable intentions on what to include and avoid when conceptualizing.

4.4 Step 4: Create a Longevity Goal



Step 4 requires the designer to reassess existing products within the product category and state which of the five Okala Longevity Strategies are met (refer to Figure 4.8). Once this reassessment has been done, the designer needs to discern whether all five of these considerations are appropriate to the product type being developed. For example, if the desired product is designed for disposal, then it does not need to meet the consideration of 'built-in durability'. This consideration can be excluded.

Figure 4.8 Five System Longevity Okala Strategies

Once ascertaining which of the five considerations are appropriate to the specified product, the designer then can consider the strategies neglected in the first evaluation when moving forward with the traditional design process. The designer should review what products reviewed do/do not meet these strategies and discover what went right/wrong for them. Defining the number of appropriate longevity strategies also defines the number of notches in the lower right triad of the golden pyramid. These notches clearly define the goals for future product development.

4.4.1 Golden Pyramid Design Goal

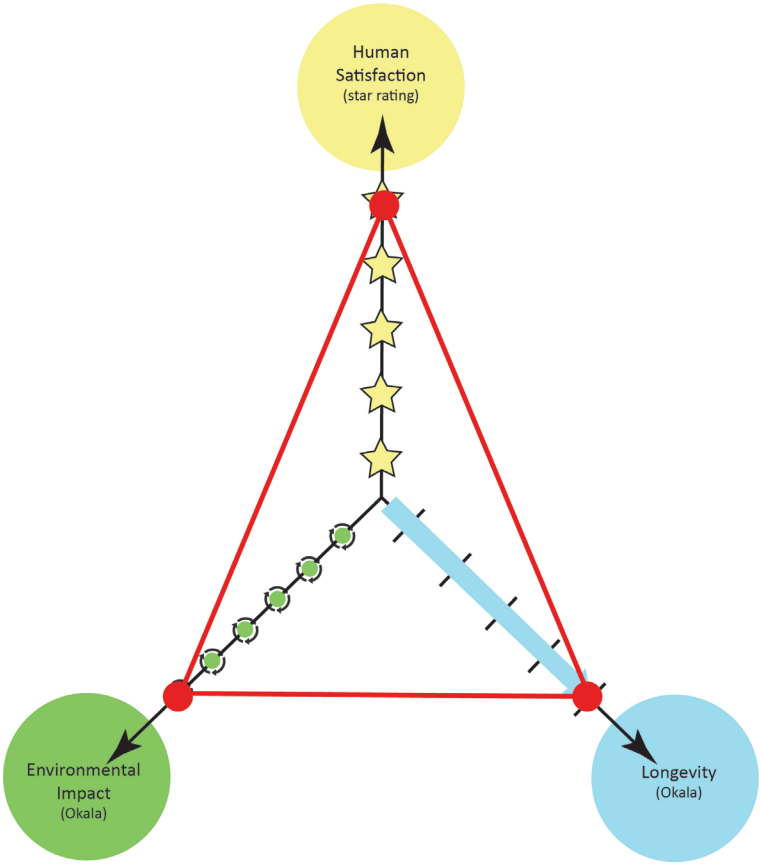


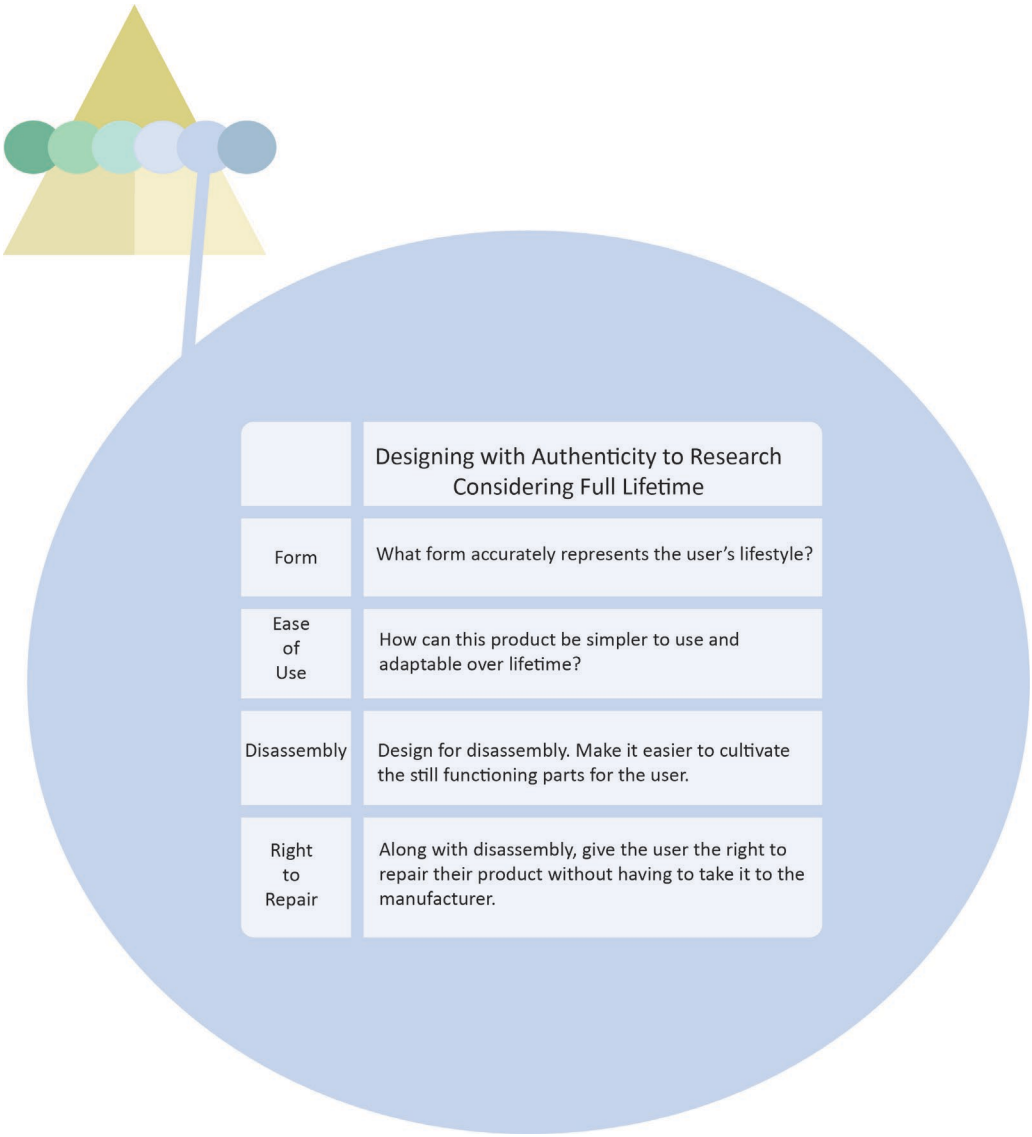
Figure 4.9 The Golden Pyramid Design Goal

Before beginning the initial stages of sketching and prototyping, the designer should re-evaluate the Golden Pyramid approach to make sure they are moving forward with implementing their design goals. The goal for every project should be to maximize the human satisfaction and longevity, while minimizing the environmental impact. Although the criteria is loosely defined and relatively subjective at this stage in the process, as the product is being further developed, the specifications can evolve and become more concrete as the designer continues. The further along the product has

matured, the designer can be more objective as to whether the product genuinely meets the potential of the intended triads.

In the first four steps of the guideline, the designer will keep in mind the best methodologies of production from the reviewed product examples. However, in the last two steps, it is important to take positive action in the design to minimize environmental impact, create sustainable long-lasting products, and ultimately reach human satisfaction. The arrows in Figure 4.9 show that compared to existing products within the product category, the designer should use proposed strategies of decreasing environmental impact while increasing both longevity and human satisfaction. As the designers begin sketch and prototype development, they should be mindful of how they might generate connectivity with the user to make sure the product has longevity and thus increases its sustainability. The peak of the pyramid represents maximizing human satisfaction. This is a product designer's main goal when developing and should remain that way, but it is also the designer's job to make sure that the goal of human satisfaction is not overpowering the foundation of minimizing environmental impact and longevity.

4.5 Step 5: Designing with Authenticity Considering the Full Lifetime of Product



In the initial stages of the design process, one needs to consider the user needs and desires. One way of doing this includes designing with authenticity (refer to 2.1.7.1). This means that going forward, the designer must consider all initial user research from the previous steps of the guideline. Instead of relying on unresearched assumptions about user types, designers should put into practice all the feedback received through

empathic modelling, design interviews, and finding product and user dependencies in the existing product research. This helps the designer create a bond between the user and product. This step includes generating multiple conceptual solutions and forms, referencing the aesthetic typology, while also considering ease-of-use, ease-of-disassembly, and rights to repair needed to prolong the product's lifetime.

4.5.1 Form and Ease-of-Use

Depending on the product category, the ease-of-use is dependent on the functioning of the product. This area of development can be attained through the information gathered in Step 3. The usability and adaptability of this product will help determine the form. These criteria will provide understanding as to how the form can provide an adequate ease-of-use specifically in the environment intended. For example, if the user type is constantly on the move, then the product needs to function efficiently. Ease-of-use needs to be strongly considered when prototyping to make sure it will not be a hassle to use. After the functionable aspects of the product has been strongly considered, the designer should consider what form best contributes to the function. Designers should consider: what forms best fit the user's body type? And what forms represents the user's lifestyle? How can this product be simpler to use and adaptable over its lifetime? This form will be subject to the research done in previous steps. This includes analyzing the observations and constraints found from empathic modelling and creating a form that is efficient for the user type.

4.5.2 Ease-Of-Disassembly and Right to Repair

While designers might prefer to create products that are easily repairable, there is often a tradeoff where the user loses this right because manufacturing methods require extra parts and/or costs that take away from profitability for the company. Referring to 2.1.2, relative obsolescence is becoming increasingly prevalent within products because of the expanse of competitive products within a market. Some companies would rather the user buy the newest version of the product instead of having the ability to repair it themselves and continue to use their current product, especially within the tech industry. Extremely successful products sometimes tend to have a short lifetime because they are difficult for the user to repair. Considering how inexpensive products can be now, many consumers would rather replace a product instead of repairing it. This is not sustainable and is detrimental to the planet due to the disposal of materials that could otherwise continue to be used. The designer needs to consider, when conceptualizing, how to componentize important features so that the user can continue using the product by replacing a component that dies.

4.6 Step 6: Golden Pyramid Reflexive Evaluation

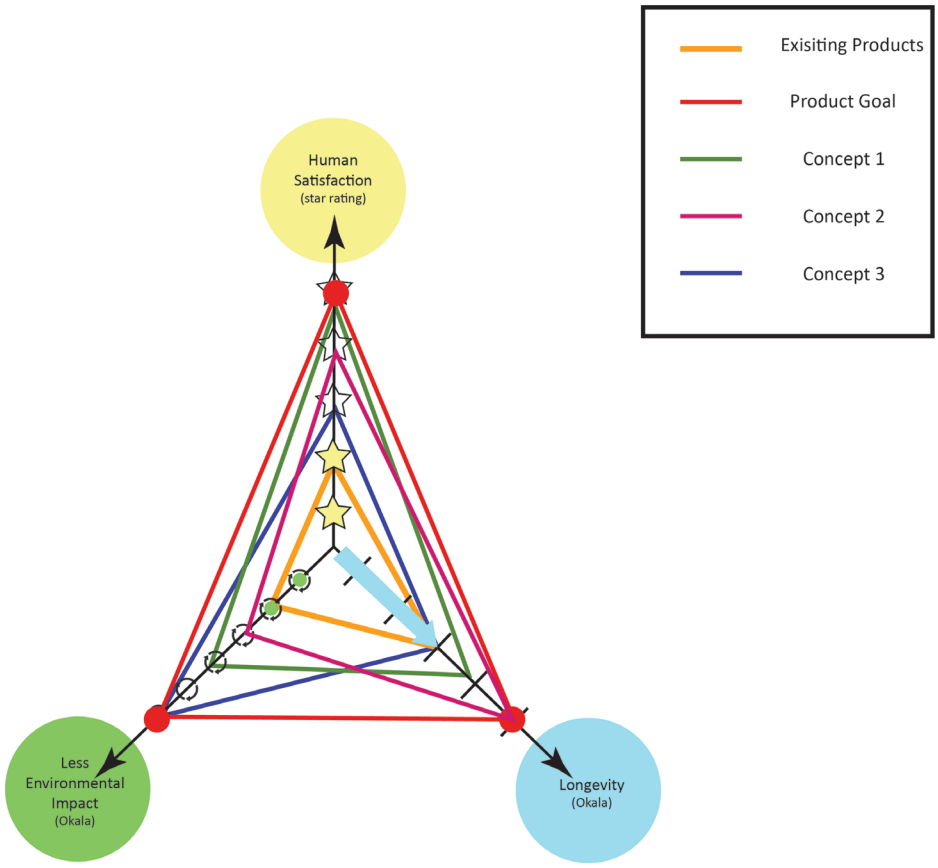


Figure 4.10 The Golden Pyramid Reflexive Evaluation

The final checkpoint with the Golden Pyramid comes with a reflexive evaluation of the finalized concepts. A reflexive evaluation retraces the layers of the pyramid by seeing which layers each design satisfies and which each hinders. A reflexive evaluation can be done at any point, regardless of the fidelity of the concept. Sketches, CAD models, or physical prototypes can be evaluated. This evaluation is an ongoing process that can be performed even after the product is manufactured. Figure 4.10 depicts three theoretical conceptual solutions. The designer can consult the design interview

groups used at the beginning of the guideline to receive their evaluation on what the strategies the concepts meet and what user desires were exceeded.

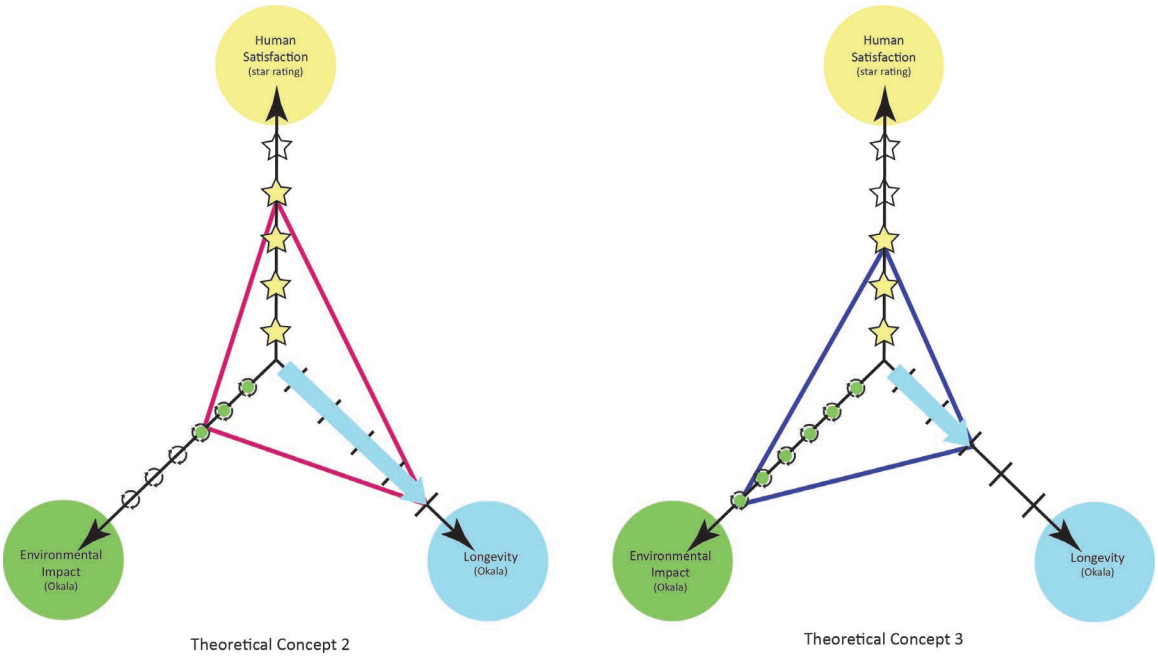


Figure 4.11 Theoretical Concept Evaluation

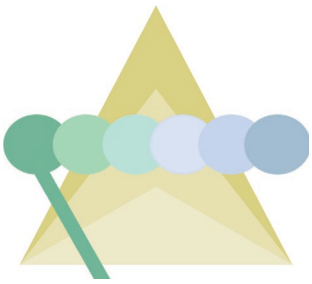
In a perfect scenario, the proposed design would maximize all three triads of the triangle; although, it is difficult to meet all these standards entirely. Here, the longevity goal is still five notches because each of the considerations are appropriate. The way to gauge the new design comes from comparing it to existing products and seeing where the new product surpasses them in relation to these goals. This reflexive evaluation will allow the designer to reflect on all their concepts and decide which one gets closest to reaching all intended goals. It will also help moving forward with future developments. The designer takes into account the best and worst performances in their concept evaluations to generate refined concepts that meet the intended goal more properly.

This evaluate/refine process may continuously repeat depending on the product development schedule/allotted time.

5 Implementation of Golden Pyramid

Product lifetime has decreased significantly in recent decades as a result of cheaper and more efficient manufacturing as well as consumer tendency to replace still-usable products. This guideline proposes to extend the longevity of products by helping the designer consider authentic human behavior, and environmentally and sustainably conscious decisions when designing new products. This chapter demonstrates an implementation of the Golden Pyramid approach as an example of how the guideline can be utilized. A Bluetooth speaker is chosen for proof of concept.

5.1 Step 1: Product Category, User Group, & Defining Existing Market



Product Category	User Type
Bluetooth speaker	Kayaker

Table 1 Establishing the Product Category and the User Group

The product category is a Bluetooth speaker. Analyzing what product is desired upfront is important so that the design is on the correct path for the entire design

process. The user type is meant to be precise so that the designer can empathize with specified lifestyles. This Bluetooth device is meant for a kayaker, requiring the ability for it to undergo uncertain terrain and weather conditions. Focusing on a kayaker suggests it can also be used by any outdoorsman when trekking.

5.1.1 The Golden Pyramid (Defining Existing Market)

The first Golden Pyramid checkpoint is where the designer compared existing speakers on the market and created an average analysis based on where they fell in line with the goals of the Golden Pyramid. To find the average human satisfaction the designer looked at previous reviews of speakers and found the average response from users. For consideration of the expertise on modern speakers in the market, Sound Guys' (a professional speaker critic company) input was considered to find which of the five satisfactory goals were met (see Figure 5.1).

Figure 5.1 Existing Product Analysis on JBL, Bose, and Ultimate Ears (SoundGuys 2022)

The products' longevity is based on the average amount of time that the speakers lasted before having significantly decreased battery life from the original state it was sold. Analyzing these subjectively, the designer found that each speaker employed sustainable strategies from the following categories: a built-in desire to care for them long term, a built-in durability, and a timeless look or fashion; however, failed

to design them for maintenance and easy repair as well as future upgrades. To find the average environmental impact, the designer used the Okala Eco-Design Strategy Wheel (refer to Figure 2.7) to analyze where the designers' (JBL, Bose, & Ultimate Ears) focus was at during the initial design stages. These speakers were built with the focus of manufacturing innovation, distribution impacts, and behavior and use impacts, which includes three stages of the Okala Strategy Wheel. The strategies such as the reduced material impacts, transitional systems, and optimized end-of-life were not considered nearly as much. To illustrate the information found in this research the designer found where the average existing speaker rated on the Golden Pyramid (see Figure 5.2).

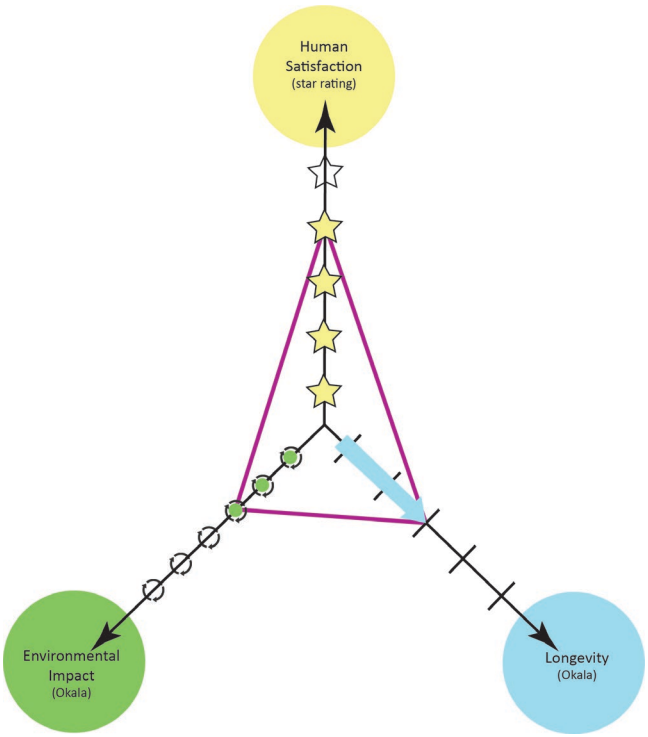
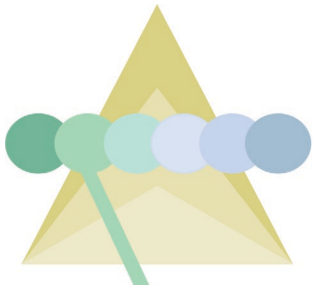


Figure 5.2 Average of Speakers Evaluated

When glancing upon this chart (Figure 5.2), one can see that the triangle formed by the averaging of these three parameters is small and irregular. This result shows that

there are many improvements to be made for future Bluetooth speakers especially in relation to promoting positive environmental impacts by considering every aspect of the Okala Strategy Wheel and extending the longevity by increasing battery lifetime.

5.2 Step 2: User Behavior Research



	Empathic Modelling	Design Interviews	Dependencies
With Product	✓	✓	✓
Without Products	✓	✓	✓

Table 2 User Behavior Research

Table 2 is the step of the implementation where the designer made a chart separating user behavior research into two categories: with product and without product. Within each the designer empathically modelled out scenarios with multiple existing speakers pertaining to their usability and ergonomic features, as well as kayaking scenarios pertaining to their anthropometrics and motion activity while in a kayak on the water. Then the designer made two design interview/discussion groups of five: one with speaker enthusiasts and one with kayakers. After, the designer gathered the information within each to find which features were dependent to an outdoor

speaker and a kayaker (refer to 2.1.7.1). The design criteria gathered in this step is included in the following sections.

5.2.1 Empathic Modelling

Within this guideline, before sketching or conceptualizing the designer empathized with the user's behaviors by testing various motions, ergonomic, anthropometric, and visual qualities. Developing this Bluetooth speaker, the designer began by analyzing three existing speaker brands to pinpoint features, forms, and qualities that are more successful compared to other products in the market (Figure 5.3). The goal was to understand a way to create a connectivity between the user and the product.

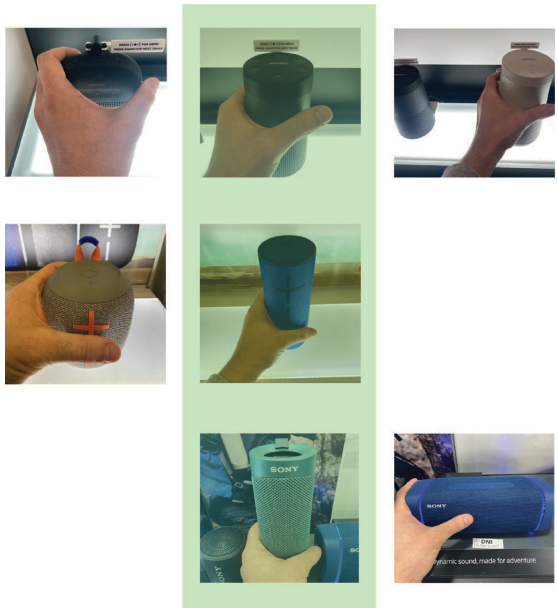


Figure 5.3 Evaluating Existing Bluetooth Speakers

When considering a kayaker while testing existing speakers, the designer contemplated what features were most portable, durable, and efficient. There was a common medium size among popular speakers designed by Sony, Bose, and Ultimate Ears that allowed them to be put into any backpack water bottle pocket while also being large enough to spot in nature. The smaller speakers were the most portable but easier to lose, while the larger speakers were much easier to spot but much too heavy and dense to be toted around or to float. Once finding a similar common medium size to conceptualize around, the designer empathically modeled user measurements and motions in a kayak (see Figure 5.4). The designer did so by exploring motions, reach, and actions typical of an adventurer using a kayak.

Figure 5.4 Empathic Modeling a Kayaking Experience

Empathic modelling with a closed kayak (Figure 5.4) concluded with the realization of how little motion and reach distance that kayakers have while seated inside the kayak. With a paddle in hand, it would be extremely difficult to simultaneously press a button on a speaker.

Figure 5.5 Control Buttons on Tested Speakers

Figure 5.5 shows the locations of the buttons on three examples of speakers. All of them require the user to reach around the back of the speaker to provide stability to press the various controls. For a kayaker or someone who is participating in activities outdoors, this range of motion is not always available. This led to conceptualizing around non-touch feature, such as voice activation.

There is also an incredible amount of side-to-side rocking while paddling. A speaker could easily fall off with one swift movement. This led to the discovery of needing a device that can be attached to the kayak. Through the process of empathic modelling the designer began to create a design mindset that is compatible to the user type.

5.2.2 Design Interviews

The design interviews described below are simulated for the sake of this thesis to give an example as to how a designer would take feedback from a group and document it for further usage in the design process. The design interviews included five kayaking fanatics and five speaker-using, music lovers. These were two different study groups composed at separate times to see what comparable and noncomparable features that they depend on.

5.2.2.1 Kayaker Design Interview

Figure 5.6 Kayaker User Group and Comments

After conversations with five different kayakers varying from extremist to beginner, many different dependencies were brought to life (see Figure 5.6). Some were no help and had no relatability to the speaker design, but all the information helped expand the designer's understanding towards user engagement. Some key quotes were extremely important for taking the next step of the design process.

5.2.2.2 Speaker/Music Lover Design Interview

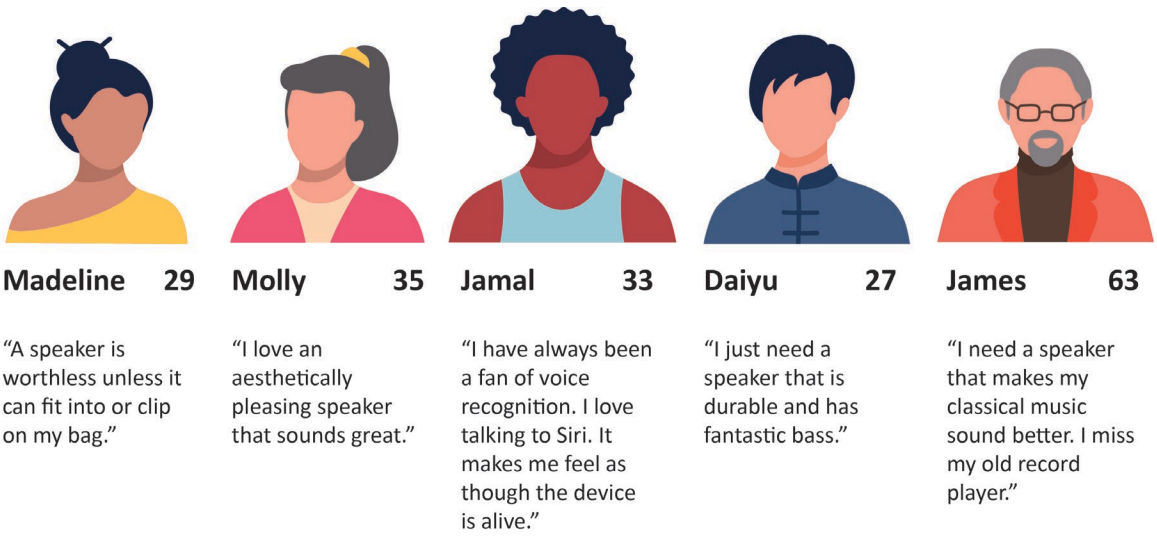


Figure 5.7 Speaker Users and Comments

Reverting away from the user type, the designer also interviewed consumers of the product category (Figure 5.7). Because the product category is a speaker, five different music lovers were chosen for this study group. Considering there are many commonalities for dependencies of speakers, much of the information attained was direct in the sense of what was desired and not. Most agreed that a speaker needs to have good sound quality, but some opinions about size and ergonomics were different based on the user's lifestyle. Most of the group agreed that no matter the size of the speaker it needed to be portable and have provision to be attached to an accessory to be kept up with. The entirety of the group agreed with Jamal that voice recognition is a fascinating feature, but it needs to be simplified for more efficiency.

5.2.3 Dependencies

Using empathy while modelling and testing as well as discussions with user groups, the designer gained an accurate understanding of what the dependencies are within the product category and the user type. By combining the two together, dependencies were discovered for a speaker that can be used by a kayaker. The designer made sure they considered these criteria when conceptualizing (Figure 5.8):

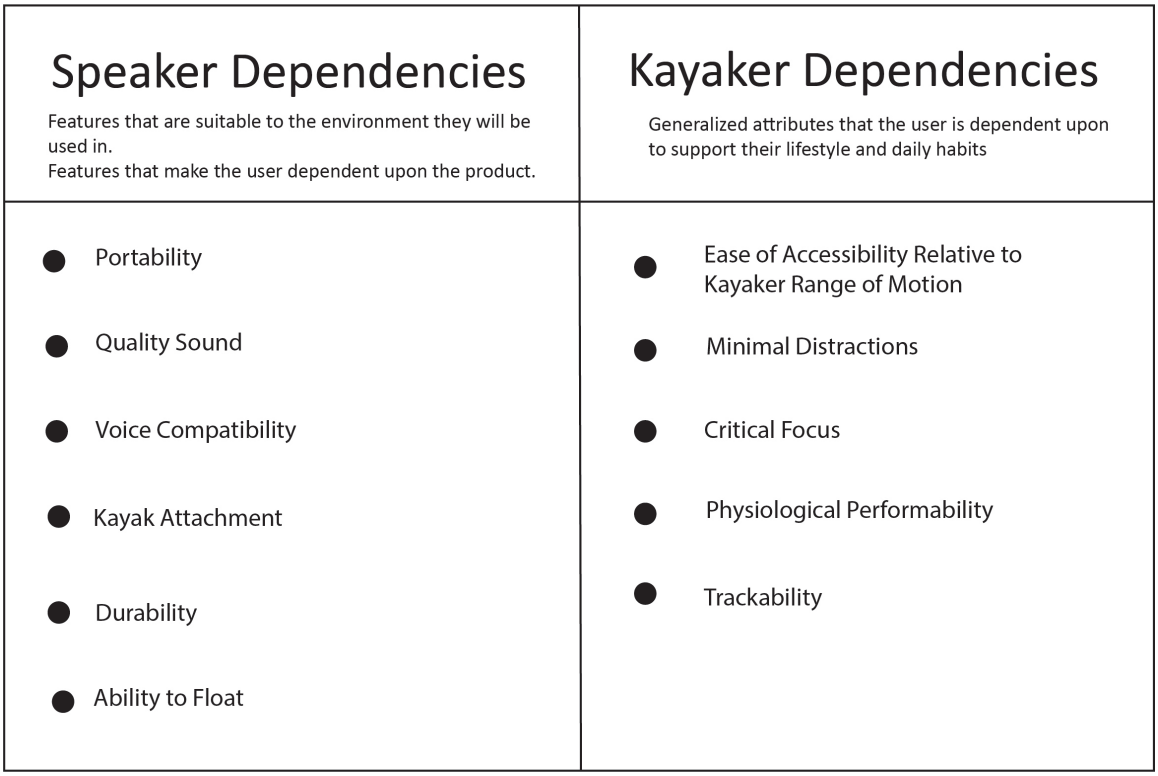
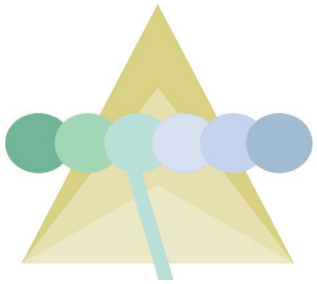


Figure 5.8 Speaker - Kayaker Dependencies

5.3 Step 3: Create "Aesthetic Typology" for Sustainable Solutions Relating to the Longevity of Existing Products



Needs	✓
Suitability	✓
Usability	✓

Table 3 Creating an Aesthetic Typology

Table 3 is the step of the implementation when the designer dissected the common sustainable solutions for speaker designs relating to the product's longevity. This helped the designer strive to attain these scenarios through the design process. The list of criteria below was developed from the dependencies found in Step 2. This was done by analyzing the generalized information gathered by empathic modelling and design interviews, and creating a more formalized, tangible list of features that provided support when conceptualizing speakers in Step 5. The design criteria gathered in this step is included in the following sections.

5.3.1 Product Needs/Requirements

The needs for the product include analyzing the internals to understand how existing products were developed and finding what components are required for the manufacturing to be possible.

Figure 5.9 Exploded View of Waterproof Speaker (Huang, 2022)

As one can see above in Figure 5.9, manufacturing a waterproof speaker requires the following:

- Box – Outer shell to contain internals
- Driver – Converts electrical audio signal to sound waves
    - Back Plate
    - Magnet
    - Top Plate
    - Basket
    - Coil
    - Spider
    - Cone

    - Dust Cap
- Wiring
- Silicone Sealing Ring
- Joinery

5.3.2 Suitability for the User

Suitability refers to the cultural appropriateness of the product to the user group it is intended to reach. Considering the speaker is intended for lovers of the outdoors, the designer appreciates a device that is manufactured in environmentally friendly ways. This includes finding sources of power, materials, and disassembly methods that are sustainable and come from natural resources.

- Avoid harmful materials that are damaging to environment
    - Could it be manufactured with recycled material?
- Provide accessibility
    - How can the product be more accessible to a user with limited range of motion?
- Use colors that are more suitable to outdoor enthusiasts
    - What colors are more aesthetic to nature?
- Find new sources of energy
    - Stored power? Solar? Manual Power?
- Create form suitable for kayaker
    - How can it be durable and flexible for bumping?

5.3.3 Usability/Adaptability

The usability of the product does not need to be stagnant. It needs to have adaptability across its lifetime to be adjustable to the environment and situational occurrences. Many existing speakers require the use of a phone to change songs and do not do much else than project sound/music. How can the designer ensure this device will allow the user to sync songs before the excursion and during it, as well as be able to flip between songs?

- Simplify voice demands
- Allow for Bluetooth and hotspot connectivity
- Make completely waterproof and buoyant
- Make carabiner retractable
- Make durable for uncertain terrain.
- Ability to survive being dropped
- Create method to recharge without power source

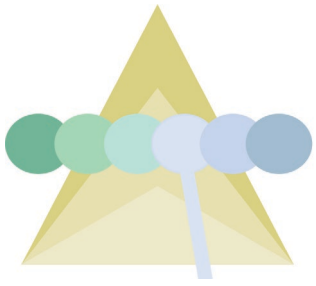
5.3.4 Organizing Information

While researching the needs, suitability, and usability, the designer organized the information into a chart that can be considered throughout the design process (see Figure 5.10).

Product Needs/ Requirements	Suitability for the User	Usability/Adaptability
● Box ● Driver ● Back Plate ● Magnet ● Top Plate ● Basket ● Coil ● Spider ● Cone ● Dust Cap ● Wiring ● Joinery	● Environmentally Friendly Material ● Earth-Tone Aesthetic ● Easy Accesibility ● Clean Source of Power ● Durability, Flexibility	● Voice/Manual Control ● Bluetooth Connection ● Waterproof/Bouyant ● Disassembly/Repair ● Durable for Terrain ● Manual Recharge ● Retractable Carabiner

Figure 5.10 Organized Information of Typology

5.4 Step 4: Create a Longevity Goal



Existing Speaker Okala Longevity Strategies	✓
Longevity Goal	✓
Golden Pyramid Goal	✓

Table 4 Longevity Goal

In the existing product research, the designer found which Okala System Longevity strategies were employed within a variety of existing speakers on the market (see Figure 5.11).

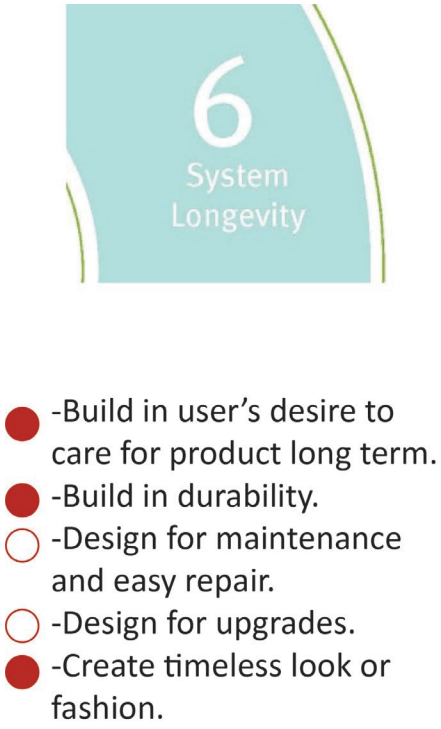


Figure 5.11 Existing Speaker Longevity Strategies Employed

After analyzing speakers from Bose, JBL, and UE, the designer found that three out of the five strategies were consistent within all three existing products evaluated. After reassessing the strategies employed in Step 1, the designer realized all five of these longevity considerations were appropriate to a Bluetooth speaker so none of them were excluded moving forward with this specific product type. Each had built in features that allowed for the product to be cared for long term and ample durability. They also had a timeless look or fashion employed. Where they tend to fall short is their inability to be disassembled, repaired, and upgraded. This is detrimental to longevity

because these strategies allow for the product to surpass the usual relative obsolescence. The main problem with speaker longevity is internal failure. Without the ability to replace the internal hardware, the user is forced to discard of the product when this problem arises. Moving forward with the traditional design process, the designer must find solutions as to give the user the ability to replace the driver, wiring, and especially the battery when the product begins to fail. This will also provide ability for upgrades in the future when new internal hardware is produced, giving the product the ability to last until its absolute obsolescence.

5.4.1 Golden Pyramid Evaluation Goal

The assumed designer's goal is always to reach the full potential in each element of the Golden Pyramid which is represented by the red line in Figure 5.12. Although perfection cannot always be achieved, it should be the initial goal going forward in the design process. How can this product exceed human satisfaction, be useful across an extended lifetime, and minimize the impact on the environment demonstrated by Okala?

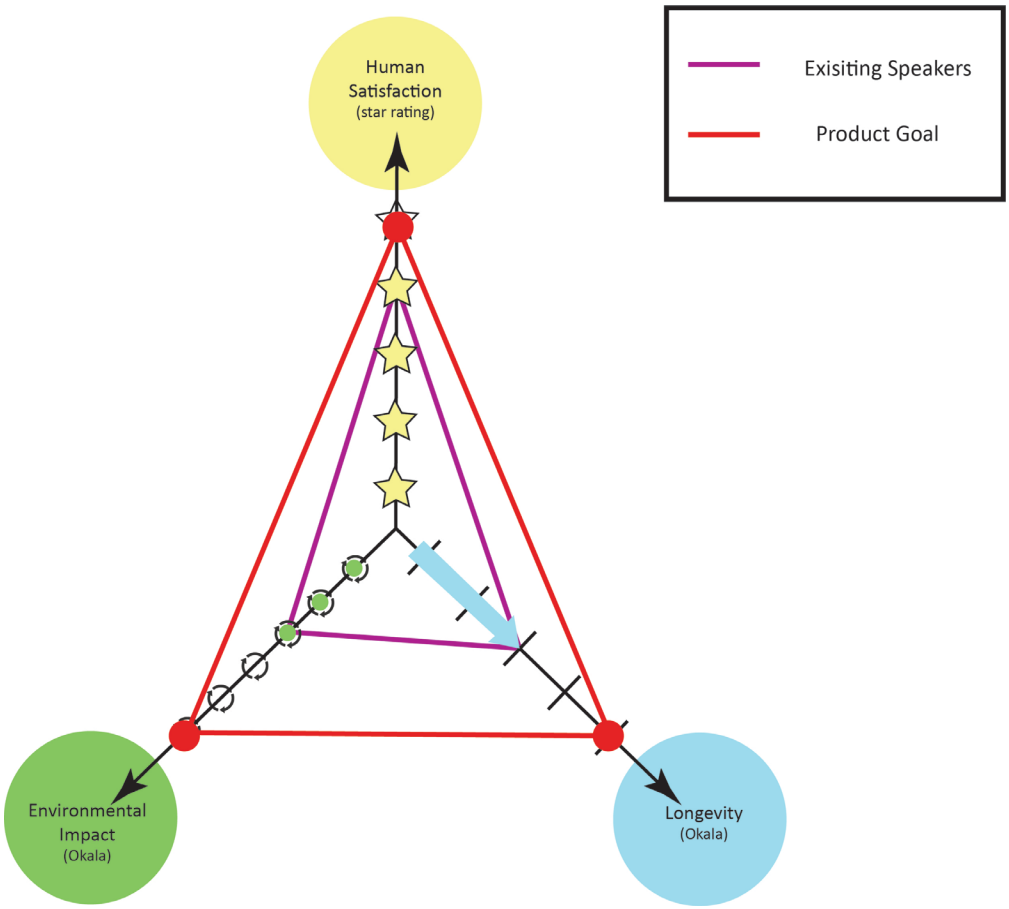
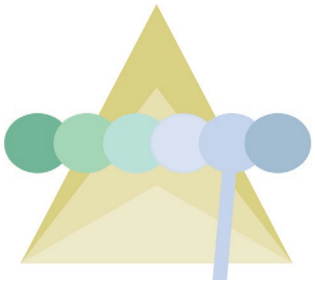


Figure 5.12 Goal for New Speaker Evaluation (red) Compared to Existing Product Evaluation (purple)

Going forward, the designer intended to design this speaker maximizing the amount of human satisfaction gained from the product, extending the longevity compared to existing product by meeting all five strategies suggested, while considering every element of the Okala Strategy Wheel considering the environmental impact. These three goals will be taken into account throughout the traditional design process.

5.5 Step 5: Designing with Authenticity to Research Considering Full Lifetime of Product



Form	✓
Ease-of-Use	✓
Ease-of-Disassembly (Modular)	✓
Right-to-Repair (Componentizing)	✓

Table 5 Design Checklist

When beginning to sketch and conceptualize the speaker, the designer needed be authentic to the research and user dependencies discovered in the previous steps. It was determined that the product should accurately represent the consumer needs while having environmentally friendly manufacturing methods. Table 5 shows the checklist designers should implement to ensure that the product can last its full lifetime. The product should meet the desires of the music lovers while making sure it is easily accessible and caters to demands of kayakers and outdoor enthusiasts. Initial rough sketches explored different forms and ergonomics. This helped the designer find a form that accurately and efficiently represented the user's lifestyle. The forms with the lower body mass were determined to be adequate for this design, considering it helps lower the center of gravity to reduce the likelihood of tipping while mounted to a kayak.

Considering authenticity to the kayaker, the device needed to be one that can be used when in treacherous terrain. This meant it needed to be durable and water/weatherproof, as well as able to be attached to the kayak.

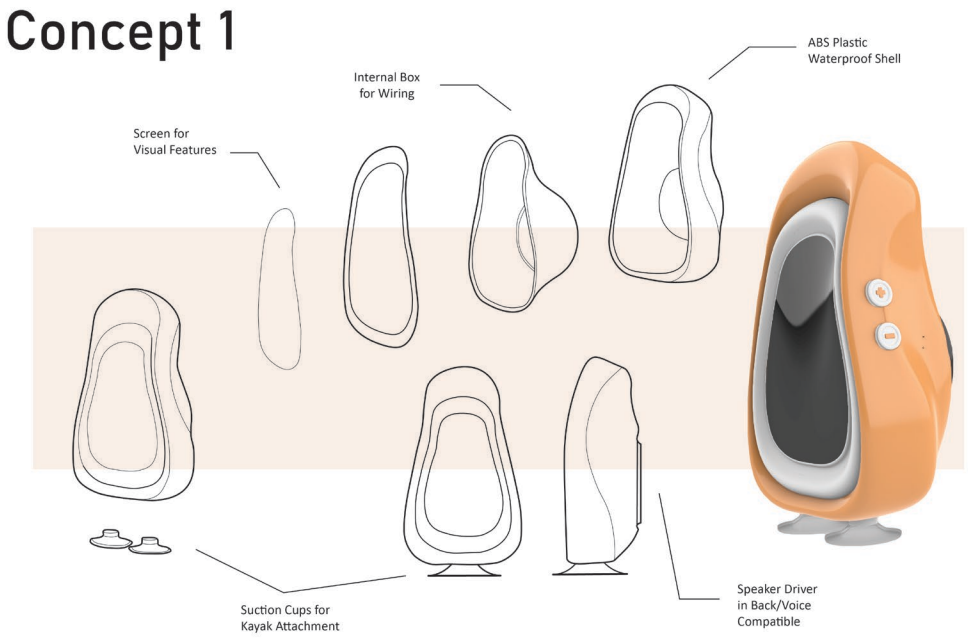


Figure 5.13 Concept 1

Additional sketching led to the development of concept 1 (Figure 5.13) that suited the user behavior needs and design interviews/discussions. Two suction cups were added to ensure that the speaker could be stuck to any part of the kayak and be secure. The screen on the front displays the weather and the user's place on the map while allowing for voice recognition commands to interchange between applications, volume controls, and song choice. This form also allows for adequate sound quality and bass because of its domed shape and air volume in relation to the bass port area.

After physically prototyping with urethane modelling foam to figure out the scale and dimensions, the process then moved on to CAD development. The initial CAD sketch

prototyping was used to conceptualize the curvature and form of the outer shell. This shell needed to be large enough to hold the internal components, but small enough to be portable and efficient. The curvature implemented was a human ergonomic need for gripping the device when wet, fitting comfortably in hand with the thumb and the forefinger. The internal components must be watertight, so to ensure a waterproof enclosure there was a small shell added, which could be made from ABS plastic and replaced once it has worn. This shell will hold the box, driver, and wiring covered with a waterproof display screen that provides information to be visually accessible. The internal shelling also provides adequate air volume in relation to the bass port allowing for maximum bass and music/voice quality.

After the initial CAD development was completed, it was noticed that the single suction cup conceptualized with sketching would not provide enough stability. A single suction cup would allow the device to wobble horizontally constantly throughout the kayak trip, making it harder for the user to visually comprehend what is on the screen. With two smaller suction cups the device would stay planted with firmness. These suction cups can also be replaced when they get worn out by an easy pop-off disassembly. This component was designed to wear out quicker than the internals, so it was the first that was needed to have the *right-to-repair*. The suction cups are inexpensive and can be cleaned with warm water and alcohol many times before having to be replaced. Also, the water splashing on the kayak will help provide extra suction.

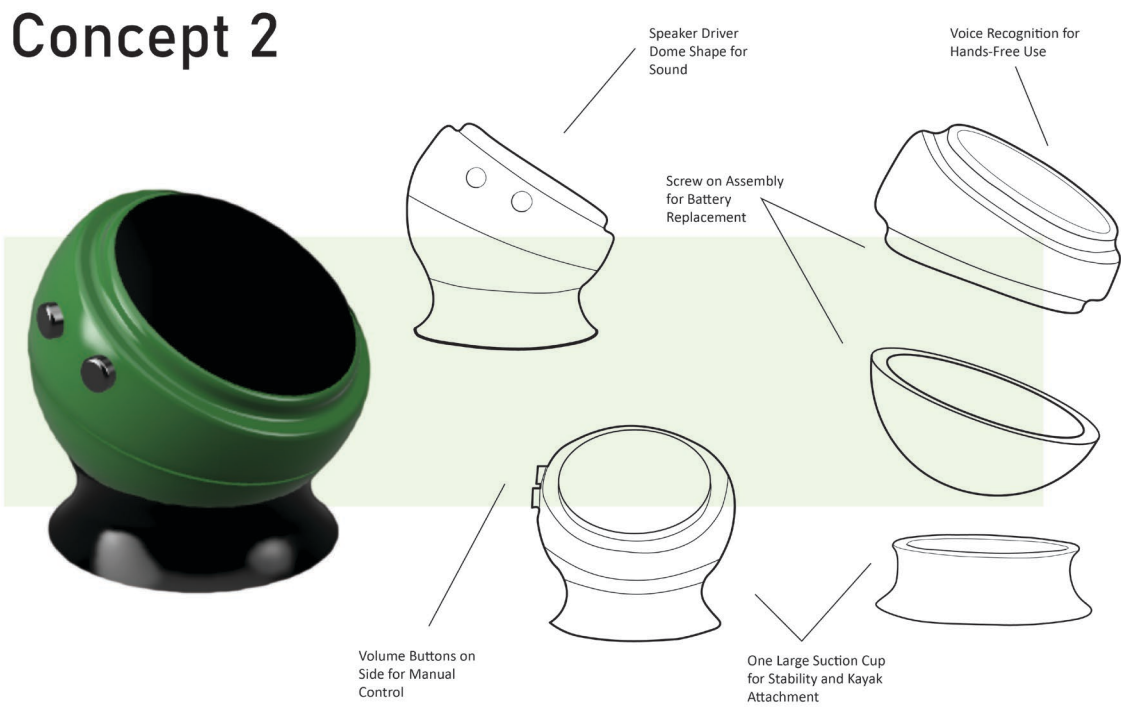


Figure 5.14 Concept 2

The next concept (Figure 5.14) explored the suction cup feature further. With the dome-like body giving it a lower center of balance, the speaker fits nicely into the suction cup's pocket allowing it to grip tightly onto any surface. The part line of the speaker is in the middle of the dome and is fastened by a watertight fastening mechanism. This allows for the user to disassemble the speaker and replace internal parts when they begin to fail. The entire body is made from 100% waterproof ABS plastic ensuring no water passes through. This speaker's external body is ultimately meant to last until it has worn due to weather.

This concept is a speaker that is designed be repaired as often as needed. It allows for the user to easily disassemble it, providing opportunity for the product to last to its potential. The product is composed of three external components: the speaker driver, the compartment for battery and other internals, and the suction cup. The entire

speaker is made from ABS plastic allowing for it to be completely waterproof. The internals are contained within the speaker body, and the body is fastened together. This allows for the user to expose the internals and replace the part that has failed. The large suction cup at the bottom allows for a secure grip onto any wet surface, and it can also be removed and replaced when it fails. When it is assembled the low center of gravity allows for the speaker to stand firm even when shaken.

The form provides easy handling when moving it from place to place, and the size is small enough to fit into a backpack or coat pocket. The dome like shape ensures that it will have superb sound/bass quality. This concept is simple, but it extends the lifetime of the product due to its ability to be taken apart and repaired.

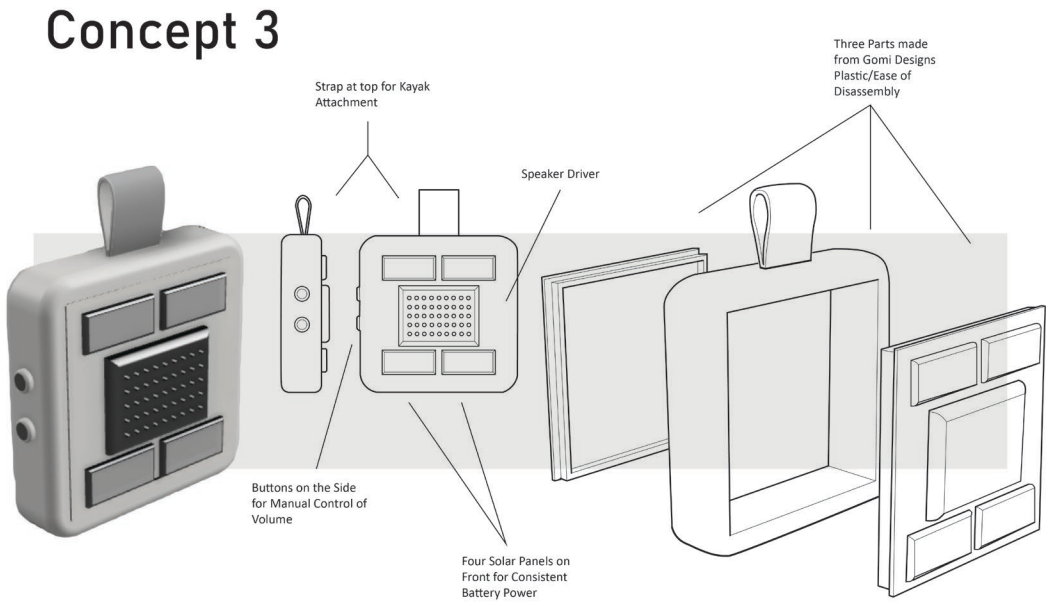


Figure 5.15 Concept 3

The third concept (Figure 5.15) was simplified as much as possible and was intended to be entirely eco-friendly. Gomi Designs in the UK manufactures a 100% recyclable plastic made from plastic that is usually nonrecyclable, such as bubble wrap,

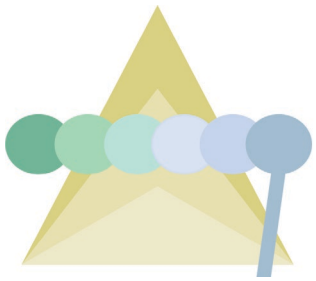
packaging, and cling film. This speaker was conceptualized to utilize this plastic in the speaker's three outer shell parts. This plastic is also waterproof and buoyant allowing for the device to get wet and float on top of the water. On the front of the device are also two waterproof solar panels. These allow the device to charge while exposed to the sun. This concept considers all steps of the Okala Strategy Wheel.

Existing speaker designs researched considered the component manufacturing, assembly and packaging, distribution and purchase, and the installation and use. They failed to consider the material extraction and processing as well as the maintenance, upgrading, and incineration. By incorporating the Gomi Designs recycled plastic for the three main components, this design option also considers the other Okala strategies.

The speaker's internal components are hidden within the walls of the structure allowing for it to stay dry when submerged into water. The internals of this device are assembled through a large opening on the back of the body frame. This opening is covered with a panel which seals to the frame and encases the internals. This solar panel/speaker driver is the only other external component and has two functions: the lid to enclose the speaker's internals and a power source. The resulting slender body is the most portable of the three concepts because of its ability to be slipped in and out of pockets with swiftness.

Along with the thin and compact body, the device contains a sturdy water-resistant strap at the top that is sealed into the device at the end of the assembly process. This strap can be attached to any rope or bungee on the kayak. The user can listen to music while simultaneously charging the battery of the device.

5.6 Step 6: Golden Pyramid Reflexive Evaluation



Tthe Golden Pyramid reflexive evaluation is shown here as the last step, but it is intended to be used at various stages in the design development to help the designer discover how well each concept meets the goals to maximize both human satisfaction and longevity and minimize environmental impact over the course of the product's lifetime. In this step the designer took all three concepts back to the original user groups that were interviewed in which they evaluated all three concepts individually and considered where each would fall on the Golden Pyramid to determine the potential success of each concept. These evaluations were placed side by side to the to the existing speaker analysis done at the beginning of the implementation (refer to 5.1.1).

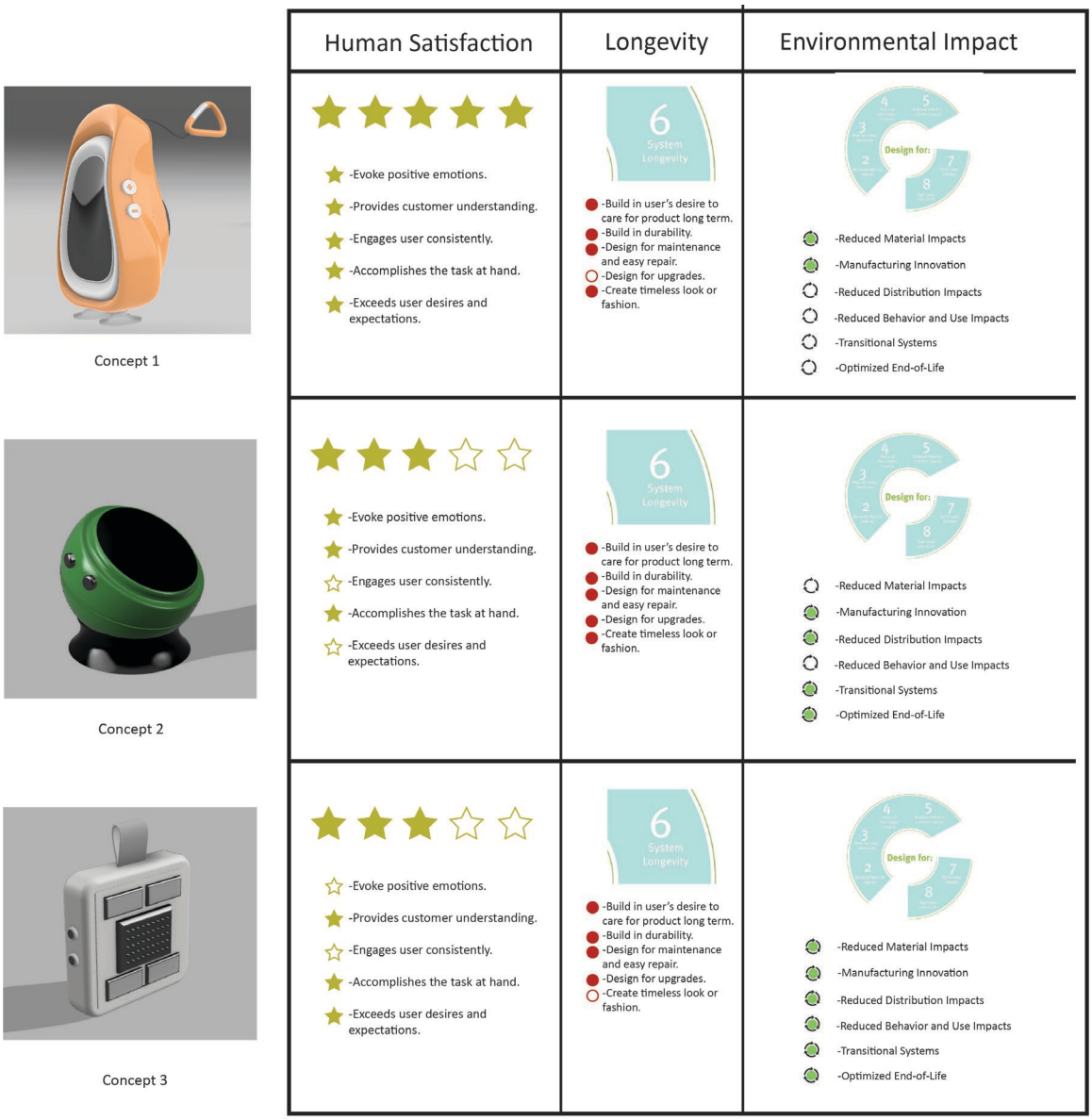


Figure 5.16 Three Concept Evaluation by User Groups

As one can see in Figure 5.16, the kayaker and speaker enthusiast user groups were put together to evaluate and discuss the three concepts produced by the designer. Concept 1 excelled in human satisfaction while the others in longevity and environmental impact. Reading further will explain the results from the image above.

5.6.1 Concept One Reflexive Evaluation

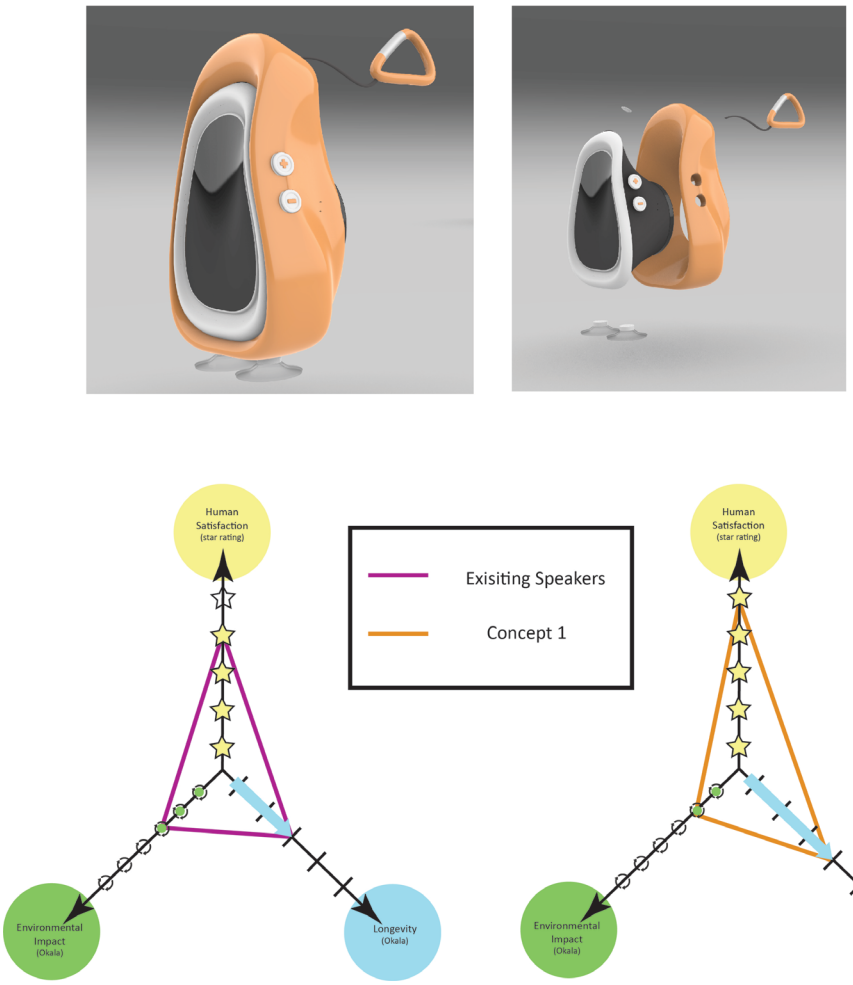


Figure 5.17 Concept 1 Reflexive Evaluation

Figure 5.17 shows a comparison of the existing speaker analysis (left) to Step 1 for Concept 1 (right). The user groups interviewed found that the human satisfaction was thoroughly met by adding significant features pertaining to their user type. Not only does the product accomplish the task at hand, is easy to engage with for the user, and provide clear understanding, but it also evokes strong positive emotions and exceeds user expectations referring to the functionality of the speaker. The product can be easily seen and attached to the kayak without fear of it falling off. The added features,

including the screen help the user create an emotional attachment and dependency towards the product. The form is easily gripped even when wet, and the device can be used entirely through simple voice commands.

When considering the longevity of the product, the designer created a design to give the user the right-to-repair and ease of disassembly. This ensures that the product can last longer than existing speakers in the market. The speaker's exterior shell is durable due to its shape allowing it to be bumped and scratched. The speaker also has a timeless fashion which encourage the user's engagement and promotes the ability to care for the product long-term. Where this product falls short in terms of longevity is that the complex form does not allow for upgrades and hinders its ability to be used for a second function.

Although the product is componentized with the intention that the outer shell could be 3D printed, adhesives were a must have to ensure that the device was completely waterproof. That compromised its environmental impact and hindered its internal longevity. The two steps of the six Okala Strategy considerations that were considered include: 'Reduced Material Impacts' due to the minimizing of the quantity of materials used in manufacturing and 'Manufacturing Innovation' due to minimizing manufacturing waste and the number of parts/components. This gave the designer ideas as to where their needed improvement in the other six Okala categories.

5.6.2 Concept Two Reflexive Evaluation

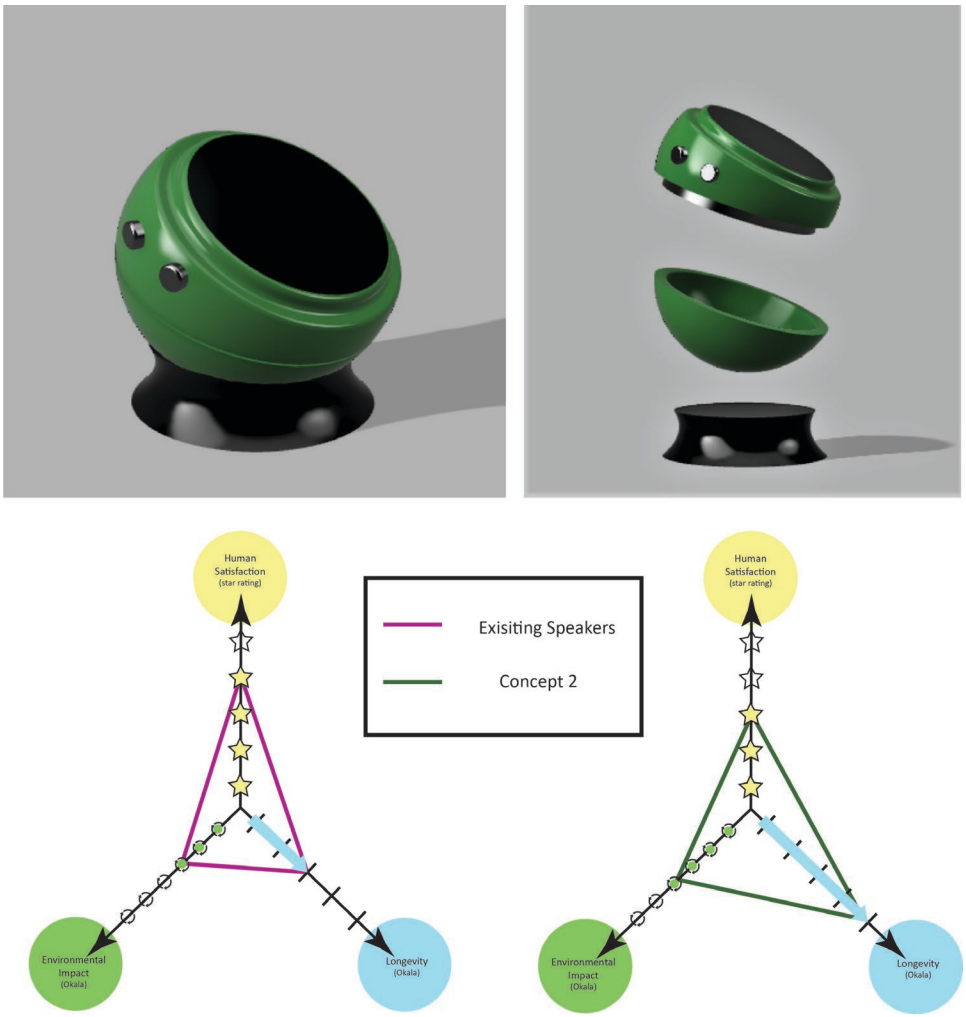


Figure 5.18 Concept 2 Reflexive Evaluation

Concept 2 was intended to focus on longevity. Figure 5.18 shows a comparison of the existing speaker analysis (left) from Step 1 to this concept (right). When reviewing concept 2 with the user groups, the designer found that this speaker accomplished the task at hand, provided adequate customer understanding, and even evoked positive emotions due to its friendly form. However, the user group felt as though the design

would not engage them consistently and did not exceed their initial expectations. The product was rated three stars in human satisfaction.

Where this concept truly exceeded was the longevity leg of the Golden Pyramid. Concept 2 has a built-in goal for the product to be used long-term due to its ease of disassembly and repair. The product has the potential to last until absolute obsolescence (refer to Figure 2.1) because it uses no adhesives which allows the user to replace the battery and internal components within the existing body of the speaker. It is durable and upgradable, while also having a timeless look. The product still would not have the ability for second life, so the designer considered that moving forward to the finalized concept.

When considering the environmental impact leg of the pyramid the designer gave the concept four loops filled for the Okala strategies that were met. 'Manufacturing Innovation' was considered due to the product's minimal number of manufacturing steps as well as number of components/materials. 'Reduced Distribution Impacts' features strategies such as reducing product and packaging volume as well as the body being a reusable packaging system. The concept's ability to reuse componentry meets the suggestions placed within 'Transitional Systems'. Lastly, the design's quick manual disassembly ensure that the 'End-of-Life' will be optimized for further use over the product's lifetime.

5.6.3 Concept Three Reflexive Evaluation

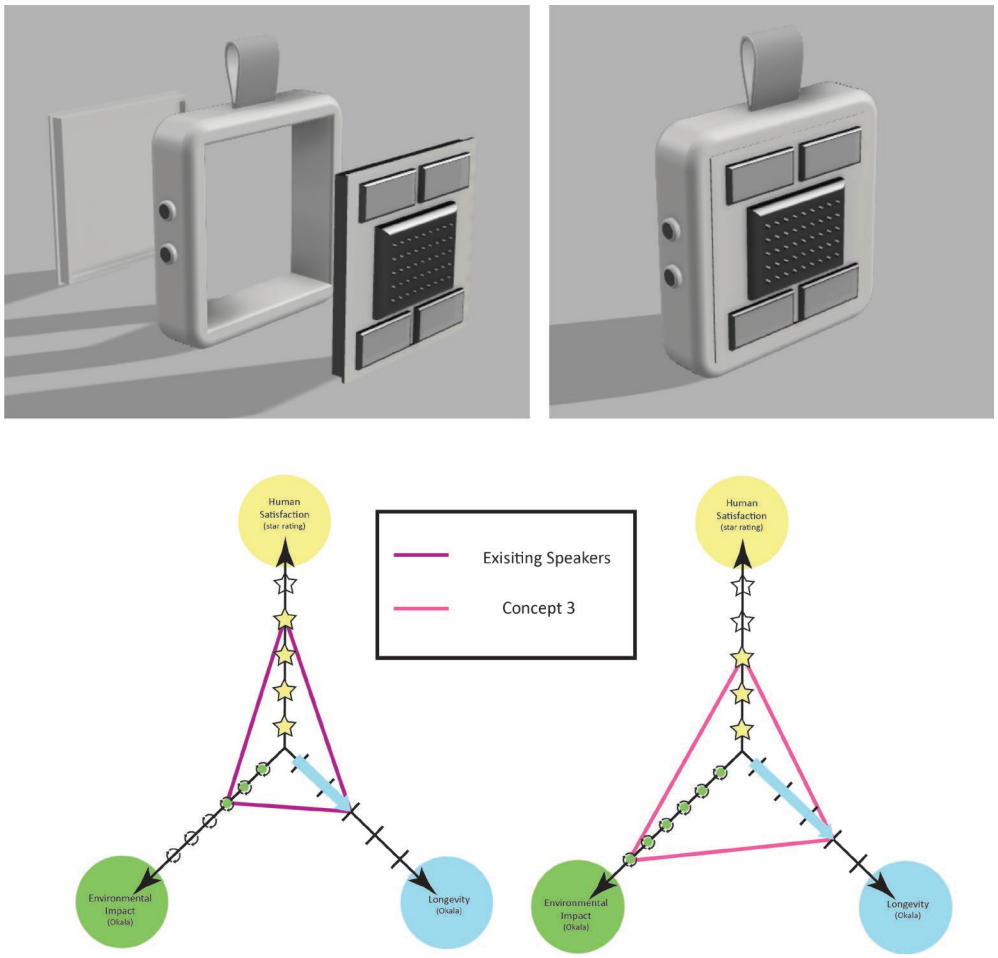


Figure 5.19 Concept 3 Reflexive Evaluation

Concept 3 was intended to focus on environmental impact. Figure 5.19 shows a comparison of the existing speaker analysis (left) from Step 1 to this concept (right).

The user groups rated Concept 3 with only three stars in human satisfaction because they felt as though the product accomplished the task at hand and provides understanding but limited their desire to engage with the product consistently. It also did not satisfy them in terms of form and features with the result of no positive emotion being evoked. Although, considering the product can charge without a charger due to

the solar panel, they felt as though the concept exceeded their expectations in this capacity. The designer considered holding on to the solar panel feature for the final concept.

The longevity leg of the Golden Pyramid hit 4/5 notches. Like Concept 2 the product had an ease of disassembly and the right to repair. This gave the concept a built-in desire to care for the product long-term as well as the ability to have upgrades and take-back programs and for reuse and recyclability. The form allowed for the product to have durability due to the sturdy external body containing filleted corners. Because the user groups lacked evoking positive emotions from initial analyzation, the designer did not give this concept credit for having a timeless look or fashion.

This concept was generated to meet every step of the six Okala Strategy suggestions to provide less environmental impact. This concept is manufactured from Gomi Designs 100% recycled plastic (Meades, 2015). This plastic is created from discarded, post-use plastics that are usually non degradable and are the main cause of Earth's waste problem and transformed into a new recycled material. This means the designer considered the 'Reduced Material Impacts' (using recycled or reclaimed materials), 'Manufacturing Innovation' (minimizing number of components/materials), 'Reduced Distribution Impacts' (develop reusable packaging systems), 'Reduced Use Impacts' (design for carbon-neutral or renewable energy), 'Transitional Systems' (design for reuse of components), and 'Optimized End-of-Life' (design recycling business model).

5.6.4 Comparison of Three Concepts

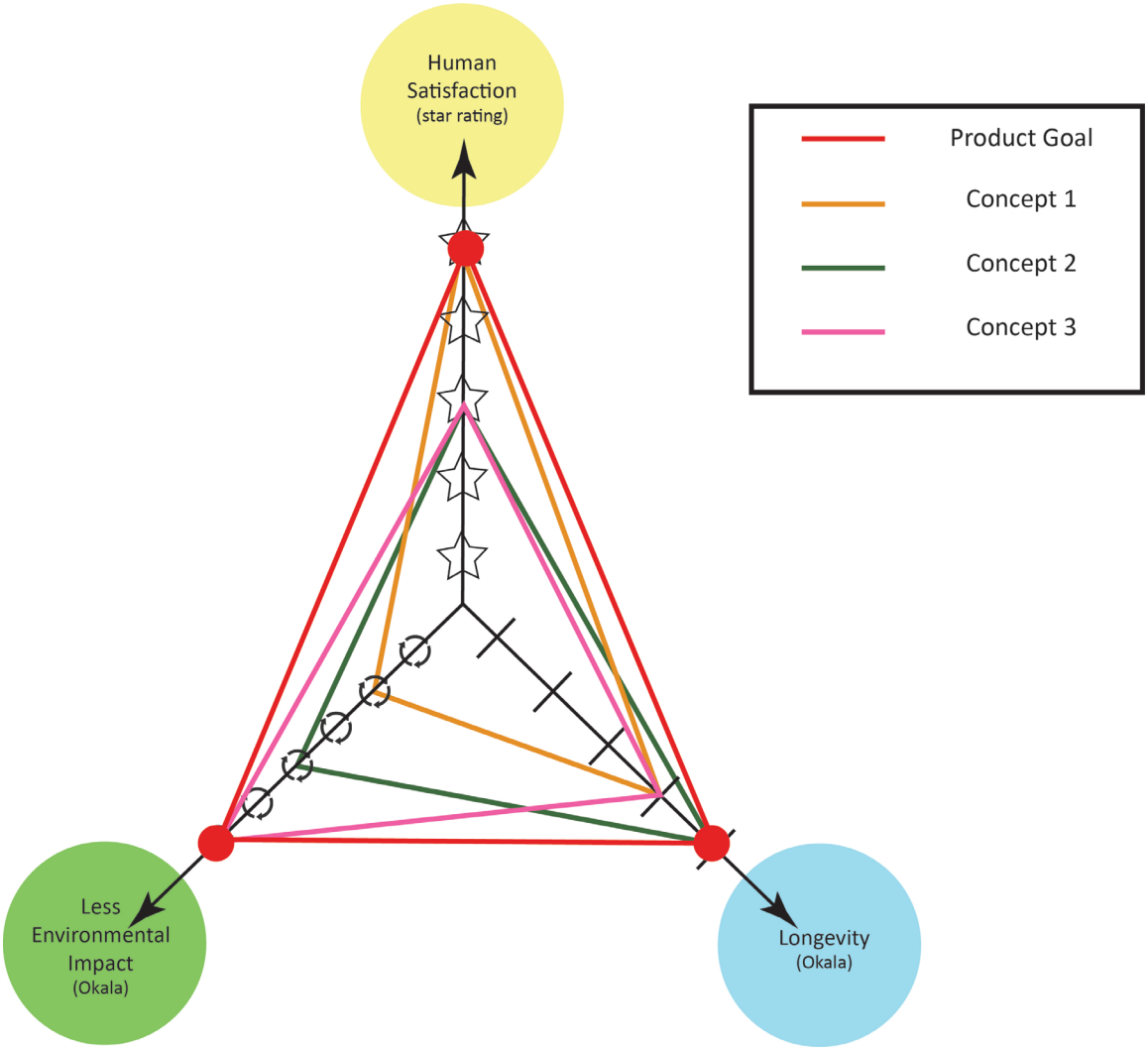


Figure 5.20 Final Speaker Concept Comparison

When reflecting over all three concepts we can see not one reached the goal to the full extent, but each one had an impact on a specific leg of the pyramid. Considering the reflexive evaluation can be done at any stage of the design process, the designer analyzed each concept with only the development of CAD models. This was done for the purpose of this thesis, but the Golden Pyramid evaluation should be continual all the way through prototyping and manufacturing phase to ensure that the product meets

the potential of the three triads. Considering much of the evaluation is subjective to the designer, evaluating periodically in the design's development will provide the designer with a more objective understanding as to if the product meets the potential of all three goals.

Concept 1 had the highest human satisfaction because it exceeded the needs of the intended user as well as the other five satisfactory goals. However, due to the complications of manufacturing it fails to meet each step of the Okala Strategy Wheel making it fall short on environmental impact. Due to the ability to replace modules, the longevity increased, but due to its organic form it would have difficulty for upgrades.

The designer met the expectations of longevity in Concept 2 that Concept 1 failed to meet by being made with a spherical form allowing it to be upgradeable in the future. The product can be entirely disassembled allowing the user to replace the internal components as they fail. This ensures that the product can last if its durability allows it. Due to material choices, the product failed to meet all the expectations of the Okala Strategy Wheel but did improve by one notch because of its modularization.

Concept 3, being entirely recyclable, eliminating plastic waste, and seeming to have the ability to be charged from natural resources, meets all the steps of the Okala Strategy Wheel. The environmental impact goal was met. The product is made from three different parts which enables the ability for modularization. With its ability to charge without a power cord, the human satisfaction results in three stars.

Following this reflection, the designer has the choice to improve their product by combining features of each concept to help reach their intended goals, or they can

select the best one to pursue for manufacturing. This step is not meant to end conceptualizing. It is intended to help the designer to move forward with their designs knowing where they need to improve. With the goal always being set at a high standard, the designer can continually research and find solutions as to how to reach the ultimate Golden Pyramid goal.

5.6.5 Action on Reflection – Final Concept

The designer then made a final revised concept that included significant features from each of the three concepts. Through initial sketching, the designer found a way to simplify disassembly and give the right-to-repair to the user. In the sketches below, one can see that the suction cup feature (Concepts 1 & 2), screw-on assembly (Concept 2), and the usage of Gomi Designs Plastic (Concept 3) were considered for further development (see Figure 5.21).

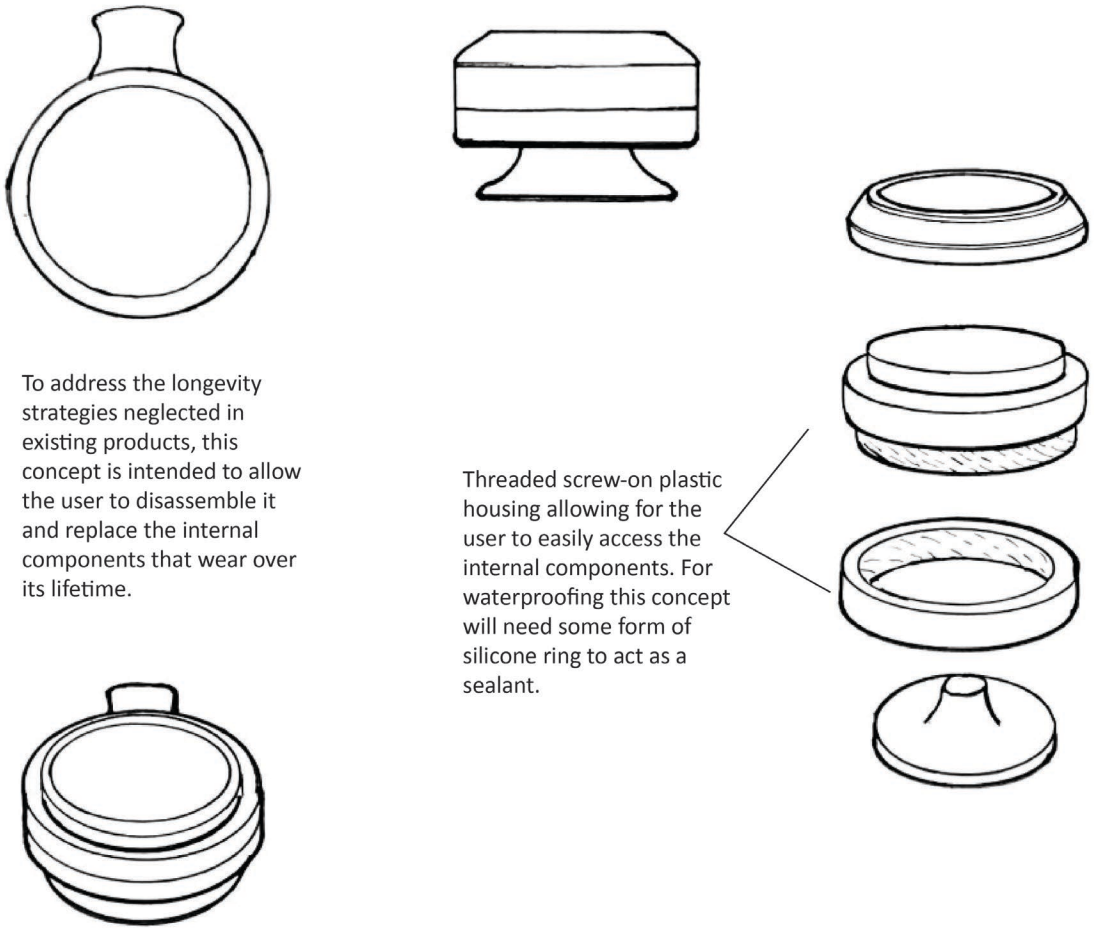


Figure 5.21 Final Revised Concept Sketches

This concept is intended to reach the initial goal of maximizing the potential of each leg on the Golden Pyramid. Further CAD development helped the designer reach all the intended needs of the product and user (see Figure 5.22).

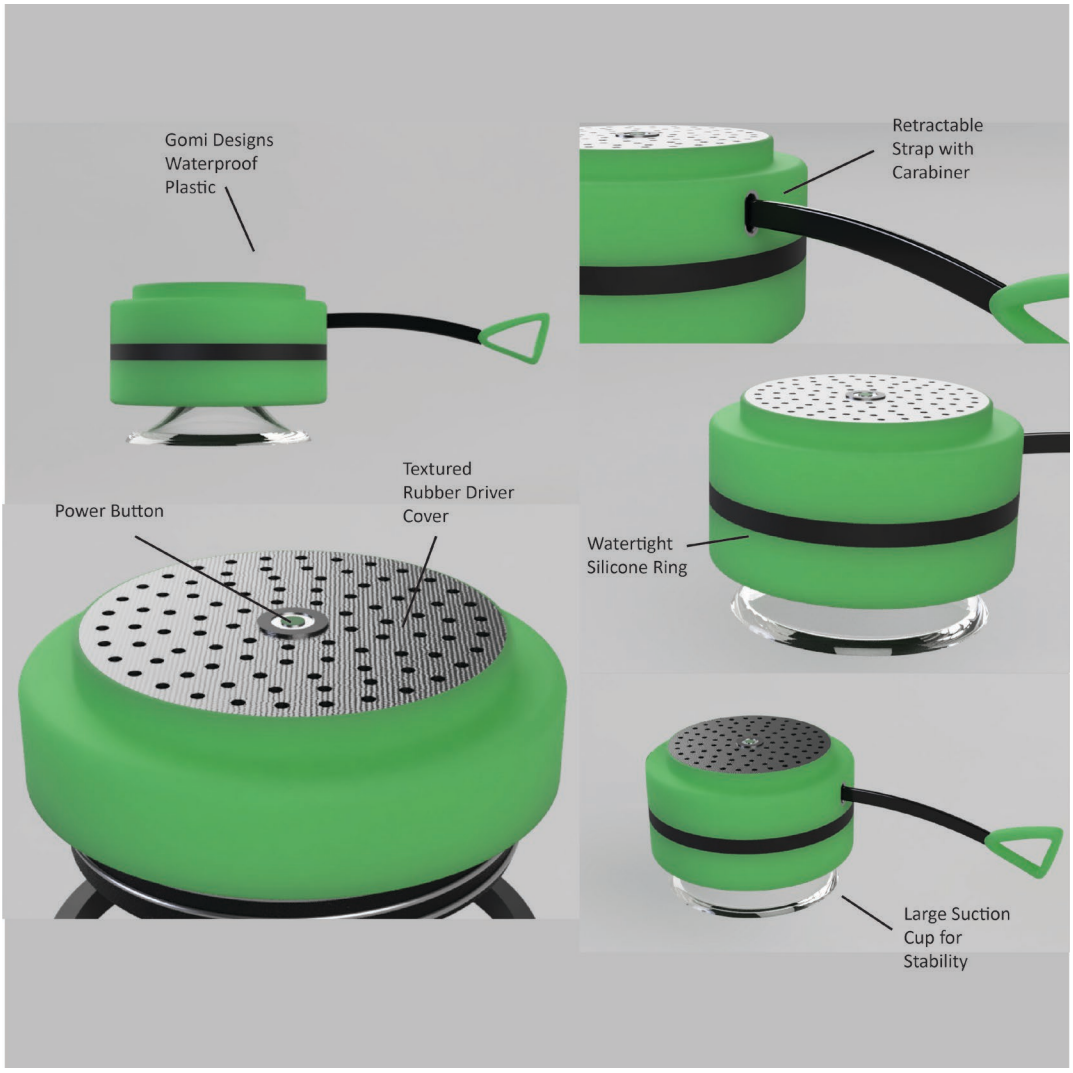


Figure 5.22 Final Revised Concept Callouts

The features include a retractable strap and voice recognition that helped Concept 1 (Figure 5.13) maximize human satisfaction due to the desires of the people in the design interview (refer to 5.2.2). Features from Concept 2 (Figure 5.14), the device's ability to be disassembled and repaired, were included into this concept to maximize its

longevity. This speaker is intended to minimize environmental impact by using Gomi Designs plastic which was a significant feature in Concept 3 (Figure 5.15). The solar panel charging was removed due to the impracticalities. The solar panel would be too small to supply a sufficient source of energy.

The internals would be incorporated into the main body of the product. This threaded plastic housing is a feature that is included to house all of the products needs/requirements (internal components) associated with Step 3 (4.3.1). These could all be replaced if they wear down before the outer components have reached their absolute obsolescence. The waterproofing of this device is provided by a silicone ring which acts a sealant when the main housing parts are screwed together. Considering this device would consistently be sprayed from all angles and have the possibility of being submerged for seconds at a time, the speaker would need to have a water-resistance rating of IPX6 and IPX7. IPX6 ensures that the device can resist high pressure and sprays from all directions, while IPX7 refers to the device being able to be submerged up to 1m for 30 minutes (Gniazdo, 2021). These requirements point to the need for a physical prototype if the design moves forward.

Figure 5.23 Speaker In-Context Photo

This design shown in use in Figure 5.23 is intended to illustrate how the reflexive evaluation can inform new conceptual solutions. This concept was formed through the combination of observed/expected user behavior and designer's opinion about ways to maximize human satisfaction, the Okala Strategy Wheel allowing for minimal environmental impact and energy consumption, and the user's right to repair allowing for the product's potential longevity. Although this is the final concept within this document, this design has more opportunities for improvement. As more concepts are generated and the design evolves, it is possible to define more objective criteria.

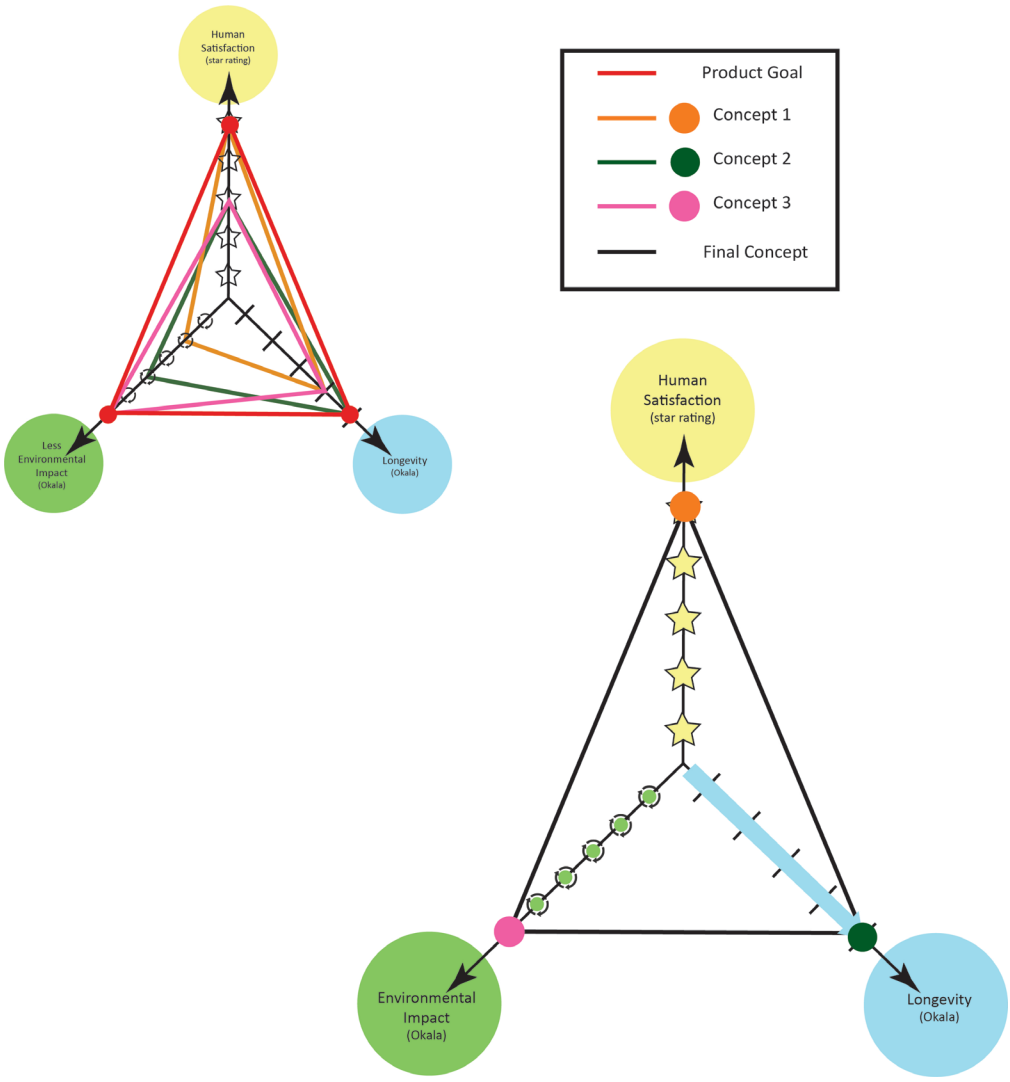


Figure 5.24 Final Concept Golden Pyramid Evaluation

The final concept incorporated the best legs from each of the three concept evaluations (shown above in Figure 5.24). Concept 1 (in orange) evoked positive emotions, provided customer understanding, engaged the user consistently, helped accomplish the task at hand, and exceeded the user's desire and expectations. Concept 2 (in dark green) had a built-in desire to care for it long-term, built-in durability, design for easy maintenance and repair, design for upgrades, and a timeless look or fashion. Concept 3 (in pink) reduced material impacts (using recycled or reused material),

included manufacturing innovation (minimizing the number of components), reduced distribution impacts (reduced product and packaging weight), reduced behavior and use impacts (design to encourage low-consumption user behavior), incorporated transitional systems (design for reuse of components), and optimized end-of-life (design using recyclable non-toxic materials).

6 Conclusion

Sustainability must be the future of design considerations to ensure the safety of our planet. The lack of it is an issue that can only be fixed one step at a time. The first step is engraining designers with the awareness of sustainable design practices and forming a thought process that moves away from unsustainable solutions. This guideline presents and recommends a process towards creating sustainable products with an extended lifetime. The longer products last, the longer they stay out of the waste stream that is harming Earth.

Creating products with longevity includes developing empathy with the users to have a deeper understanding of their behaviors and needs. Developing such an emotional connection between user and product will help the product be utilized longer and to its potential. Emotional durability is composed of authenticity and dependency. Products that truly satisfy and meet and exceed the expectations of the user will have a large impact on decreasing the rate of products being discarded before their life potential. The range of conscious choices made by the designer using this approach can have a variety of different impacts the product has on society.

To create sustainable products, designers should also consider modularization to guarantee the main component(s) of the product can last. Instead of designing many discrete parts, the designer should think about how the individual pieces could be componentized. This will allow the user to replace one component as needed as opposed to replacing the entire product. As learned in the Quip case study (refer to 3.4),

the designers found the toothbrush head could be replaced without the entire body being discarded. This is a great example of how product designers can consider componentizing their product as a sustainable solution.

In addition to prolonging individual products, the designer also has the responsibility for promoting a healthier environment. Throughout the design steps within this approach, the Golden Pyramid should be considered to meet the designer's environmental responsibilities. This approach is a way of gauging concepts by comparing them to existing products in the market during the product design process. Even if only incrementally, the designer should strive to create sustainable, long-lasting, dependable products that minimize negative environmental impact while still maximizing human satisfaction. This pyramid provides a sustainable foundation for future product development. The Golden Pyramid evaluation can also be used within any design process (without the six steps of this guideline) as more of a general consideration for design concepts going forward.

6.1 Moving Forward with Golden Pyramid

A primary goal of this design guideline is for products to be designed with compassion towards the user and environment, helping make the world cleaner and people's lives better. It is hoped that designers will begin to see the influence they have regarding damage to the environment and be more conscious of decisions and solutions they develop. This pyramid will help them progressively make products that satisfy the user more while harming the environment less, even if in modest steps.

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