7-26-2017

Instruments of Generation

Bradley Dunn
bd1162@rit.edu

Follow this and additional works at: http://scholarworks.rit.edu/theses

Recommended Citation
R.I.T
Instruments of Generation

By Bradley Dunn

A Thesis submitted for the requirements for the Degree of
Master of Fine Arts in Industrial Design

Department of Industrial Design
College of Imaging Arts and Sciences

Rochester Institute of Technology
Rochester, NY
July 26, 2017
Signatures

Stan Rickel - Graduate Director Industrial Design, Associate Professor, RIT

Jeff Smith - Education Program Manager at Autodesk

Amos Scully - Associate Professor, Design, RIT
Acknowledgements

I would like to extend my thanks to my committee of Stan Rickel, Amos Scully, and Jeff Smith for many thoughtful discussion with regards to how and why we make things. Stan, our informal conversations in studio were immensely valuable in the development of my explorations in generative design. Amos, without our conversation in your office I am sure I would of never stumbled upon how important curation is to making wise choices. To Jeff thank you for you insight into Fusion 360 and the upcoming tools available through Autodesk.

To my fellow students, who constantly challenged me and gave me many projects and ideas to play with. In particular, David Cohen for always asking questions and making me think deeply about the value of 3D printing.

To many other faculty who acted as unofficial advisors:
Melissa Moukperian, Soft Goods Professor, RIT
Robert Fleck, Lead Systems Administrator, RIT
Rick Auburn, Shop Technician, RIT
Josh Owen, Department Chair RIT ID

And too my family and friends for their constant support and honest engagement.
Table of Contents

Abstract
Introduction
   Objectives
   Impetus
   State of the Art

Research 1 - It’s the Economy Stupid
   1.1 Globalization
   1.2 Economic Trust
   1.3 The “Sharing” Economy

Research 2 - From Panoptes to Hydra
   2.1 Software Advancement - To the Cloud
   2.2 Software Advancement - Generative Design
   2.3 Manufacturing Advancement - 3D Printing
   2.4 Cultural Advancement - Prosumers

Research 3 - The Problem of Choice
   3.1 More is More
   3.2 More is a Chore
   3.3 Cultural Assistance
   3.4 Amazonia
   3.5 Chipotle Design Methodology

Explorations
   4.1 Eating
   4.2 Because every designer wants a chair
   4.3 Modularity
   4.4 Structure
   4.5 Crutches
4.6 Developing an Interface

Future Advancements

Conclusion

Bibliography

Additional Resources
Abstract

This Thesis is a study into possible outcomes on products from recent trends in business culture, virtual and physical tools, and marketing and sales.

Product design has remained relatively unchanged through a tumultuous time in global economics and advancements in computation and sales methodology.

We will first look at our changing economic and political systems. The situations provide insight into the way goods are produced, by whom they are produced, and the general mood of consumers insights. From there we will consider how changing tools and strategies may lead to similar changes in how we design. And finally we will consider research in customer choice in a world of abundance.

My own explorations into different product sets will attempt to reconcile some of the problems mentioned above as well as serve as starting points for developing systems that can acquiesce to a customer’s needs.

Introduction

Objectives

The primary purpose of this thesis is to explore the possibilities offered by advanced tools on the creation of objects. These tools are both virtual and physical and so the relationship between the creator, virtual, and physical ‘avatar’ will be explored. Multiple projects will hope to show how the different context require different organizations of the three parts; creator, computer, constructor.

The projects will be guided by concepts from physical needs, choice, culture, and the relationship of the creator to the designer. Studies in the virtual avatar were attempted to be
made program agnostic, by using two different 3D modeling softwares on a majority of the studies.

The goals are listed below:
To understand how customers decide
To develop workflow for creating rules based design
To develop workflow through various softwares leveraging each’s skills
To create a deeper connection between thing and user
To create a deeper connection between designer and user

**Impetus**

April 25th, 2015. Protesters in Baltimore turn to violence after the death of Freddie Gray in police custody. The riots that began on April 25th would cost millions of dollar and much like previous city riots will continue to have non-valued costs, such as white flight, increased distrust between police and residents, etc. (This issue of trust will come up repeatedly in various guises).

As a recent resident of Baltimore who had moved to Rochester only months before to begin this MFA, I was deeply disturbed by not only what I saw on TV but by the difference from what I saw on the news and what I heard from friends and co-workers on both sides of the issue living in Baltimore. It seemed all the voices of sanity were being lost on both sides of the issue and that competing factions had lost a way to communicate in a constructive manner, leading to the final outlet of emotion, violence. This inability to communicate would show up again in the UK Brexit vote and 2016 US presidential election as electorates looked for anything not exhibiting a relationship to the status quo and retreating from broad multinational cooperation.

The events themselves and the inability to predict them illustrate a disconnect between those chosen to lead (Designers) and their constituents (Users).
The State of the Art

With the rise of Social Media and new business models such as Uber, there has been much talk about the decentralization of thought and business in the modern world. For all of its promise we must also be wary of its challenges.

Newer, cheaper tools for creation are entering the marketplace. In 2009, Makerbot was founded and as one of the first successful consumer 3D printing companies, they would soon bring a technology that had existed for 30 years into the mainstream. These $1000 3D printers were affordable enough for your average maker or entrepreneur to have one on their desk, rather than the larger, more complex industrial printers which cost on average $87,000 in 2014. (Cotteleer and Joyce 2015, pg. 111 - 112) In 2013, Autodesk released the world’s first cloud based software created specifically for product design. Fusion 360 offered an ability to collaborate anywhere in the world on a single product and combined the tools of product engineers and designers into one simple program. Their CEO at the time, Carl Bass, a maker in his own right had led the company to develop a cheap, easily dispersible platform for individuals to make what they wanted.

This development of cheap effective virtual and physical tools has helped bring about a decentralization of labor within the industrial design world. This decentralization occurs due to the low cost of capital required for entry into the market (besides one’s education that is). And can be illustrated in the growing number of freelance designers and independent design studios. Luckily for designers or perhaps because of forces related to decentralization, companies understanding of design as a value add for products has increased.

I would argue this value add could be partly attributed to the partisanship of culture, which increasingly relies on branding in the age of abundance. Consumers, both of goods and ideas, are increasingly retreating to the safety of “brand-truths” whether economic or political respectively. This consolidation of “hives” is both dangerous and helpful in an ever diversifying world as we will discuss both economically and through the lense of making choices.
This consolidation is also occurring within the corporate world. Corporate acquisitions and mergers are happening at an unprecedented rate as large multinational organizations strive to gobble up a larger global market share.

1. It’s the Economy, Stupid!

We will discuss how certain economic trends worldwide and here in the United States have affected the present and may affect the future of making things. We will start with the opening up of new markets for production and consumption through Globalization. Then discussing how certain factors of globalization and deregulation have eroded public trust in our economic ecosystem. And finally how these factors have led to the current shift of “sharing” economy.

1.1 Globalization

The fall of the Berlin wall and the opening of China saw the Neo-Liberalization of economics under Reagan and Thatcher. International Trade became the priority as multinational companies saw eastern markets as the quickest easiest ways to increase revenue and reduce cost. Concurrently, this deregulation started to allow companies to consolidate holdings.

Globalization supplied wealthy western nations with cheap foreign goods produced free of labor laws and environmental policy. Product manufacturers in particular were able to take huge advantage of these policies as the reduced cost of goods allowed more consumers to buy. As we enter the next phase of globalization and once poor countries like China and India see their GDP rise, we will see the creation of their new consumer bases. Ones that will begin to exert buying power equal or greater than post-industrial nations. As such, leveraging the diversity of culture and thought will be paramount to successful global production.

As trade expanded internationally, corporations followed by buying out regional producers, creating the multinational organizations we see today. As of 2011 the 200 Largest companies have sales comprising more than 25% of the world’s total gross domestic product. (Derber
This drive to consolidate is due to a drive to reduce marginal cost. This means that as a good travels through the market ecosystem of consumption, production, and sales each party involved in the process “is marking up the transaction cost to include a profit margin large enough to justify their participation” (Rifkin 2015, pg.4-5).

By consolidating consumption, production, and sales under a single banner our largest companies have reduced marginal cost to almost nothing. Consider General Motors, a conglomeration of many previous independent brands. In 2010 GM went through a major restructuring following bankruptcy leading to the sale or discontinuation of such brands as Saab, Pontiac, Saturn, Hummer. (Elliot 2009) Overlap between marketing and product had reached a point where each brand was competing with themselves. Welcome a world where “economic life [is] characterized by abundance rather than scarcity” (Rifkin 2015, pg.11)

It will be new tools we will talk about shortly that will help designers develop products which provide for the needs of the customers in a world with so much abundance. Generative design provides the specificity to the consumer, while 3D printing will allow for small scale production.

1.2 Economic Trust

This trust has been in steady decline throughout the globalization period discussed earlier. With the consolidation of power within corporations to reduce marginal costs there are less groups marking up a transaction cost for their participation in the system. Prices decrease but so does participation within the economic system, and participation is vital to our trust or as Jeremy Rifkin calls it, Social Capital. “While currencies have been backed up by all sorts of valuable metals, ...anthropologies observe that behind these assets lies a deeper asset - Social capital - without which currency as a medium of exchange would be valueless” (Rifkin 2015, pg.318)

The trust of customers in the products they buy is indicative of the price they are willing to pay. For instance, Apple has driven design as a brand initiative to illustrate why consumers should part with their precious dollars for their products. And Patagonia can justify their high price
point with policies which build upon the trust of the customer. New technologies such as cloud computing design can allow us to better understand and communicate with consumers to build trust.

Another way to provide social capital is through the structure of the organizations themselves. Credit Unions and Cooperative business entities with engage in more profit sharing are beginning to grow. Are there other ways to increase participation in our economic system while still keeping marginal cost of production minimal? Can consumers supply something besides their precious few dollars to this economic ecosystem to justify cheap goods.

1.3 The “Sharing” Economy

There has been much talk since the election about outsourcing and technological improvements leading to less middle class jobs. Whatever the reason their is no doubt that the middle class of the United States is shrinking. “The share of adults in upper-income households increased in 172 of the 229 metropolitan areas, even as the share of adults in lower-income households rose in 160 metropolitan areas from 2000 to 2014. The shifting economic fortunes of localities were not an either/or proposition: Some 108 metropolitan areas experienced growth in both the lower- and upper-income tiers.” According to the Pew Research in May 2016.

This redistribution of funds away from the middle class has led to the popularization of the concept of the sharing economy in the US. The sharing economy little more than a thinly veiled return to the commons. A system which “emerged in feudal societies where powerful overlords pauperized local populations… coming together in a sharing economy became the only viable way to ensure the meager largess they were left with would be optimized.” (Rifkin 2015, pg. 20)

Optimization will be important moving forward as the world’s population continues to expand and our resources dwindle. Consider, Uber which helps to minimize resources by consolidating many independent contractors under a single banner. It is also expanding our resources, in the use of cars and drivers that would normally be sitting idle.
The sharing economy works well for soft skills. In the case of Uber, most Americans over the age of 18 have experience driving a car, and such their possible labor force is large and has very little bargaining power due to the size of the possible labor force. “The employers most likely to face problems are those in manufacturing clusters. These pockets have many companies that are small, hire relatively few people, and lack the broad training resources they’d need to develop skills. As a result, the chance of a skills gap is much higher in these areas.” (Sherman 2016) Can we decrease the skills gap by insidiously training consumers how to be designers and manufacturers? By participating in the design and construction of things they will be more apt to be apart of the global supply chain rather than dismiss it and choose to tear it down.

Elements of the sharing economy are beginning to break out into high capital markets such as the energy market. In Minnesota, “community solar, where multiple clients can subscribe to a single network — called a solar garden — to split costs and avoid the hassle of personally owning housing panels” has led to a twelve-fold increase in solar energy production since 2015 (Fouriezos 2017). This shows that customers are willing to take on larger amounts of risk in capital investment so long as they receive returns. As 3D printers proliferate into the marketplace, we could see a future where machines purchased by a variety of companies and consumers share in the workload of production.

2. From Panoptes to Hydra

New tools using the internet as the basic infrastructure allows product design to evolve from a centralized unit within a company to a multi-headed beast leveraging the sharing economy. These factors creates a less risk sensitive environment for businesses, and could provide economic benefit to consumers

2.1 Software Advancement - To the Cloud

Cloud based software such as Adobe Creative Cloud and Autodesk Fusion 360 provide a subscription based model which not only provides better cash-flow for their corporate interests but also allows for constant updates for the user. These updates prevent translation errors
among software users that were so common when collaborators in a project may have been working on different versions of similar software.

New software takes the advantage of cloud based software to a new level not only preventing translation errors but allowing collaborators to work independently from the same specific file. For example imagine working for Hamilton Beach designing a new blender. The team would have electrical engineers designing the circuits for the motors, input screens and user buttons. Mechanical Engineers designing the motor and blades for the devices sole purpose. Industrial Designer shaping the object and organizing placement of User Experience concerns. These three collaborators would be using each individual proprietary software and slowly working to fit the component parts together in a way that hopefully fulfills each groups needs.

With Cloud computing each collaborators work is seamlessly integrated into one constantly updating model. Not only does it speed up the process but it also affects how each collaborator sees the product. By actually operating together each constituent is more acutely aware of the other, producing an environment where goals of the constituent groups are more easily understood.

The cloud is affecting how all business is done not just Industrial Design. Consider the proliferation of cloud-based collaboration tools such as BaseCamp and Slack. These softwares are important as the complexity of products continues to grow, requiring larger and larger groups for their success. If these groups grow too large the investment of individuals in the collective shrinks as “humans evolved to live in groups of up to 150 that were relatively egalitarian” (Haidt 2013, 276). Haidt goes on to discuss how we can create groups which are more hivish, and gives three tools to promote the hive; Increase similarity, not diversity. Exploit Synchrony. Create healthy competition among teams, not individuals. Cloud based

2.2 Software Advancement - Generative Design

As an undergraduate architecture student I had the privilege of studying at a university which identified and promoted the power of computation in the field of design. It was here I was introduced to a plug-in to a stalwart in CAD software, Rhinoceros. The plug-in grasshopper
allowed designers to model parametrically in a unique way. Unlike traditional parametric modeling which operated in the typical user interface. Grasshopper runs through a separate window, allowing designers to set up rules i.e script, with or without seeing the outcome in real time.

At the time of this thesis Autodesk has also developed notable advancements in generative design with a new suite of softwares; Dreamcatcher and Within. “Dreamcatcher is a generative design system that enables designers to craft a definition of their design problem through goals and constraints. This information is used to synthesize alternative design solutions that meet the objectives. Designers are able to explore trade-offs between many alternative approaches and select design solutions for manufacture.”(Autodesk 2015) The figure below shows how the compute can offer many varieties of a single product based on inputs provided by a designer of engineer.

(Fig. 2: Dreamcatcher - developed chair alternatives, Mogk 2014)

Not only does this tool provide product developers with a greater volume of possibilities and a deeper understand of structural or utilitarian constraints, it can also produce very unexpected results. “Researchers in cognitive psychology and engineering have demonstrated that designers experience a powerful tendency to adhere to designs they have encountered
previously” (Seepersand 2014, pg.11) Generative Design will allow us to break out of our expectations, explore novel solutions outside of our experiences.

Other brands are exploring their own algorithmic tools for considering unseen ideas which their customer bases may want. Stitch Fix uses algorithms at the onset of their design process that “works with the company’s order data to predict which clothes customers will want to wear. The team identifies viable gaps in the company’s inventory—clothes that people would buy but a designer hasn’t made yet” (Gershgon 2017)

According to Autodesk’s website, “Autodesk Within is built around a powerful optimization engine that takes input parameters – such as desired weight requirements, maximum stress and displacement – then generates designs with variable-density lattice structures and surface skins to meet exact specifications. The resulting components are higher performing and can be considerably lighter weight than traditional designs. They are as stiff or as flexible as needed, and are refined to enable faultless additive manufacturing.” These systems would not be producible without our next Advancement, 3D printing.

2.3 Manufacturing Advancement - 3D printing will rule the world

Much ado has been made of 3D printing potential for the future of mankind. Its ability for rapid iteration, lower volume production, customization, and innovative forms have been extolled as game changers. (Smith 2016) And it is because of the power of 3D printing that Autodesk set out to build the software mentioned in the previous section.

I personally was first introduced to 3D printing technology in 2005, during my architecture undergrad. During this time the technology available at cost provided useful models for form finding, but they were delicate, and expensive. Early “prosumer” grade 3D printing was often referred to as “rapid prototyping” for this reason. Meanwhile, companies like 3DSystems and Stratasys were hard at work developing newer more advanced iterations which could work with other materials. These new novel materials and processes for additive manufacturing have allowed the field to expand outside of prototyping and into full scale production.
Large corporations began to take notice and invest in 3D printing due to its abilities to create complex shapes that would be impossible to construct efficiently otherwise. In the 1990’s GE began research on new more fuel efficient jet engines, but the complexity of fuel nozzle tips led to some issues, “The tips’ interior geometry was too complex. It had more than 20 parts that had to be welded and brazed together. It was almost impossible to make.”(Kellner 2017) They then began development with the help of a 3D printing pioneer of a new method of construction, which not only led to the construction of one unified part, but also a product that was 25% lighter and more durable.

It is this ability to create complex shapes which led to the development by Autodesk of Dreamcatcher and Within. Many other companies including design firms and major manufacturers such as Airbus are using these tools and exploring how algorithms and nature inspired designs can optimize their product solutions.

Research and Development costs for new unique parts decreased as 3D printing made the need for molds obsolete. But cheaper parts extends well beyond research of future products. The ability to efficiently lower production volume makes it so large manufacturers no longer must hold in stock millions of spare parts for their products, but can print them instantaneously when an order arises. Considering $72.7 billion worth of car parts were sold in 2010 (Kurman 2014, pg. 47). This industry alone could save huge sums of money from low volume production.

This low production volume leads to the next factor of customization. With no added upfront cost to build one or ten thousand many companies are experimenting with customization at a scale never before seen. Diahatsu, is exploring allowing owners to apply one of twelve types of effect skins to body panels of their cars (Hornick 2015, pg. 41). This is only the beginning of larger period of customization where designers sell programs for their users to manipulate and build as they see fit. It is this idea of customization which has the greatest ability to catapult the industry into the mainstream but it is also the least understood. Are consumers ready to design or build for themselves?
As the patents on aspects of this technology has expired companies such as Makerbot, adhering at the time to strict open source policies, built cheap ready to build 3D printers. These printers became the envy of the market at the turn of the first decade of the 21st century leading to speculation of 3D printing takeover of global manufacturing. While this takeover is still very much in its infancy, these cheaper printers have led to a growing movement of consumers ready to build. In fact, many startups are leveraging this growing community of makers by creating Printer networks. 3D Hubs, for instance, acts as an Uber for 3D printer owners connecting professional shops and in-home printers to allow makers to get the correct specs of a printer for the job needed.

2.4 Cultural Advancement - Prosumers

The “Sharing” economy illustrates how consumers are evolving in the 21st century commons. As our economic needs increase we must put our limited resources back to work. We can no longer afford to merely consume a car, it must now provide economic value back to us, besides transporting us to work of course. It is this need which has allowed Uber, a matchmaker between prosumer and customer, to become the economic powerhouse it is.

Likewise, policies such as community solar in Minnesota, are showing how the sharing of resources can be used in capital intensive industries like energy production to provide for the needs of the constituents. Makerbot early on envisioned this within the 3D printing space and quickly launched Thingiverse. Its purpose was a library of 3D modeled items which could then be printed out at ones home. This library was meant to be a depository for all the makers and consumers of Makerbot products and bring about a new era of 3D printing where the consumer would not need to know how to use CAD software, they could merely download or purchase products they wanted and print them at home.

While the vision was laudable, the technology utilized had yet to reach maturity. Makerbots technology was plagued by reliability issues as well as a minimal amount of printable materials. The site lost even more favor among its users when Stratasys acquired Makerbot and the open-source “sharing” DNA of the company evaporated.
These growing pains are occurring at the exact time that I am writing this thesis and I consider them valuable insight into the technology and culture that surrounds it. Most technologies that have been successfully integrated into the sharing culture are significantly more mature, and once makers are no longer tinkering 3D printing could erupt as the combatant force against cheaper foreign goods. In order to do this they provide value beyond a “Made in the USA” tag. New products must speak to culture in which it is created and it is in this vein that customization can play a big role. Using 3D printing and its lower volume production we can exploit cultural market difference with limited extra cost.

Makerbot attempted this as well in the Thingiverse library by later releasing a customizer function seen below.

![Thingiverse Customizer, Toilet Paper Holder](image)

Here is an example of something available on Thingiverse, at the time of writing this thesis it is actually one of the few useful customizable items available outside of a cell phone case. I chose it to illustrate some of the problems with customization as well as user interfaces. Many of which I hope to fix in my own iteration of a web based customization tool.
Problem 1. This simple example of a Toilet paper dispenser has 16 parameters that can be changed. All Parameters are shown at once, creating an overwhelming environment.

Problem 2. It is composed of multiple parts but they are unshown and cannot be shown in the context of the environment or the other parts.

Problem 3. Output is restricted to a virtual model for 3D printing, meaning I must print the design myself or spend effort finding someone who can.

3. The Problem of Choice

Western Culture is predicated on the idea of freedom, and freedom requires choices. As we discussed earlier the reduction of cost of producing goods has allowed for a proliferation of choices in the consumer market. Here we will discuss the benefits and pitfalls of our increasing choices in goods.

3.1 More is More

The diversity of life on planet earth, illustrates the power of having more things. For millions of years life has evolved as changes to their genetic makeup have allowed creatures to be better suited for a given environment at a specific point in time. Some have survived and thrived while others languished or went extinct. These genetic mutations illustrate the concept Optionality, or the “Ability to engage in rational forms of trial and error, with no comparative shame in failing, starting again, and repeating failure.” (Nassim 2014, pg. 171) All of this trial and error adds up to a form of intelligence capable of sustaining life on our planet despite multiple mass extinction events. This diversity is an expensive system, consider its remnants are being dug up to create the products we use today through fossil fuels.

The technological advance of generative design is predicated on this concept of more. Allowing the computer to run millions of iterations of a product is essentially condensing years of genetic mutation and testing them against the current environment. There has been a relatively recent trend in Industrial design to develop empathy with our user to build a better
product. While this trend is laudable and has no doubt created better and more sellable products, it is inherently difficult to walk a mile in someone else’s shoes. The more options we can create and test, the better chance we will have had of walking in their shoes in that testing universe, and as such we can create even better products.

3.2 More is a Chore

Based on our western beliefs, with all the options and choices which surround me I must surely be able to find what I would like and thus be a perfectly happy individual. Unfortunately the current political environment and opioid epidemic might show how wrong this belief in more is.

The American psychologist, Barry Schwartz calls it the paradox of choice.

At its most basic level the more options we have cause heightened risk of choice paralysis. If I have 7 years to write this paper thats 2555 days I can choose to write or not write. Also, the certainty of a correct choice erodes when so many are presented. People are also less satisfied with the result of the choice when there are so many possible futures that could have been better.
When you are certain about your choice after all the effort you have put into it your expectation of that outcome increases, which in turn often reduces the satisfaction in that choice.

Lastly, responsibility falls on you. “With a hundred different kinds of jeans on display, there is no excuse for failure. And so when people make decisions, and even though the results of the decisions are good, they feel disappointed about them; they blame themselves.” (27)

It is because of these factors that we must work to build a system which still gives consumers the freedom to make choices but actively reduces the effort input of those choices.

3.3 Cultural Assistance

One thing that separates Humans from our primate ancestors is the ability to not just share information but act on it together. And “early humans domesticated themselves when they began to select friends and partners based on their ability to live within the tribes moral matrix.” (Haidt 2013, pg. 245)

Without seeing an end in sight to the number of choices available to us what methods do we have to help make our decisions easier. In “The Art of Choosing” Sheena Iyengar discusses how different cultures react to solving problems.
In her study Anglo-American and Asian-American school children were asked to complete a set of anagrams. While the anagrams were the same, they were told that different groups of people had chosen the anagrams for them to solve. In this study we can see the vast difference in how different cultures raise their children to solve problems but also tools that may be effective for helping us all make choices. “For [Asian-American students], choice was not just a way of defining and asserting their individuality, but a way to create community and harmony by deferring to the choices of people whom they trusted and respected. If they had a concept of being true to one's self, then that self, most likely, [was] composed, not of an individual, but of a collective. Success was just as much about pleasing key figures as it was about satisfying one's own preferences. Or, you could say that the individual's preferences were shaped by the preferences of specific others.” (Iyengar 2010)

Specific others exist in all cultures and subcultures, parents and teachers are obvious answers. But to the younger digitally native generation the internet offers another specific other. How many times have you asked google or siri to answer a question for you? We are already leveraging the internet to offer us further trusted others who can aid in our decision making process. Can we leverage the choices of friends and family to aid in our decision making process? Social media can aid this effectively and we have already seen recommendations on Amazon and Facebook work in this way.

In another study, Iyengar gave shoppers 8 choices to make each with their own sets of options. Here the shoppers were less likely to default, give up on completing all the choices, if they started out with less options and were able to educate themselves on the decision making process. She learned we can be “Condition[ed] for complexity. It turns out we can actually handle a lot more information than we think we can, we've just got to take it a little easier. We have to gradually increase the complexity.” (Iyengar 2011)
Another strong form of culturalization that allows us to make better choices is categorization. I consider this part of culture as it is a prevailing set of guidelines for how you are supposed to interpret a set of information. “If I show you 600 magazines and I divide them up into 10 categories, versus I show you 400 magazines and divide them up into 20 categories, you believe that I have given you more choice and a better choosing experience if I gave you the 400 than if I gave you the 600. Because the categories tell me how to tell them apart.” (Iyengar 2011) And it is in this fashion that our current e-commerce organizations manage the millions of products they have available for purchase.

3.4 Amazonia

All this abundance is best illustrated by Amazon.com, the first marketplace to fully utilize digital tools, reduction of marginal cost, and the sharing economy together. The centralized nature of big box retailers is being undercut by a massive distribution network of millions of companies and logistics centers which make up the Amazon marketplace. 2017 is on pace to see the largest decrease in big-box retailers in nine years, the brokerage firm Credit Suisse said in a research report released earlier this month that it’s possible more than 8,600 brick-and-mortar
stores will close their doors in 2017. (Wattles 2017) While Amazon.com and other ecommerce web platforms continue to grow in market share.

There has been much talk over the years about the convenience of shopping online, but this is a broad word and what does convenience even mean anyway. Many assumed it was the saved time of travel to and fro a brick and mortar store, but consumers say it is actually the ability to shop at an anytime and the ability to compare prices of a plurality of options which drive them to e-commerce websites as seen in the figure below.

More important than price: e-Commerce is especially popular due to its 24/7 availability

*Consumer View*

Top reasons why consumers worldwide shop online instead of at physical shops

![Bar chart showing top reasons for shopping online.](Fig. 7: Offline vs. Online Retail, Bohnhoff 2017)

And while many users like the multitude of options available from online retailers, as we have discussed earlier we are beginning to reach the event horizon of product choice. The numbers of products available for a single search on amazon crushes the consumer under its sheer weight. An innocent search for “cell phones” on amazon provides over 37 million hits.

So what sort of items do people generally purchase on Amazon, it would seem that even though a consumer may have 37 million “options” for cell phones, it is still a commonly purchased online item.
The more generic a product is, the greater its potential for e-Commerce

**Consumer View**

*Online vs. Offline retail shopping preferences*

<table>
<thead>
<tr>
<th>Category</th>
<th>Prefer to purchase via offline retail</th>
<th>Prefer to purchase via e-commerce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Books</td>
<td>32%</td>
<td>68%</td>
</tr>
<tr>
<td>Electronics</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>Office Supplies</td>
<td>51%</td>
<td>49%</td>
</tr>
<tr>
<td>Sporting Goods</td>
<td>56%</td>
<td>44%</td>
</tr>
<tr>
<td>Household Goods</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>Clothing and apparel</td>
<td>76%</td>
<td>24%</td>
</tr>
</tbody>
</table>

(Fig. 8: Offline vs. Online Retail, Bohnhoff 2017)

Books and Electronics are far and away the most preferred purchases online. The marketers may tell you this is because we already know what we are getting from an experiential side when we are purchasing them we do not need to invest extra energy in unforeseen uniqueness which may dissuade or persuade a purchase.

The title of this chart is very telling to me, from a pure product viewpoint books and electronics might be the more generic items on the list. But from the experience of use they are probably the least generic. As tools for communication; books and electronics also provide the most unique experience for the user by their very nature, even if the product itself is generic. As such the user knows they will imprint their own “culture” on how the consumer the object.

This is very different from the category at the bottom of the chart, clothing and apparel. Apparel is an interesting product, on one level the brands in which you buy are an outward
communication device of the things that you value. When you're wearing a thousand dollar suit “you project a different aura. And then people treat you differently” (Norman 2004, pg. 93) But in another sense, they must be designed to fit something close to your specific body. Each manufacturer uses their own fit models and sizing guides. This causes the interesting juxtaposition we have all seen of the ill fitted yet exceptionally well branded wearer and his or her opposite. In effect, you lose control over the “culture” of the item.

3.5 Chipotle Design Methodology

A great example of the commercialization of some of these practices explained by Sheena, is the Chipotle restaurant chain. Culturalization, Categorization and Conditioning are all present in the company’s purchasing experience. Let’s quickly walk through that experience and see how we could possibly translate into other products.

Step 1: Pick the vessel to carry the ingredients layed out before you. 5 Choices. Hard Taco, Soft Taco, Salad, Burrito, Burrito Bowl.
Step 2: Pick Filler 1. 5 Choices. White Rice, Brown Rice, Black Beans, Pinto Beans, Fajita Veggies
Step 3: Pick Protein. 6 Choices. Carnitas, Barbacoa, Steak, Chicken, Sofritas, and newly added Chorizo
Step 4: Salsa + Toppings. 8 Choices. Mild, Medium, Hot, Corn, Sour Cream, Cheese, Guacamole, Lettuce.

Culturalization occurs both before entering a Chipotle as you have already made the choice of going somewhere with limited options compared with the usual restaurant fare. It also occurs at in some of the progressive steps of operating particularly the first two steps, as choosing specific vessels, or the vegetarian option may change or open up the choices available to you at later stages of the process.

By organizing the steps in the way they have, Chipotle has categorized the options as I have described above; Vessel, Filler, Protein, Toppings. These categories make the personalization
easier for both the producer and consumer. Think of all the times you have had a problem getting a cheeseburger without mayo or tomato at a fast food burger chain. At these locations the emphasis is on speed and mass production and so a slight deviation from the normal creates gross slowdown. Chipotle uses this deviation to their advantage, providing an unique experience but also something more.

At a typical burger chain the meal is not made before your eyes and so the lag between ordering and receiving actually makes the process seem to take longer even if it is actually a shorter construction period. By keeping the customer involved Chipotle provides a better customer experience and thus they are more likely to return.

As you can see at each progressive step the number of choices increases as the consumer has been conditioned for the experience. This conditioning is vital if such a platform would be able to succeed for other products. A burrito is an infinitely less complex item than even say a toothbrush as the consumer has already been conditioned to the event by their own experiences cooking. Very few consumers will have had prior experience constructing “things”.

(Fig. 9 Chipotle Serving Line)
4. Explorations

I began applying concepts of Chipotle’s customer experience to the design experience. Thinking of a product not as one finished entity but as a recipe within which the user could impart their own cultural wisdom and apply their own “brand”.

4.1 Eating

The act of dining is a hugely cultural experience; from the organization of place setting, function of utensils, and the sounds and smells associated with the act; different cultures express their delight, status, and courtesy in unique ways.

I set out to devise a system for designing vessels and utensils which could take into account these factors, and deliver a custom product based on the needs of the users.

I divided the Utensils into 4 categories seen in most cultures around the world; Fork, Knife, Spoon, and Stick. Each of these utensils has sub-categories which are designed to suit certain actions. I.e. Knives are made for spreading, pairing, butchering, trimming, etc. The image below shows the hierarchy of western utensils and how the script takes into account both function and cultural cues of the designer.
A similar system was used for the development of the Vessel. In western culture outside of the cup, the vessel is a table bound object. Utensils operate on the transfer of sustenance from the table to the mouth.

In eastern cultures that use chopsticks the vessel is frequently used as a utensil in its own right. Here I used the secondary customization as a way to fit the bowl to the users hand.
4.2 Because every designer wants to make a chair
The exploration of the barstool, was one of the power of complex form and expanding upon the generative capabilities of computing within design. A script was written comprising of 4 “Loop Groups” which each act symbiotically to lift and support the seating platform. Variables such as the height and width of the overall stool form as well as the material selected and thinness of the loops affect the overall design, either prompting the script to create more or less “leg” units and affect how the 4 “Loop Groups” interact with each other.

(Fig. 12: Loop Groups creating Structure)

The computer was implemented by evolutionary modeling. With such a large number of variables having myself sit and look at each possibility was itself an impossibility. Instead I let the computer run the script millions of times searching for the least amount of material (In this case, the shortest loops) to provide me with a small number of optimized options. (Fig. 1)
By allowing the script to run these calculation I also determined that some of the variables I had originally intended to make changes to the design provided no variation to the amount of material. Thus these variables, stuck out with red lines below, were locked in future iterations, and other variables were added.

Six barstool models were then 3D printed using PLA and a water soluble support structure which allowed for the complex geometry. Different variations of placement of the model in the
3D printing bed were attempted to determine optimal orientation for strength, reduction of support material, and time to print. During these tests it was determined that while an upright orientation provided the least amount of support material it took double the amount of time and was more prone to failure.

(Fig. 15: 3D print tests)

4.3 Modularity

Modules have always played an important role in the construction of things, they provide an economy of scale for construction, as well as a system of organization for difference. This exploration set out to determine how a rule-based computer algorithm could be utilized to develop difference in a module. In this case the module would not provide economy of scale but illustrate functional difference within a holistic aesthetic. The product being developed is a lamp that would use a module to mimic the flexibility of a gooseneck lamp, which allows the lamp head to be directed where light is needed.
Drawing inspiration from the Zoob building set, a variation of the red module with a Male/Female connection was used to connect the modules together.

(Fig. 16 Zoob BuilderZ)

The “cone-shaped module” was designed in Fusion 360 to provide the organic look and then the geometry was broken down into 7 circles which made up the essence of the shape.(Fig 17) These 7 circles could then be manipulated by the script depending on the function of that specific modular unit. The vertical slits cut into the form provide the flexibility required for connection with the next module in the set.

(Fig. 17: Lamp Base Module)
In Fig. 18 you can see how the script began to "grow" individual modules to provide a base and head for the lamp. The rules provided limit the size difference between connecting modules, and so they grow and shrink in a progressive matter based on their neighbors and the need for flexibility in the neck of the lamp.

(Fig. 18: Mutations of Unit)

Final construction of the lamp shows how the pieces interlock. Further improvements in the script would include more units for increased flexibility of the neck and a larger base needed to accommodate the weight of the units.
4.4 Structure

Necessity breeds Creativity. While working on scripts for my explorations I discovered that a second monitor would greatly increase my productivity, allowing me to see the physical manifestation of my scripts in real-time. I had an extra computer monitor but the stand was broken. Rather than purchasing one, I designed one and used the tools I was exploring.

I once again distilled the stand into its most important parts. By looking at existing stands I noticed that all of them had three common points; a connection to the monitor, and two tough points for the desk. These three points became the base of the design, with the physical structure of the stand moving through each of these points.
For the monitor the two variables which would affect the screens usefulness were the angle of the screen and its height. In order for the monitor to work the stand would also need to support its weight and not tip. So it was determined that the angle could be changed through the connection point. The form of the stand would be determined by the height of the monitor and its weight, which would determine how far the base touch points would need to be separated from each other.

The structure developed through these variables was then tested using Fusion 360’s structural analysis program to make sure it could support the weight of the monitor. As you can see from (Fig. 6) the initial structure required additional braces to account for the flexibility of the PLA. The bottom brace, prevented the stand from flexing at the base which caused the system to fall over backwards, while the braces at the top of the stand kept the connection piece from flexing too far forward, which caused the system to fall forward.
4.5 Crutches

This exploration stems from a need of customization provided by another set of students working on crutch designs. Examining the traditional crutch provided in the US, they determined that the while the design offered customization based on the dimensions of the individual using it, there were sever flaws in its design.
1. Underarm support was frequently overused by crutch users. This part of a crutch is designed not as a weight bearing area, although most crutch users use it as one, causing injury and discomfort.

2. The Handle is set perpendicular to the ground, causing injury and discomfort to the wrist, as the arm moves through a weight bearing transfer of a step.

3. The design does not take into account the gait of the individual which has profound impact on the weight bearing needs of the crutch at specific points.

Further, research showed that while current crutches were customizable and could possibly be shared by multiple users, after a temporary need was resolved, they were generally used by one person and stored away or lost.

This led them to work on development of a crutch which would be cheap to produce at scale for one individual and would take into account the three problems listed above.

My help was enlisted in the creation of a customization script which would take into account the three identified problems. (Fig. 7) shows 5 crutch versions with take into account the arm length, height and gait of the user.
Further iterations of this study should include more research in gait analysis. This would affect the angle at the wrist support, and may include more shaping as seen in study crutch 5 with the knob at the end preventing hand slippage.

4.6 Developing an Interface

“Good behavioural design should be human-centered, focusing on understanding and satisfying the needs of the people who actually use the product.” (Norman 2004, pg. 81) For years this has meant user focus groups, observation, and a designer’s intuition. But we now have the tools through enhanced computing power and manufacturing technologies to allow constant feedback from users and consumers to modify and grow better products.

Research in Software and Manufacturing Advancements, User Choice Experience, and economic trends led me to to hypothetical construction of an online platform for product generation. Here consumers could explore product solutions, while imparting their own design sensibilities in an easy to manage application. Their modifications could be used by the designers to further optimize their products and understand their customers needs and wants.
The application is organized in a series of steps which lead the consumer through a design process:

1. Introduction
2. Search
3. Choose
4. Modify
5. Make
6. Share

Step 1: Introduction

(Fig. 25: Creating a Sharing Interface)

From the main interface a user can link information about themselves, as my research shows a user's previous cultural choices will have a profound affect on their choices within the platform. These can be used both to provide proper curation of the site for the user, and to gather information based on their choices in the modification section.

Steps 2 + 3: Search + Choose
Here the consumer is given basic design frameworks, which fall under the search category, in this instance Bar Stools. They can search based on a variety of factors including complexity of production, price, material and keywords. They will be notified as to the number and type of modifications they can make to the product as well as methods of making.

Upon finding a base product which fits their sensibilities and needs they will be prompted to modification.

Step 4: Modify
Much like Chipotle the consumer will go through a series of prompts designed to lighten the choice load of the new “designer”. Choices progress along the hierarchy developed by the designer, as described in Exploration 4.1 Eating. Here we are using screen shots from a consumer’s modification to the Stool in Exploration 4.2 to show the different choices at each step. Icons located on the page illustrate the number of steps and type of decisions they will be making.

The choices made by the consumer in the modification may have an impact upon further construction choices, and these impacts may be hidden or explained depending on the skill level of the specific user. In the example below, such impacts are hidden and the user simply follows the three steps illustrated in the top left of the interface.
Step 5: Make
Thanks to our globally connected economy the user can choose from many avenues of construction. Designers and Manufactures may already have your custom design in stock based on its popularity. Smaller parts factories could produce custom parts to fit into the larger more generic framework of a design. Furthermore, with the growing use of consumer 3D printers many designs may have an option for printing at home. This not only reduces the price for the consumer but also reduces capital investment on the part of the designer or manufacturer by reducing their workload.

(Fig. 30: Prosumer Manufacturing)

Step 6: Share

As we have seen social capital is extremely important to a successful economic system. Collaboration between the consumer, marketer, designer, and manufacturer allows the application to improve all aspects of product generation and consumption. It also can be a platform for marketing as users may share their modifications with friends showcasing producers manufacturing prowess and the concepts systematized by designers.
5. Future Advancements

Advancing the explorations of this thesis, I would work on developing a cloud based platform that would operate by combining the specific skills of users, designers, and manufacturing. Leveraging changes to the user interface to allow for easier decision making by users. These choices could then be taught to designers allowing them to create better products.

I fear that bringing more choice into the equation could further hamper sales, but by building out an extensive framework using the cultural tools above we may be able to create a valuable ecosystem that assists the designers, manufacturers, marketers, and consumers by allowing each an open stake in the creation ecosystem.

I would caution that designer and engineerings using some of the methods I have described to create better projects think deeply about the variables allowed to change. I have found in many of my studies that many were unnecessary. Luckily, this can also be learned by mining the choices consumers have made to “solidify” variables which are less optionalized by consumers.

9. Conclusion

Instruments of Generation started as a study of how to engage with consumers to create a deeper participation in our economic system. After witnessing the closing of a large steel mill in
my home city of Baltimore and the Riots surrounding the death of Freddie Grey, I felt (as only an American can) that I could help by redirecting our consumer culture to a more meaningful end. I felt that 3D printing could be the right tool at this period in time to bring about some of the necessary changes. My research shows that while many experts would agree with this assertion it is still many years off.

In the short term we can hope that leveraging both the software tools and 3D printing in an efficient manner can reduce the upfront costs of new products. When networked with a digital marketplace offering knowledge based on targeted customer groups buying habits we can, we can cheaply test both the viability of sales and reduce the risk on companies. This in turn could act as buffer preventing the need to reduce cost through consolidation.

I learned how important trust is to our general well-being. On the macro-scale it is the basis of our global economy. Closer to home it determines who makes determines policy that will affect everyone living in our nation. But it also plays an important role in what we choose to wear when we wake up everyday, how we comb our hair, and what sorts of foods we purchase.

And lastly, I have had many designers tell me that this sort of system would be the end of design. For them I leave with a quote, “we cannot reverse engineer the taste of food from looking at the nutritional label” (Nassim 2014, pg. 224)

10. Bibliography


Jackie Wattles, “Stores are closing at an epic pace” CNN Money, accessed April 22, 2017


https://www.thingiverse.com/thing:1450268


https://autodeskresearch.com/projects/dreamcatcher


Zoob BuilderZ. https://www.funlearning.co.uk/35-piece-zoob