Tsung-Yu Shih, hereby submit this original work as part of the requirements for the degree of Master of Design in Design.

It is entitled:
Customization
A Viable Strategy of Sustainable design for E-Product

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Customization

A Viable Strategy of Sustainable design for E-Product

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Abstract

In mass production, customization has been employed by device providers to allow customers to design products that they desire. By accommodating customer’s needs and wants, brands are supported and emotional bonds between customers and products are enhanced. Products that customer’s perceive as unique to their personal needs, create strong bonds with customers and instill brand loyalty. The purpose of this paper is to examine a strategy to help reduce this problem by extending the life of cellular phones in particular through the strategy of customization. This paper proposes specific principles for customization of cellular devices and then attempts to test those through a survey to determine viability of those principles.
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CH.1 Introduction

“If brute force doesn't solve your problems then you aren't using enough.”—American idiom.

1.1 The E-Waste Problem

It is undeniable that the waste created by the electronics industry is a particularly difficult problem. The waste from cell phones, computers, and televisions (E-Waste), is not only voluminous, but also very toxic. The disposal of these products has been largely exported to lands far away and become a serious environmental problem for those unfortunate enough to live there.

In considering the world of cellular devices and mobile phones, it is apparent that the following observations are true:

A. Most cellular devices are designed to appeal to a broad market, i.e. they are not designed for a particular target market and try to be all things to all people, even though many customers may not need all the functions they offer.
B. Most cellular devices are designed to last only a few years, playing into the changing desires of fashion.¹

C. Typically they are not easy to maintain and difficult to recycle.

D. Mobile phones are the most popular electronic product in the world. Most people in modern society have at least one of them. There are around 5.9 billion mobile service subscribers in the world², equaling to 87% of the world’s population.

E. In the mobile phone market, product comparison for consumers has become difficult and frustrating. Even though choices are somewhat limited compared to other markets, the specifications and features can be confusing, often resulting in customers paying for features they may not understand or utilize. They may not really have a good understanding of what they have purchased. They often purchase a device with extra unnecessary functions and spend extra money. This increases price and material waste, and is ultimately harmful to us all.

1.2 A Resource Issue

Ten percent of the world’s population controls ninety percent of world resources, according to the World Bank (2008)\(^3\). Most of the resources we have used are in the landfill now. In 2009 Americans generated about 243 million tons of trash, and 54.3% ended up in landfills. In 2010, the percentage increased to 65.9\%.\(^4\) This alarming increase points to the serious nature of the problem. We produce 25 million tons of expensive, short-lived and toxic electronics trash (E-waste) a year.\(^5\)

The main purpose in this thesis is to examine a strategy to reduce this huge problem of electronic waste. How can we increase a customers desire to own a phone longer, extend a product’s useful life, and keep it out of the waste stream, especially landfills.

In mass production, customization has been employed by device providers to allow customers to


design products that they desire. By accommodating customer’s needs and wants, brands are supported and emotional bonds between customers and products are enhanced. Products that customer’s perceive as unique to their personal needs, create strong bonds with customers and instill brand loyalty. The purpose of this paper is to examine a strategy to help reduce this problem by extending the life of cellular phones in particular through the strategy of customization. This paper proposes specific principles for customization of cellular devices and then attempts to test those through a survey to determine viability of those principles.

1.3 Is Customization a Natural Solution?

One might consider that a product offering customization would be more sustainable. A suitable and affordable product designed for all kinds of customers needs, that can also grow to fit evolving customers needs will have a longer product life. The customer is not compelled to purchase new device as often. As customers become more aware of the harmful glut of e-waste in our landfills, it is also natural to conclude that this product would be more desirable in the marketplace in that it would stay out of the waste-stream and have a longer useful life.

A sustainable strategy that is widely accepted is bio-mimicry. In mimicking nature, which does
not create waste and takes only what it needs, prolonging a product’s useful life pursues that goal.

In David W. ORR’s book, “The Nature of Design,” the first of eight ecological design principles is to honestly determine whether we need the product in the first place”6. This aligns with the natural principle of taking only what we need.

This amazing picture was taken by Michel Denis-Huot while he was on a safari trip in Kenya’s Masai in October, 2010. “These three brothers (cheetahs) have been living together since they left their mother at about 18 months old,” he said. “On the morning

we saw them, they seemed to not be hungry ... -Walking quickly, but stopping at times to play together. At one point, they met a group of impala. They all ran away except one youngster who was not quick enough and the brothers caught it easily. They just walked away without hurting him.

Mimicking nature and taking only what we need is widely accepted as a principle in Permaculture and Slow Design. This is critical to reducing unnecessary waste. The ability to select services that specifically match individuals’ situations (customization of services), is also a powerful strategy to reduce waste. In addition, matching our resource use to basic needs instead of excess, being responsible with our products and managing our resources, is the only way to protect the circle of life on earth.

In considering customization as a strategy for meeting customer needs, the opposite of that idea is the long accepted manufacturing strategy of standardization. Five levels of this spectrum are suggested by Lampel and Mintzberg (1996): pure standardization, segmented standardization, customized standardization, tailored customization, and pure customization. From the level of customized standardization, an important idea, modularization, is highlighted because it offers an easier way to upgrade, downgrade and maintain the product. A modular design can facilitate these functions and help to match customers’ needs. In both segmented standardization (level 2) and customized standardization (level 3), customization of electronics (especially computers and laptops) focuses on performance and styles. For example, when buying a laptop, customers choose one model among all the choices.
exemplifies the segmented standardization level, wherein the basic price, usage and style is
decided by the model provider. Then customers can move to the customized standardization
level, in which they are offered the choice to upgrade the performance, memory, efficiency or
warranty. Only very few modules or services are choices.

Typically cellular devices offer even fewer options. However, if providers could provide higher
level of customization, they might better fit a customer’s needs as they move through different
social-economic stages. This would likely create stronger bonds between customers and their
phones and perhaps encourage them not to discard them as quick?

2.2. A Hierarchy of Needs for the Cellular Phone Customer

Based on the theory “the hierarchy of needs” of Abraham Harold Maslow (A. H. Maslow) in
1940’s9, we can draw a parallel analysis of customers’ needs for electronics. This is proposed as a
tool in helping to analyze customer behavior and will offer some insight as to why customers are
willing to get rid of their phones so readily. In other words, the customer’s hierarchy of needs
offers a foundation to understanding the customer cellphone ‘relationship.’ This hierarchy also

serves as the basis of the five customization principles for prolonging the life cycle of cellular
phones that this paper is proposing as guidelines to designers and manufacturers who wish to
extend product life.

2.3 H. Maslow's hierarchy of needs

H. Maslow mentioned five levels
of human's motivation of needs in his
article *A Theory of Human Motivation*
(1943): physiological needs, safety
needs, love/belonging needs,
self-esteem, and self-actualization.  

Zang and Xu, in their article
"Application of Maslow's Hierarchy of
Needs to Modern Chinese Furniture," translated each level of needs into design principles for

---

products. The hierarchy is now adapted to include product attributes which are:

provides basic functions, is safe and and friendly, provides social connections,

enhances quality of life, and appeals to higher values feeling (Figure 2.)

2.4. A Product’s Value to a Customer Changes over Time

For a customer, their interaction with a product happens in definable stages in which their needs are being met differently, affecting their value of the product. The five stages are shown on the figure below. The first is the purchase of the product, which usually involves the customer perception that the product meets his highest level of needs. In the next three stages, Starting Use, Use, and Decline of Use, correspond with the needs level also

Figure 2. A.H. Maslow’s hierarchy of needs in Design

11 Han Ning Zhang and Ji Feng Xu, ”Application of Maslow's Hierarchy of Needs to Modern Chinese Furniture,” Applied Mechanics and Materials 37-38 (2010): pg. 188
diminishing. When the most basic needs of the customer are not being met, he begins to withdraw from the product and dumps it.

2.4.1. Product’s Emotional Value to customer Decreases Naturally

Two main factors likely cause this decline in value to a customer: first, users’ needs are evolving or changing; second, the meaning of the product or the functions of the product have declined.

When a product’s value becomes too low to satisfy a user, dumping occurs. When a product’s value is decreased or gone, it will be dumped immediately (Figure 3). The factors are hard to
define in this pattern, but we can still infer that some emotional reasons (like colors, styles, functions, or perceptions) would be factors.

2.4.2. Product is Damaged, Broken or Dies

When a cell phone is damaged, broken or lost, even if the user error is to blame, the impact on the perception of value is huge. Most companies provide one or two year warranties on their product to protect customers, and also repair products to prolong the product life. However, there are still some products that are designed to be un-repairable, such as Sears’ power tools,
to increase company profits. The customers accept this in products because the companies make sure it is cheaper to replace than to buy a new one. Many companies also design their warranties to promote replacement over repair.

2.4.3. Planned Obsolescence

Planned obsolescence has been an intentional strategy for many years, and is in fact a big part of our consumerist culture. One can argue that the profession of Industrial Design was

Figure 5. Planned Obsolescence
founded upon the ability to create consumer desire for the new and disdain of the outdated. The fashion industry has perfected this concept and institutionalized it. The appearance of the latest and greatest in the marketplace often results in products being dumped long before their functional value has decreased. One could argue that the customers emotional needs stop being met by the old product and dumping is immediate (figure 5). In Japan, the current lifespan of a cellphone is six months.

2.4.4. New Technologies Decrease Value of Existing Technologies
When new technologies emerge in a product, product replacement occurs, sometimes on a
grand scale, which is then referred to as a disruptive technology. For example, when the LCD
(Liquid-Crystal Display) television was introduced to the market, the whole television system was
disrupted and completely changed. The CRT (cathode ray tube) television was immediately
relegated to the trash heap, especially when the broadcasting systems were also updated to
digital technologies. Even though in some countries analog signals is still provided and the CRT
television still occupy the major part of the TV market, the global LCD system shares 83.1% of
the market, and the CRT system is 10.2%\textsuperscript{12}. The previous television system is almost completely
replaced by newer technologies.

\textsuperscript{12} NPD Group, "LCD TV Shipments Rebound Ahead of 2011 Holiday Selling Period - DisplaySearch," DisplaySearch Is the
2.4.5. Becoming antique restores products' values

Some products’ values will increase after years and become (so called) antiques. Take cameras as an example (Figure 7), the Nikon FM2, the old-styled film cameras’ values increase after 20 years. The users nowadays might be different from those 20 years ago and the meaning of the values may also change to include nostalgia or reverence for the quality and materiality of the past. In this case, the value moves from photographers to collectors. Time, social environment, economy or culture changes are factors.
For most products, their one basic function, reflect the products’ basic value. Some argue that the older analog systems have qualities not met in the new digital versions. This is usually related to the value of the product as an antique or collectable. The short product lives of our E-products nowadays make it hard to imagine them as moving into the realm of valued antique.

2.4.6. Trading into another market restores products’ value

Figure 8. Trading into another market restores products’ value
When a customer purchases a newer and higher-valued product, while the previous device/product still has some kind of value, the older product might be transferred to the used-product market. This second use scenario can often create some new profit opportunities for both sellers and buyers and also serves to extend product life.

Although the signal service is not well developed in many poor areas, many low-income people still want to save their money for fancy phones, even if they are second hand.\(^{13}\)

### 2.5. Six Design Principles for Customization

Informed by the patterns of product-value changes illustrated in the diagrams above, a table of design principles to prolong a products’ life cycle is proposed below. These principles are proposed specifically for application to mobile phone design. They also correlate to the five levels of customization referred to in section 2.1.

\(^{13}\) For instance, smuggling the used iPhones to Vietnam is a common discussion topic online. According to the author’s experience, Vietnamese love fancy mobile phones and that is the symbol of showing individuals’ social status. Most Vietnamese buy fancy smart phones for appreciating, not for the service it provides. Same issue is also discovered in China.
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<th>Design Principles</th>
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<td>Design for Tailored Customization</td>
<td>Create emotional bonds between customers and products, unique to each customer</td>
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<tr>
<td>2 Product is Damaged, Broken or Dies</td>
<td>Design for Modularity</td>
<td>Provide easy Maintenance and Repair-ability for customer</td>
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<tr>
<td>3 Planned Obsolescence</td>
<td>Design for Upgrade-ability or Downgrade-ability</td>
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<tr>
<td>6 Trade in to another market can recreate products’ values</td>
<td>Design for Reusability, Interchangeability and Flexibility</td>
<td>Employs modularity and standardization for refurbishment and repair</td>
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Chart1. The six design principles of customization

In the next chapter, we test these design principles. The testing goal is to learn about the customers’ acceptance level of a product designed by following these design principles, and subsequently, the customers’ willingness to keep and use that product for a longer period.
CH.3 Testing and Outcome

3.1 Testing Methods

To test the design principles outlined in section 2.5, the first step was to design a mobile phone based on those principles. The phone concept was modeled in a 3D program and the details were outlined in two videos. An online survey was created with the videos embedded in it. Respondents reviewed the videos, which were essentially sales brochures with an explanatory voice over, before they responded to the survey questions. The videos attempted to simulate a realistic marketing environment in that they were presented like advertisements. These videos can be viewed at: http://youtu.be/YZdOy6xkxtY and http://youtu.be/Z5x8UaM9Zo.

We identified ourselves as a new mobile provider, the YoDo Company, which has just entered the market with the new YoDo Phone, a more sustainable mobile device. The videos explain our company’s sustainable design goals and explain how our products customization and modularity create value for our customers. Compared with mobile devices currently on the market, our benefit is that customers can customize their own devices by purchasing different modules and
inserting them at home. Each module has discreet functions, each one providing only one subset of functions in the whole product, such as the CPU, the power module, the camera, the screen, etc. The device can be upgraded or downgraded after the customers’ purchase. Hence, customers do not need another product until the next disruptive technology occurs in the future. This highly customizable device can fit customers’ needs in their different social-economic stages. Users can return their used modules and purchase new ones at a cheaper price. When a module has to be discarded, it can be easily returned to the manufacturer for refurbishment and secondary sale, or recycled to reclaim technical nutrients. This also aids in disassembly and reclamation of materials. The recycle rate can be increased because materials in one single module are simpler than a whole cell phone.

Our company is willing to accept customers’ returns because we can resell used but workable modules again to other markets at reduced prices. This action not only satisfies needs of people of lower social-economic strata in poor countries, but also creates additional profit for our company.
3.2. The Proposed Mobile Phone Concept used in Testing

A new mobile phone was designed to follow the six design principles outlined above in order to facilitate testing of those principles, and acceptability of customization levels to selected markets.

The image below reflects the idea of tailored customization.
A. Tailored Customization and Modularity: The modular design shown here allows customers to choose different physical interfaces and functions based on their different needs and budgets. This provides a higher level of customization (tailored customization) to customers. The three-layer design (face, modular board and battery) is contained in a case that can be easily opened by customers and the parts easily accessed for removal or replacement.
B. Upgrade-ability and downgrade-ability: When a customer wants to upgrade the phone, the company only needs to charge him the price gap between old and new modules and depreciation.

C. Simple Maintenance: Each part only participates in a simple function, so each part is not as complex as a regular cell phone, so it can be more easily recycled and be reused by the company. Changing modules is easy enough to be done by most customers.

D. Modules are designed to be easily removed and installed by the customer with out need for any special tools or skills.
E. Design for Reusability, Interchangeability and Flexibility: Each modular phone has another life after it is dumped. The company assumes the responsibility of recycling, refurbishing, and reselling. The company can collect the old modules, refurbish and sell them to another market, such as a used market or a poor country for a cheaper price. This allows every scrap of material to be used repeatedly and keeps more out of the waste stream.
3.3. Testing Procedure

A survey was created to test general acceptance of the proposed design and posted online at Survey Monkey at : (http://www.surveymonkey.com/) and is still available for viewing. The invitations to take the survey were posted on Facebook and these respondents were the first to participate. These people were from all walks of life, different nationalities and demographics and their responses are reflected in the survey results below. As an extension of the initial
testing, eighteen students in Professor Dale Murray's Design Theory class were asked to complete the survey as well. They all went online, viewed the videos, and then responded to the questions. This provided an interesting opportunity for the students to see design research in action, and the discussion that followed was very valuable.

### 3.4. Survey Results: Survey Design and Analysis of Data

The survey is designed with two sections. The first section (from Question 1 to 11) is for understanding respondents' background, including their genders, ages, professional, current cell phone brands, and etc. The second section (from Question 12 to 15) is for obtaining respondents' acceptability of customization.

In this study, we used both qualitative (interview) with quantitative (data) to round out our findings. The first four questions resulted in the following data:

- Total respondents: 42 (24 male, 18 female)
- Respondents who finished the survey: 39
- 23 respondents (54.8%) were between 18 to 25 years old
- 16 respondents (38.1%) were between 26 to 33 years old.
• 3 respondents were over 34 years old.

• 22 respondents were Americans

• 2 respondents were living outside USA when taking the survey.

In the following data analysis, we calculated average and standard deviation for questions 12, 13 and 15, because these involved five level answers reflecting agreement or disagreement. In calculating the average, strongly agree is 5 points, somewhat agree is 4 points, neutral is 3 points, somewhat disagree is 2 points, and strongly disagree is 1 point. Averages larger than 3 are positive, and averages less than 3 are negative. The basic average of the agreement values reflects the general feeling about the concepts, but it was felt that standard deviation calculations would provide more understanding of how strongly they felt. The figures created to reflect this data use standard graphing techniques in which the position of the point reflects the average of the answers, but also includes a dot pattern interpretation around each point that reflects Standard Deviation values. The larger the standard deviation value, the more concentrated the dot pattern around the point appears. Since standard deviation is used to understand the “strangeness” of an answer, it was felt that this form of analysis would offer some level of understanding about the acceptance of the customization and modularity
concepts. When the standard deviation is higher, answers to the 5-levels-agreement questions are more uneven and diverse, so the ‘strangeness’ is stronger.

In the following Figure 9 and Figure 10, the position of the points on the graph represents the rating average. Higher position represents more positive result (agree), and lower position represents negative (disagree). The middle lines in the figures represent rating average 3, completely neutral. The gray dot patterns represent the standard deviations. Smaller and darker dots represent higher standard deviations (stronger); the bigger and lighter dots represent the lower standard deviations (weaker).

Quotations from the respondents online, and from the design students, reflecting general comments and opinions, are shown after the following tables.

In the second section, five questions were presented:

*Note: Survey respondents were notified of this special consideration: “this survey is intended to evaluate the new concepts in function and service only. Please do not base your answers on the aesthetic appeal of the proposed concept models in the videos.” This was included to encourage respondents to only consider the concepts of customization and modularity.*
3.4.1 Question 12: “This product is attractive to me because...”

This question is attempting to determine the validity of the six design principles on customization. The six questions each test one different design principle and are configured for five-level-agreement-scale responses. The goal of each question is to verify the strength of each design principle when applied to product design. The six design principles are:

A. Design for Tailored Customization

   Example positive answer: “I expect to love this phone's unique features.”

B. Design for Modularity

   Example positive answer: “I expect to maintain it more easily than my current phone.”

C. Design for Upgrade-ability or Downgrade-ability

   Example positive answer: “I expect to easily upgrade or downgrade its functions”

D. Employ Materials that can be Retained in a Cyclic System

   Example positive answer: “The materials in the product are very durable.”

E. Design for Simple Maintenance

   Example positive answer: “If it breaks, I expect I can easily get it fixed.”
F. Design for Reusability, Interchangeability and Flexibility

Example positive answer: “I expect it to have a longer product life.”

The Data Analysis of the six questions are graphed below:

The average rating average is 3.78, and standard deviation is 6.72.

Five findings can be drawn from this data:

A. All the results in this test are positive, but 2 of them (modularity / lifespan and durability)
are closer to neutral (average is lower than 3.5). None of the principles are close to strongly agree. The last point on the graph represents the overall average and average deviation.

B. All six design principles are suggested for prolonging product life, but the average is only close to "somewhat agree". This means that extending product life may not become a significant market strategy to attract customers, but can help promote the value of the product. Aesthetic appeal is an unavoidable emotional factor for customers. We tried to avoid this in our survey with a disclaimer, but respondents still reacted to the aesthetic appeal in judging the concept. According to the interview, respondents agreed that their biggest concern is still form, which affects their first impression of a mobile phone. It might be expected that this is especially true of the design students because of their sensitivity to aesthetics (average is 3.83), but in analyzing the results, non-designers were almost equally motivated by aesthetics and form (average is 3.65).

C. The appeal of modularity is unexpectedly very weak, which means that this design principle is not significant enough to insure product acceptance or longer life. This may
be caused by A) greater differences in users' opinions shown by very low value of standard deviation, B) other unknown factors affect the result or C) unclear survey questions. In the interview, students recommended that the modular design should be simplified so that customers can understand it more easily.

D. In the interview, many students responded that this concept is too difficult to imagine. Such a radically different configuration is too unfamiliar. They would rather stay with their present model than jump into new one that is so different. It exceeds the acceptability factor for new technology. There are several possible causes for this response: A) Customers are thoroughly immersed in the current business model due to conditioning by cell phone providers, B) The modularity needs to be well explained and promoted through marketing techniques that help customers to understand the new system, otherwise this product would be too complex for customers, C) Even though our mobile phone concept images were designed purely for demonstrating the customization concept, some students still expressed doubts about the ability to engineer and build the modular concept.
3.4.2 Question 13: “Please compare this customizable phone with your current phone. This YoDo Phone is attractive to me because....”

This question is attempting to assess the respondents’ emotional agreement with this concept, and establishing future design guidelines for customizable mobile phones. Each of the five responses is suggesting different possibilities and benefits for customers. Respondents are asked to rate their acceptance of this new product through the five-level –agreement format.

The five responses which require rating by the test subjects are:

A. It offers me more choices (than my current phone).
B. It addresses frustrations I have (with my current phone)
C. It is more cost effective and affordable (than my current phone)
D. It will serve my needs better (than my current phone)
E. I would keep it for a longer time (than my current phone)

Data Analysis: The average rating average is 3.48, standard deviation is 6.36.
Four findings can be drawn from this data:

A. Even though the data shows that all responses are positive, the average respondents are not excited about this new concept. No dramatically positive response occurred. The highest average is 3.67, the lowest average is 3.23, all the results are located between somewhat agree and neutral.

B. Two results (it offers me more choices and I would keep it for a longer time) are shown...
more positive than the other three results (the average are higher than 3.5); however, the standard deviation is lower than the average (6.36.) This result shows that respondents may not be clear about the information they received about the design concept, or may not fully understand these two questions.

C. The responses for “it is more cost effective and affordable” has the lowest standard deviation (5.64). Some respondents mentioned that A) they do not really know their cost because their family paid for them, or B) they simply do not believe this phone can be cost effective if no clear price is shown. One respondent stated that buying four cell phones in eight years might be cheaper than using YoDo phone, which cannot be verified one way or the other.

D. In the responses for “it will serve my needs better,” some students noted that they are confused by this new system. They were concerned about how they might choose their modules, and noted that many of their needs might emerge after they experienced the phones for a while. A proven service system would be required to build their faith in this new idea.
E. Some students in the interview were of the opinion that older more established customers might have stronger motivation for using a customizable mobile phone. Younger people, especially teenagers, may be less likely to care about the length of the product life and may be more likely to damage or lose the phone.

3.4.3 Question 14: “When this product is more expensive than comparable products, but can be used four times longer, what is the maximal percentage of difference you would be willing to pay when you just purchase it? Please compare with your current phone (not including your monthly payment.)”

This question is basically asking respondents’ to compare the value of their current phone with the expected value of this new product. This data may have value for the YoDo Phone Company in helping to determine the companies’ future needs, in feasibility assessment and in cost control.

The possible responses are:

A. I would expect to pay less.

B. I would expect to pay the same.
C. I would pay 10% more
D. I would pay 20% more
E. I would pay 30% more
F. I would pay 50% more
G. I would pay 100% more

Data Analysis: 44% of respondents would expect to pay less or the same, 56% of respondents willing to pay more for this product.

The average of this question is 3.42 (when “I would expect to pay less” is 1, I would pay 100%
This result is located between 10% and 20% more, approximately 15%. However, the standard deviation (3.55) of this question shows that testing samples are not certain with increasing price. Most people (34.2%) expect to pay the same price they have now, and almost half (44.7%) of respondents hope the price increase would not happen.

3.4.4 Question 15: “Would you like to use this new product as your next mobile phone?”

This question is simply asking the testing samples' purchase intentions of this new concept. Five-levels agreements are used as answers in this question.

![Pie chart showing distribution of responses to Question 15]

The rating average of this question is 3.37, and standard deviation is 6.43. Even with over half
of respondents (55.26%) showing their agreement with the customizable mobile phone, the rating average shows that the purchase intention is still close to neutral. Most respondents have optimistic expectations with this product, but uncertainties are also shown with this concept until the real product can be seen.

3.5. Outcome

3.5.1 Measurement Errors

One interesting result is discovered from the survey design. Fewer measurement errors would occur if we only asked respondents’ whether they agree or disagree with the proposed design principles; but this kind of simple survey offers only vague understanding. Respondents are much less involved and cannot offer more nuanced opinions. Bias is increased when respondents see only dogmatic questions, and can respond only in simplistic answers. This situation was observed in many sustainable design books: authors only provide some clauses as design principles, which limits the audiences understanding of the meaning and application of the principles in applying them to sustainable design practice. The five-level-agreement format was specifically used here to avoid that problem.
In this survey, by creating a sales brochure to mimic the marketing environment, some unexpected information was uncovered in the interview because respondents were more engaged. While this may have increased measurement errors, more insights were gained than in more dogmatic and specific survey formats. In testing design principles, gaining insight is often a more valuable goal than specific numerical values.

Some other factors might have affected respondents’ decisions in choosing answers for the survey: First, this survey aims to understand the customers’ agreements with six design principles as applied to the design of a new phone concept that employs principles of customization and modularity to improve the customers experience, but ultimately to extend the product’s life. Because respondents were not informed about the background theories, they judged the new YoDo Phone based on their aesthetic judgment or engineering knowledge. Second, in order to limit the length of survey, we provided only two one-minute videos, which did not adequately explain the whole idea and created some questions for respondents. According to the interview with the students, the above two factors did not deeply affect their answers. The respondents were unclear on only certain issues with the product itself rather than the background theories. The caveat here is they were in fact participating in a design
theory class, a much different group than random mobile phone customers. Hence the measurement errors occurring on Question 13 (design outcome) are likely more pronounced than Question 12 (the six principles).

3.5.2 Outcome

There are four general conclusions that can be drawn from this survey exercise.

A. The impression of the general public of this new proposed product is positive. They might agree to try it even if the price is slightly higher (under 15% more) than regular mobile phone.

B. Even if a completely customizable phone better fits customers’ needs, shapes and forms may create better bonds between customers and their mobile phone than functions. This means that, for example, a beautiful case can establish a stronger connection than a GPS chip.

C. An intense and informative marketing strategy is required for communicating with customers. Customers might be scared away when they think a product is too complex for them to understand, especially when special skills are required for selecting modules, as in customizing a PC computer desktop.
D. The six design principles for implementing a customizable and modular approach to cell phone design, are viable for creating a new product and its life may be extended, but many other factors may affect its success in the marketplace.
Based on the results of the survey and interview and the analysis of the data, the six proposed design principles have been refined and simplified and three more principles were added. The chart below is the result:

<table>
<thead>
<tr>
<th>Design principles</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design for Tailored Customization</td>
<td>Create emotional bonds between customers and products, unique to each customer</td>
</tr>
<tr>
<td>2 Design for Modularity</td>
<td>Provide easy Maintenance and Repair-ability for customer</td>
</tr>
<tr>
<td>3 Design for Upgrade-ability or Downgrade-ability</td>
<td>Upgradeability or Downgrade-ability to meet changing user needs</td>
</tr>
<tr>
<td>4 Employ Materials that can be Retained in a Cyclic System</td>
<td>Uses Recycled material or material can be recovered for reuse on newer products to save cost</td>
</tr>
<tr>
<td>5 Design for Simple Maintenance</td>
<td>Simple parts that are easier for companies or customers to fix</td>
</tr>
<tr>
<td>6 Design for Reusability, Interchangeability and Flexibility</td>
<td>Employs modularity and standardization for refurbishment and repair</td>
</tr>
<tr>
<td>7 Allow more cost options for customers</td>
<td>Lets customers control their budgeting and attracts more markets.</td>
</tr>
<tr>
<td>8 Provide for changing appearance, adding accessories, and personalization</td>
<td>Enhances customers emotional attachment and extends fashion relevance</td>
</tr>
<tr>
<td>9 Make it Simple to Use and Easy to Understand</td>
<td>Reduces frustration of customers</td>
</tr>
</tbody>
</table>

Chart2. The nine design principles of customization
The idea of customization is not a significant innovation in design and manufacture, but addressing the problem of dangerous E-waste is critical to life on earth. Studying ways to extend product life is an important endeavor, and customization is a viable strategy for prolonging the customer-product relationship. The study performed here may have some serious limitations, but the results point to the need for further investigation of this strategy. A much larger and more complex test should be done that expands upon the principles and more e-products need to be designed and developed for testing. This requires exceptional collaboration among business, marketing, engineering and design, and significant investment, but the need is irrefutable. All sustainable design strategies are in need of greater and immediate study and application by industry, academia, and government.

We need to do more to awaken and inform customers, to collect them together to help create a more sustainable world. Customization and modularity in mobile phones provides a whole new possibility in sustainable design. The current all-in-one mobile phones are hard to challenge, because mobile phone providers have coached customers for years, and also provide higher profit for suppliers. However, our survey shows that and customers are optimistic and willing to try new things if the marketing message is clear and exciting. If this can be presented
as disruptive technology, the transition to more sustainable products may be more viable.

Designers play a significant role in providing a more sustainable world. They can also build upon existing design theories and principles to offer guidelines to emerging designers in other fields. By utilizing the principles presented in this thesis and other sources related to the issue of sustainable design, designers can help bring about a new age of cleaner, user-centered, and socially responsible products.
Reference


Zhang, Han Ning, and Ji Feng Xu. "Application of Maslow's Hierarchy of Needs to Modern


Attachment A

THE SURVEY:

A. Introduction:

The goal of this survey is to evaluate a new concept for mobile phones, the device model. To make cell phones more sustainable and reduce planned obsolescence, these concepts employ customization to make phones last longer and serve a users needs for a longer period of time.

There are three main sections in this survey: we will ask you about your background, your product experience, and your opinion of a new product.

You will view two one-minute videos. Please prepare your listening equipment. You will be asked to compare the cellphone concept with the phone you have now.

This survey is intended to evaluate the new concepts in function and service only. Please do not base your answers on the aesthetic appeal of the proposed concept models in the videos.

This survey will take you around 10 minutes. Thank you for your time and thoughtful consideration.

School of Design, College of DAAP, University of Cincinnati.

Tsung-Yu Shih
shihtu@mail.uc.edu
B. Respondents’ backgrounds

Question1. Gender:

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>57.1%</td>
<td>24</td>
</tr>
<tr>
<td>Female</td>
<td>42.9%</td>
<td>18</td>
</tr>
</tbody>
</table>

42 answered question
1 skipped question

Question2. Age

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>under 18</th>
<th>18-25</th>
<th>26-33</th>
<th>34-41</th>
<th>42-49</th>
<th>50-57</th>
<th>58-65</th>
<th>66&amp; older</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>My age is</td>
<td>0</td>
<td>23</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>42</td>
</tr>
</tbody>
</table>

42 answered question
1 skipped question
### Question 3: Nationality

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td></td>
<td>52.38%</td>
<td>22</td>
</tr>
<tr>
<td>Taiwan</td>
<td></td>
<td>16.67%</td>
<td>7</td>
</tr>
<tr>
<td>China</td>
<td></td>
<td>11.90%</td>
<td>5</td>
</tr>
<tr>
<td>Korean</td>
<td></td>
<td>7.14%</td>
<td>3</td>
</tr>
<tr>
<td>German</td>
<td></td>
<td>4.76%</td>
<td>2</td>
</tr>
<tr>
<td>Mexican</td>
<td></td>
<td>2.38%</td>
<td>1</td>
</tr>
<tr>
<td>Caucasian</td>
<td></td>
<td>2.38%</td>
<td>1</td>
</tr>
<tr>
<td>Canadian</td>
<td></td>
<td>2.38%</td>
<td>1</td>
</tr>
</tbody>
</table>

- **answered question**: 42
- **skipped question**: 1

### Question 4: Highest level of education

What is your the highest level of education? (May be currently enrolled)

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school</td>
<td></td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Post-secondary or Trade School</td>
<td></td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Bachelor's Degree</td>
<td></td>
<td>47.6%</td>
<td>20</td>
</tr>
<tr>
<td>Master's Degree</td>
<td></td>
<td>45.2%</td>
<td>19</td>
</tr>
<tr>
<td>Doctorate</td>
<td></td>
<td>2.4%</td>
<td>1</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td>4.8%</td>
<td>2</td>
</tr>
</tbody>
</table>

- **answered question**: 42
- **skipped question**: 1

### Question 5: Current mobile phone
### Question 6. Two-year contract

**Do you have a 2-year contract with this mobile device?**

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>66.7%</td>
<td>28</td>
</tr>
<tr>
<td>No</td>
<td>33.3%</td>
<td>14</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

**Answered question:** 42

**Skipped question:** 1

### Question 7. Mobile phone prices

**Approximately, how much did you pay for your current cellphone when you purchase it? (Not including monthly payment and other additional fees.)**

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
</table>

53
Question 8. Monthly payment

<table>
<thead>
<tr>
<th>Monthly Payment</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>$100+</td>
<td>2.5%</td>
<td>1</td>
</tr>
<tr>
<td>500-699</td>
<td>5.0%</td>
<td>2</td>
</tr>
<tr>
<td>300-599</td>
<td>7.5%</td>
<td>3</td>
</tr>
<tr>
<td>100-299</td>
<td>55.0%</td>
<td>22</td>
</tr>
<tr>
<td>Under 100</td>
<td>17.5%</td>
<td>7</td>
</tr>
<tr>
<td>It was a 0-dollar phone</td>
<td>12.5%</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>12.5%</td>
<td>3</td>
</tr>
</tbody>
</table>

Answered question: 40
Skipped question: 3

Question 9. Smartphone or traditional phone

<table>
<thead>
<tr>
<th>Mobile Phone Type</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>78.6%</td>
<td>33</td>
</tr>
<tr>
<td>Traditional cell phone</td>
<td>21.4%</td>
<td>1</td>
</tr>
</tbody>
</table>

Answered question: 42
Skipped question: 1
Question 10. Smartphone

Please indicate the level of your current smartphone?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-end smartphone (at the same level as iPhone4S, iPhone4)</td>
<td>84.8%</td>
<td>28</td>
</tr>
<tr>
<td>Middle-end smartphone (at the same level as iPhone3GS, iPhone3)</td>
<td>15.2%</td>
<td>5</td>
</tr>
<tr>
<td>Low-end smartphone (at the same level as iPhone2, iPhone1)</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 33

Question 11. Traditional phone

Please indicate the level of your current cell phone?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-end cellphone (has camera and music player, can upgrade storage and do Web browsing.)</td>
<td>20.0%</td>
<td>2</td>
</tr>
<tr>
<td>Middle-end cellphone (has camera or music player, or even can upgrade storage.)</td>
<td>60.0%</td>
<td>6</td>
</tr>
<tr>
<td>Low-end cellphone (only has basic functions, such as calling, texting, or alarm clock.)</td>
<td>20.0%</td>
<td>2</td>
</tr>
</tbody>
</table>

answered question 10

Question 12. Six design principles

This product is attractive to me because...

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Neutral</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
<th>Rating Average</th>
<th>Response Count</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I expect to love this phone's unique features</td>
<td>6</td>
<td>21</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>3.74</td>
<td>39</td>
<td>7.95</td>
</tr>
<tr>
<td>I expect maintain it more easily than my current phone</td>
<td>8</td>
<td>11</td>
<td>10</td>
<td>7</td>
<td>3</td>
<td>3.36</td>
<td>39</td>
<td>3.11</td>
</tr>
<tr>
<td>I expect easily upgrade</td>
<td>13</td>
<td>18</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>4.05</td>
<td>39</td>
<td>7.46</td>
</tr>
</tbody>
</table>
or downgrade its functions

| The materials in the product are very durable | 5 | 9 | 21 | 2 | 1 | 3.39 | 38 | 8.11 |
| If it breaks, I expect easily get it fixed | 16 | 12 | 5 | 5 | 0 | 4.03 | 38 | 6.35 |
| I expect it to have a longer product life | 14 | 15 | 10 | 0 | 0 | 4.10 | 39 | 7.36 |

Including survey data analyzing and related commons from the interview.

A. Tailored customization:

- “This concept is good. We should ask them do this.”
- “I know they told me not to judge the concept by my aesthetic appeal; but as a design student, I really can’t like this design… but I think that general public like my parents would like it.”
- “I like that my phone has features I don’t know about because I’m always learning and downloading new things. I might not know to buy a GPS chip if my phone didn't come with it, convincing me that I do need it!”

B. Modularity:

- “This is a manufacture nightmare.”
- “It seems too complicate for regular users… How about provide a, for example, game combo, so your customers would accept it easily?”
- “Just like Apple v.s. Microsoft, and this is Microsoft.”
- “This project is so far outside of the current mobile paradigm that it is almost unimaginable or too theoretical.”
C. Upgradeability and downgradeability

- “But my fear is that the electronic market changes so fast that even if I can upgrade this phone will be outdated before the 8 years have passed. This would make it hard for me to purchase it if it has a great upfront cost.”
- “Sometimes I bought a phone was for the new function, such as voice control,..The old one did not have that. That was attracting me more…”

D. Materials’ lifespan and Durability:

- “I need to know more about costs and materials to answer above questions.”

E. Decentralization and transparency:

- “We cannot predict the future, so it is hard for us to jump in this product.”

F. Reusability, interchangeability and flexibility:

- “I am worrying that when I drop it, it would fall apart.”

**Question 13. Customization Vs. Current Model**

<table>
<thead>
<tr>
<th>Please compare this customizable phone with your current phone. This YoDo Phone is attractive to me because....</th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Neutral</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
<th>Rating Average</th>
<th>Response Count</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>It offers me more choices (than my current phone)</td>
<td>8</td>
<td>17</td>
<td>8</td>
<td>5</td>
<td>1</td>
<td>3.67</td>
<td>39</td>
<td>5.89</td>
</tr>
<tr>
<td>It addresses frustrations I have (with my current</td>
<td>4</td>
<td>14</td>
<td>18</td>
<td>3</td>
<td>0</td>
<td>3.49</td>
<td>39</td>
<td>7.76</td>
</tr>
</tbody>
</table>
phone)

It is more cost effective and affordable (than my current phone)  

It will serve my needs better (than my current phone)  

I would keep it for a longer time (than my current phone)  

Question14. Expecting price

When this product is more expensive than comparable products, but can be used four times longer, what is the maximal percentage of difference you would be willing to pay when you just purchase it? Please compare with your current phone (not including your monthly payment.)

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would expect to pay less.</td>
<td>10.5%</td>
<td>4</td>
</tr>
<tr>
<td>I would expect to pay the same</td>
<td>34.2%</td>
<td>13</td>
</tr>
<tr>
<td>I would pay 10% more</td>
<td>10.5%</td>
<td>4</td>
</tr>
<tr>
<td>I would pay 20% more</td>
<td>13.2%</td>
<td>5</td>
</tr>
<tr>
<td>I would pay 30% more</td>
<td>15.8%</td>
<td>6</td>
</tr>
<tr>
<td>I would pay 50% more</td>
<td>10.5%</td>
<td>4</td>
</tr>
<tr>
<td>I would pay 100% more</td>
<td>5.3%</td>
<td>2</td>
</tr>
</tbody>
</table>

answered question 39
skipped question 4
Question 15. **Purchase intention**

Would you like to use this new product as your next mobile phone?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Neutral</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
<th>Rating Average</th>
<th>Response Count</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>18</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>3.37</td>
<td>38</td>
<td>6.43</td>
</tr>
</tbody>
</table>

answered question 38

skipped question 5

C. **The Interview Recording**

The one hour recording of the interview with Professor Dale Murray’s design theory class in University of Cincinnati. (UC user mane and password are required.)

https://myshare.ucfilespace.uc.edu/shihtu/