Interlink Furniture System

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The Practice of Sustainable Design

A15.1 – Design Project - Final

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Original design challenge and project concept

Furniture material waste amounts to an average of 12 million tons of bulky waste per year. Finding a way to meet consumer needs while providing a modern and upgradable furniture system that does not create a surplus of parts and material byproducts and instead provides a circular economy and a service to customers that allows them to stay "on trend" without sacrificing the environment and our collective health and happiness is a significant design challenge.

Key stakeholders who this design challenge affects:

- Young adults and College Students
- Business professionals
- Couples and Families
- General consumers
- Interior design professionals
- Architectural industry professionals
- Furniture owners
- Distribution Businesses
- Manufacturers
- Local Community
- Global Community
- Earth/Environment/Biosphere

Defining the Problem

Key issues

- Furniture waste and lack of material stewardship will be addressed within this system. Sustainable packaging solutions will be promoted and employed. Engagement by consumers in product implementation, exchange and recycling services will be addressed. The interlink furniture system will reduce overall waste and CO2 and methane production due to the ability to easily change out worn components using a recycling service for outdated or worn items.

Key design drivers

- Creating a modular/interlinked furniture system that utilizes the same key components to provide a broad range of furniture pieces will be the main goal. This system will aim to reduce waste by reducing diversity of parts and assembly pieces while provided a sleek and streamlined aesthetic in a price range that a young and not establish consumer can afford to encourage the continuation of the circular furniture system.

Key design objectives

- Create no new problems
- Reduce gross material waste
- Provide upgradable system to retain customers and stay “on trend”
- Focus on health and happiness of consumers through smart and safe material choices
- Enable the consumer to be an active but not inconvenienced part of the recycling system

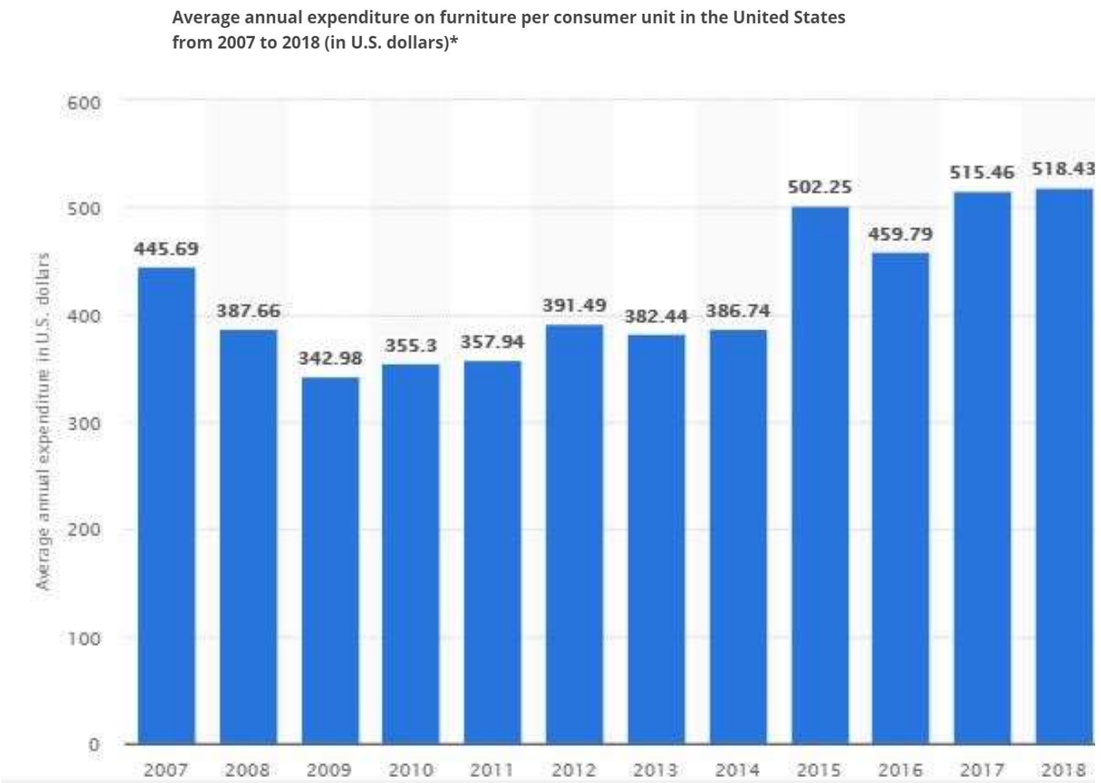
Components within the system to be observed/addressed

- Focusing on which components of common furniture pieces could be interchangeable between different furniture types and applications can provide insight into how this system could utilize the same components for different functions within the system.

Furnishing	Components
Couch	Frame, Cushion, Upholstery, Legs
Easy Chair	Frame, Cushion, Upholstery, Legs
Task Chair	Frame, Cushion, Upholstery, Legs
Side Table	Frame, Legs
Coffee Table	Frame, Legs
Console Table	Frame, Legs
Dining table	Frame, Legs
Desk	Frame, Legs

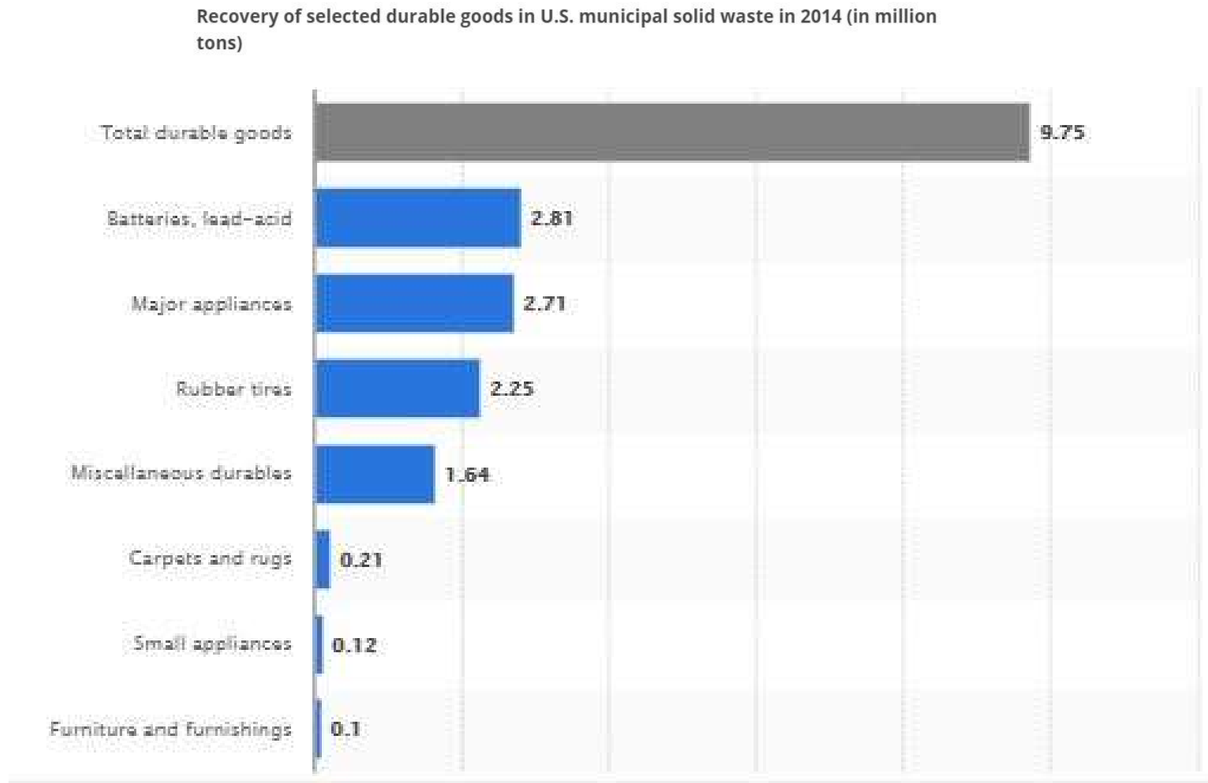
- This system will:
  - Meet fundamental needs
  - Consider future generations
  - Facilitate recycling
  - Design to encourage low consumption behavior
  - Optimize functionality

- As of 2018, the average consumer spends $518.43 U.S. dollars on furniture per year in the United States (see chart immediately below) according to Statista. Consumptive tendencies and buying trends are on the rise.



Source: https://www.statista.com/statistics/305566/us-expenditure-on-furniture/

- The furniture and furnishing sector recovered only 100,000 (0.1 million) tons of materials in the durable goods industry in the United States as of 2014.



Source: https://www.statista.com/statistics/186310/us-municipal-solid-waste-durable-goods-recovered/

The purchasing of new furniture and furnishings and the disposal or displacement of old furnishings is frequent within the average American household contributing to material waste and material disposal in landfills which does not result in biodegradation but instead results in mummification or wood cellulose degradation in an anaerobic environment.

This process is a major producer of methane (greenhouse gas 26 times more harmful than carbon dioxide).

Key Challenges - “How might we..” questions:

Extra packaging material created when ordering new furniture, sending in components that need to be replaced or upgraded, and when ordering additional accessories.

- HMW 1: How might we reduce packaging materials created by initial purchase and furniture recycling service?
  - HMW 2: How might we utilize the structure of the furniture itself as a secure storage container?
  - HMW 3: How might we sell this product?
- Assembly components (nuts, bolts, paper instructions, disposable tools) contribute to the waste creation issue.
  - HMW 1: How might we assemble components without nuts and bolts?
  - HMW 2: How might we encourage users to view assembly instructions online?
  - HMW 3: How might we stop using cheap disposable or included wrenches?

Brainstorm – Trigger Method

- Reusable shipping materials contracted out to a reusable shipping material specialist
- No shipping materials used at all
  - Components assemble into a box and then reassemble into the furniture piece itself
  - All accessories nest into box
- Components sold in store only
- “Give a penny take a penny” style exchange system for components parts in store only
- “One size fits all” legs/support structure works for all furniture applications
- Packaging material is biologically friendly and is used as the pad/filling for soft seating components
- Fastener-free flat pack design
  - CIRA aka “Computational interlocking furniture assembly”
- Furniture exchange program for outdated styles to be remanufactured into new styles
- 3D Print at home furniture
  - Sell rights to design files as service
  - Can 3D printing materials be recycled?
- Online library for assembly instructions
  - Discount for using online instructions instead of printed instructions
  - How to videos
  - Email layout idea of the week to keep clients interested and engaged
- Removable/washable covers
- Removable skin on solid state components to guard against damage
- No extra tools needed
  - Interlocking components
  - Snap together components
  - Held together by weight of user/gravity
- Sold online through company with sustainable packaging/shipping methods already in place
  - Match their standard
- Market to universities for modular dorm room furniture.
  - Students could buy the set when they graduate?
- Provide rehoming service for furniture (not my brand) that customer will be replacing with my furniture system
  - Guarantees no harm done
  - Catches items destined for waste stream
  - Potential to repurpose materials from other furniture lines
- Product sold online with reusable packaging only

  - or –
- Product sold in stores only for in person pickup without packaging materials

Brainstorm – SWOT Chart

Existing System (based on existing system of use and disposal)

Strengths:	Weaknesses:
- Easy to get rid of furniture pieces you don't like or that don't work in your space - Donation helps low income families and those in need of the comforts of home at an affordable price	- Feeds consumer mentality - Items lose value overtime - High shipping costs of large/fully assembled pieces
Opportunities:	**Threats:**
- Regaining cost of articles that were originally purchased through resale - Tax breaks for donated goods - Ownership of on trend goods	- Material shortage from unsustainable use - CO2 creation from landfill/incineration of furniture piece – alternately methane is 84 times more potent/harmful than CO2 and is an often overlooked byproduct of this system

New System (based on the implementation of an alternate system of furniture design for upgradability.

Strengths:	Weaknesses:
- Ability to adapt components to the changing design trends - Reduces disposal of entire furniture piece when only one component has been affected - Marketable as RTA (ready-to-assemble) system which most consumers prefer - System most sustainable when used by first-time furniture buyers who do not have a furniture set to replace	- Furniture reclamation programs through Ikea and HNI are beginning to be introduced - Brand Loyalty - Established customers at chains may stick with what they know - Upfront waste creation if individuals replace their existing furniture with this new system - Supply/Demand on varying leg/upholstery replacement components, Versatility must be achieved.
Opportunities:	**Threats:**
- There are not many systems like this in circulation – impactful to practice of interior design - Ability to explore different furniture design styles while sticking to a set standard base component frame - Reduction of material waste entering waste stream through implementing system materials management on day one	- Big box stores could steal the idea - Customer loyalty to existing brands, consumer trends, and style/aesthetic - Durability of removable parts - Shipping cost for large pieces versus small components - Cost of refurbishing and reintegrating returned/broken parts into system

Observe

- Observation of goods drop off and inventory at Goodwill, Stuff, Etc., and Salvation Army Store
    - Upon secondary observation, one of the three stores was turning away donations due to a surplus of goods in store.
- By observing my coworkers' purchasing habits and asking pointed questions about their favorite/standard places to buy furniture, most people said Ikea online, Ashley Furniture, Facebook Marketplace, and Stuff, Etc as they were the best price for the style they were looking for. A few of my neighbors have purchased items off of Wayfair.com and were happy with the quality of items received.
- When asked how items were disposed of upon replacement, most of my coworkers responded that they list their used furnishing on Facebook marketplace or consign items at Stuff, Etc, when not leaving items on the curb for disposal.

Common disposal methods (of approximately 20 people surveyed)

Location	Method	Frequency	Convenience
Landfill/Incinerator	Dispose of, set out at curb	frequent	Most
Donate to second hand store	Relocate and donate	frequent	Least
Re-sell	List item for purchase	frequent	Least
Give away	Give to friend/family	infrequent	Least
Abandon	Leave on the curb/abandon in place	infrequent	Most

Of 35 stakeholders surveyed, when presented with the prompt, "You get rid of furniture when... Check all that apply.", these were the responses:

ANSWER CHOICES	RESPONSES	
It doesn't serve its function anymore. (A chair is missing a leg)	71.43%	25
It's not in great shape. (The tabletop is scratched and split)	40.00%	14
I need a change of décor. (I found a style I like better)	20.00%	7
I'm moving! (Time for a fresh start)	22.86%	8
NA	8.57%	3
Total Respondents: 35		

When presented with the prompt: “Reducing waste is the starting point for any solid waste management effort. Please check the box for the services you or your organization would be willing to implement or participate in.”, these were the responses:

ANSWER CHOICES	RESPONSES	
Participate in a materials exchange program to donate, share, sell, or buy used furniture, or use refurbished and reclaimed C&D materials	63.64%	21
Create internal reuse programs within operations	30.30%	10
Change purchasing practices to reduce waste	45.45%	15
Passive timber recycling	18.18%	6
Use only lumber certified by the Forest Stewardship Council	24.24%	8
None of these	18.18%	6
Total Respondents: 33		

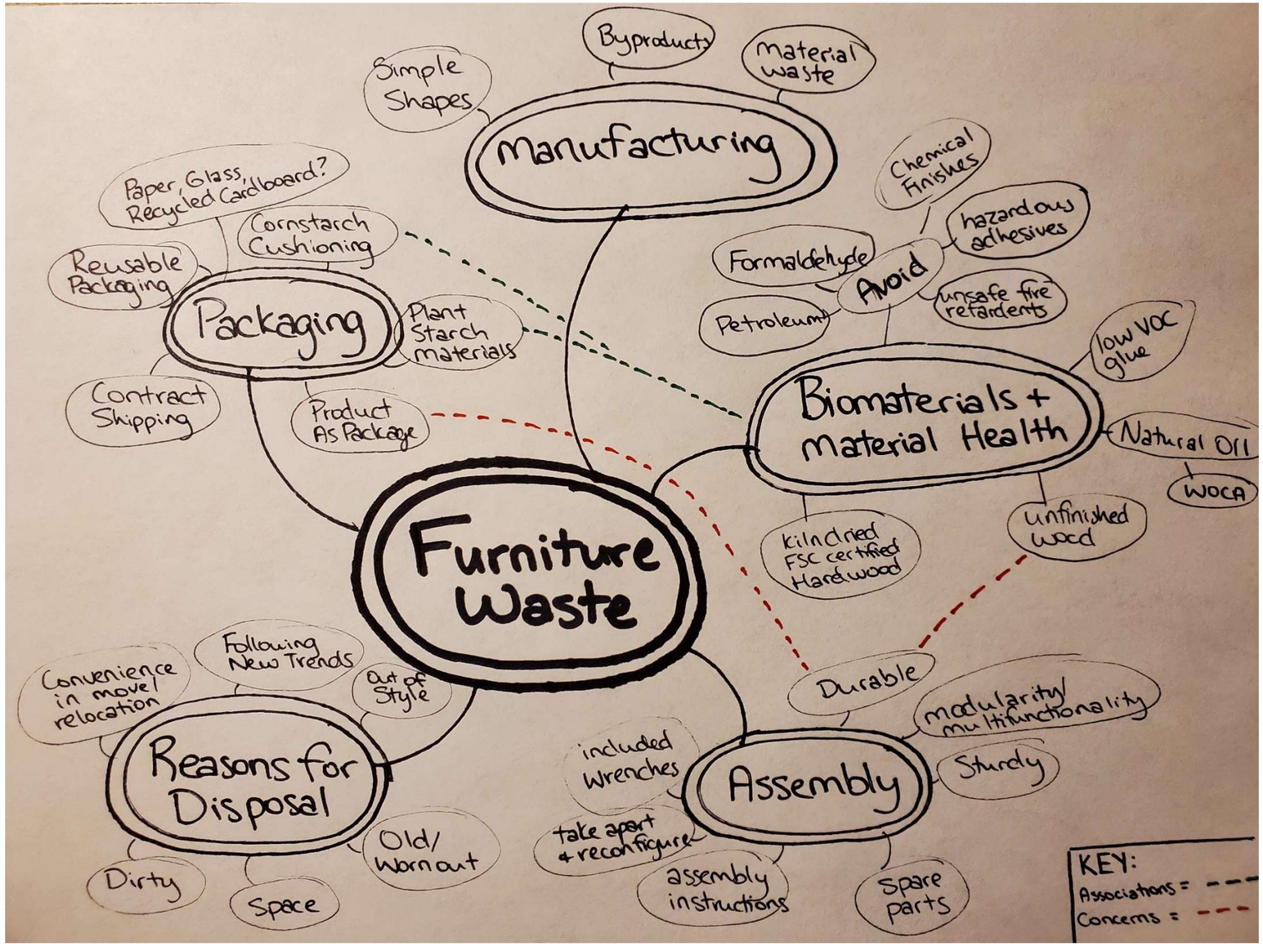
When the same set of stakeholders was presented with the prompt, “Which sustainable factors do you consider in a furniture purchase or construction project? Check all that apply.” These were the responses:

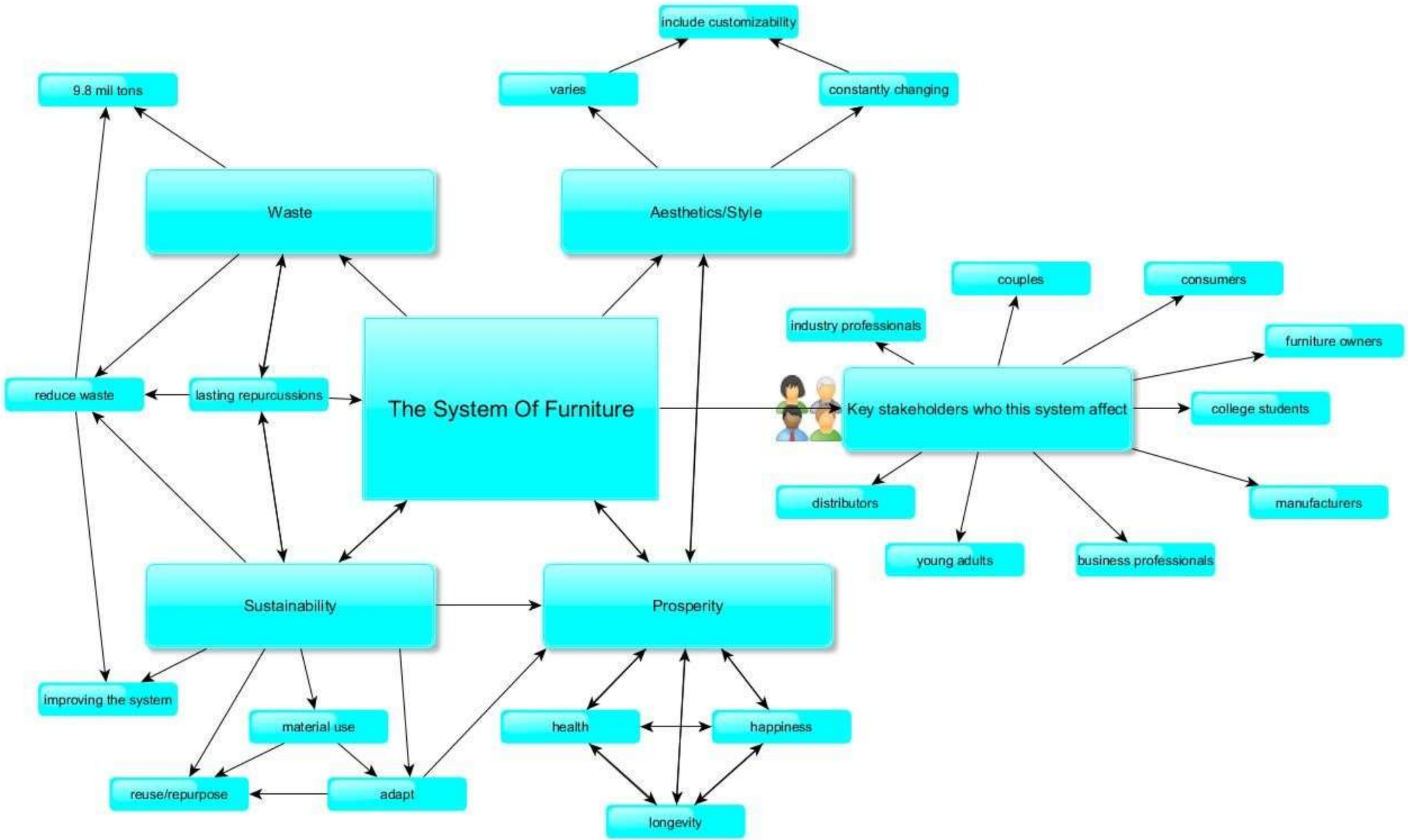
ANSWER CHOICES	RESPONSES	
I don't consider sustainable factors	14.29%	5
Quality of material (ex. hardwoods and high quality lumber/FAS vs. high knot content/soft woods/Common grade)	48.57%	17
Type of material (ex. solid wood vs. particleboard)	57.14%	20
Manufacturing Location/Process (ex. handmade locally vs. mass produced elsewhere)	34.29%	12
Longevity (ex. built to last a lifetime vs. built for occasional use)	57.14%	20
Function (ex. two in one)	37.14%	13
Finish (ex. natural oil vs. polyurethane)	20.00%	7
Total Respondents: 35		

Organize and capture – Narrow the focus

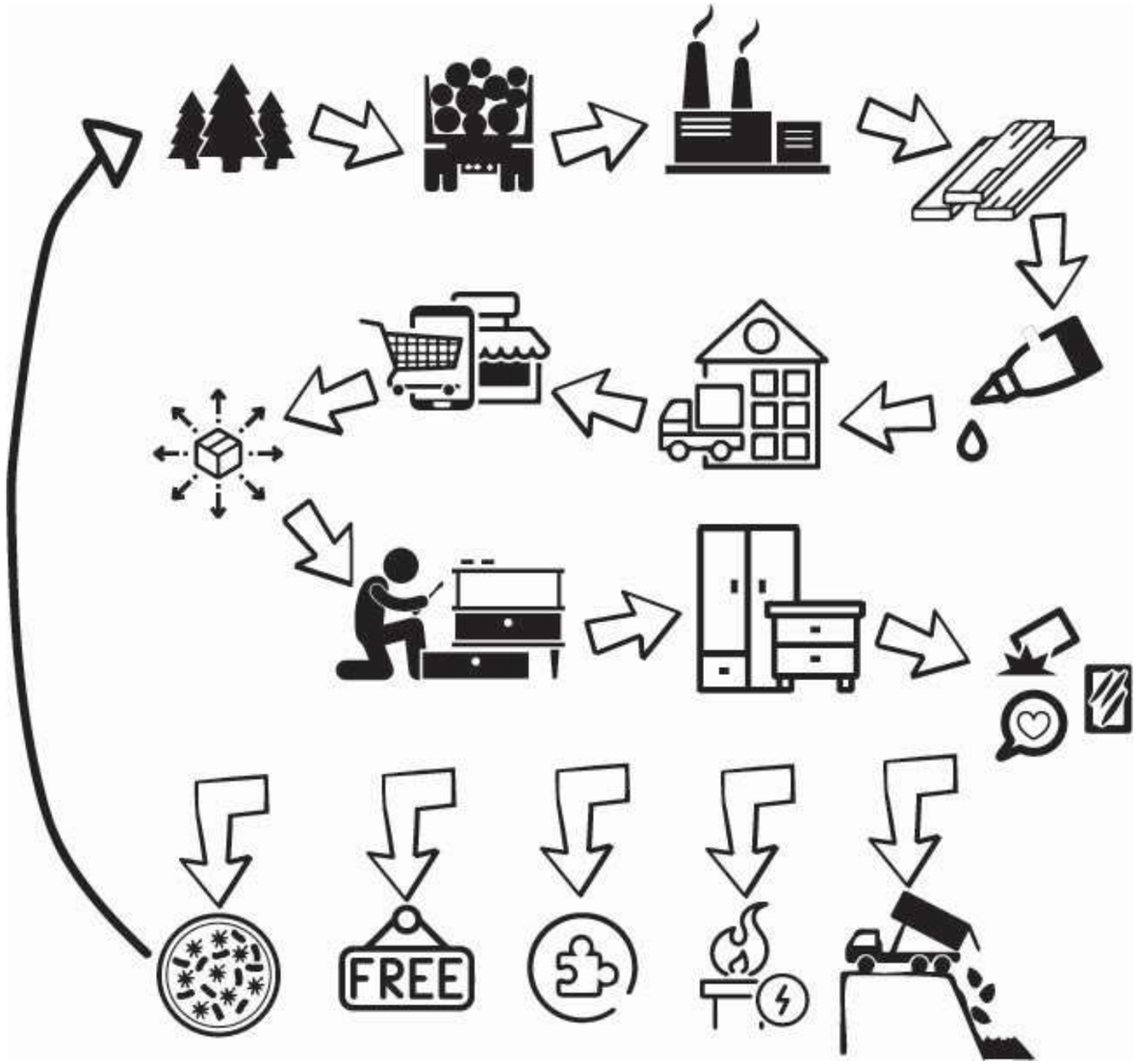
- Shipping Methods:
  - Return packaging to be reused
  - No shipping materials used at all
    - Components assemble into a box and then reassemble into the furniture piece itself
    - All accessories nest into box
    - Removable skin on solid state components to guard against damage
- Reducing Byproduct Waste:
  - Fastener-free flat pack design
    - CIRA aka “Computational interlocking furniture assembly”
    - Interlocking components
    - Snap together components – how many cycles can these components mate
    - “One size fits all” legs/support structure works for all furniture applications
- Provide rehoming service for furniture (alternate brand) that customer will be replacing with my furniture system

Mind Maps


Furniture Waste
Manufacturing
Byproducts
Material waste
Simple Shapes
Packaging
Paper, Glass, Recycled Cardboard?
Cornstarch Cushioning
Reusable Packaging
Plant Starch materials
Contract Shipping
Product As Package
Biomaterials + Material Health
Chemical Finishes
hazardous adhesives
Formaldehyde
Avoid
unsafe fire retardents
Petroleum
low VOC glue
Natural Oil
WOCA
Kiln dried FSC certified Hardwood
unfinished wood
Reasons for Disposal
Convenience in move/ relocation
Following New Trends
Out of Style
Old/ Worn out
Dirty
Space
Assembly
Durable
modularity/ multifunctionality
Sturdy
included wrenches
take apart + reconfigure
assembly instructions
spare parts
KEY:
Associations = - - -
Concerns = - - -


include customizability
9.8 mil tons
varies
constantly changing
Waste
Aesthetics/Style
couples
consumers
industry professionals
furniture owners
reduce waste
lasting repurcussions
The System Of Furniture
Key stakeholders who this system affect
college students
distributors
manufacturers
young adults
business professionals
Sustainability
Prosperity
improving the system
material use
health
happiness
reuse/repurpose
adapt
longevity

Existing Lifecycle Diagram



Impact Assessment and Lifecycle Analysis Forms

Okala LCA Forms – The basis of my LCA forms was on two versions of the same table with different wood materials as the structure which resulted in vastly different adhesion methods and product lifespan due to rigidity, ability to be refurbished, and overall product quality. Lower quality and less raw materials drastically increased total impact of lifetime. The tells me that quality over quantity is important.

Okala Impact Assessment Form		
	Date: 11/30/19	Finctional Unit: (Default: impacts/hour)
Designer: Stephanie Wyler	Product Lifetime: 7 years x 600 hrs/year=4200hrs	
Product Concept Name: Stainless Steel Assemblage	System Boundaries: excludes replacement	

BILL-OF-MATERIALS	AMOUNT	UNIT X	OKALA FACTOR POINTS	UNIT=	OKALA IMPACT POINTS
Stainless Steel	1	lb	13	/ lb	13
steel milling	1	lb	1	/ lb	1
us high v	1	kv/hr	1.7	/ kvhr	1.7
degreasing	1	sqft	0.0004	/ sqft	0.0004
Chrome Plating	1	sqft	2.1	/ sqft	2.1
truck 16+, ave.	5	ton-mi	0.31	/ ton-mi	1.55
car, gas, ave.	1	p-mi	0.39	/ p-mi	0.39
					Total Impact / lifetime: 19.7404

impact/product lifetime: 19.7404
lifetime hours: 4200 hours

equals

impact/hour: 0.047000952

Okala Impact Assessment Form

	Date: 11/30/19	Finctional Unit: (Default: impacts/hour)
Designer: Stephanie Wyler	Product Lifetime: 7 years x 600 hrs/year=4200hrs	
Product Concept Name: Particleboard Table	System Boundaries: excludes cleaning and	

BILL-OF-MATERIALS	AMOUNT	UNIT X	OKALA FACTOR POINTS	UNIT=	OKALA IMPACT POINTS
Lumber - hard wood - misc	30	lb	4.3	/ lb	129
ureaformaldyhyde binder	3	lb	11	/ lb	33
compression molding	33	lb	0.73	/ lb	24.09
melamine	1	lb	2.7	/ lb	2.7
wood glue	0.5	lb	1.1	/ lb	0.55
stainless steel	0.5	lb	13	/ lb	6.5
steel milling	0.25	lb	1	/ lb	0.25
us high v	2	kwh	1.7	kwh	3.4
truck 16+, ave.	10	ton-mi	0.43	ton-mi	4.3
car, gas, ave.	1	p-mi	0.39	p-mi	0.39
					Total Impact / lifetime: 199.88

impact/product lifetime: 199.88	equals	impact/hour: 0.0475904762
lifetime hours: 4200 hours		

Okala Impact Assessment Form

	Date: 11/30/19	Finctional Unit: (Default: impacts/hour)
Designer: Stephanie Wyler	Product Lifetime: 14 years x 600 hrs/year=84200hrs	
Product Concept Name: Hardwood Table (Dining)	System Boundaries: excludes cleaning and	

BILL-OF-MATERIALS	AMOUNT	UNIT X	OKALA FACTOR POINTS	UNIT=	OKALA IMPACT POINTS
Lumber - hard wood	50	lb	4.3	/ lb	215
Wood Glue	1	lb	1.1	/ lb	1.1
Dry Rough Lumber	10	lb	0.11	/ lb	0.11
Acrylic, H20	1	lb	1.4	/ lb	1.4
stainless steel	1	lb	13	/ lb	13
steel milling	0.25	lb	1	/ lb	0.25
us high v	2	kw-hr	1.7	kwh	3.4
truck 16+, ave.	10	ton-mi	0.43	ton-mi	4.3
car, gas, ave.	1	p-mi	0.39	p-mi	0.39
					Total Impact / lifetime: 238.95

impact/product lifetime: 238.95	equals	impact/hour: 0.0284464286
lifetime hours: 8400 hours		

Lifecycle Form

Component	Natural Environment	Raw Material Extraction			Material Processing		
	Where does it come from?	Virgin Material	Input/ Outpu	Detail	Process	Input/ Outpu	Detail
Particleboard / Low Density Fiberboard	Forests, Tree Farms, Nigeria, Amazon, Canada,	Wood	Input	Energy to grow, harvest, refine, and transport	Growth	Input	Sunlight, water, fertilizer, time, energy, observation
			Input	wood byproducts (saw dust, chips, etc)	Harvest	Input	equipment, time, strategy
			Output	Carbon and oil from harvesting implements, manufacturing plant use, and transport	Refinement	Input	Cutting, planing, discarding and chipping to be used
			Output	Deforestation resulting in displaced animals and humans	Compression	Input	Adhesive, pressure, force, mixing
			Output	Visual and Physical disruption of landscape and natural inhabitants	Shipping/Transportation	Output	Box truck/semi
			Output	Carbon that was previously stored in tree		Output	Carbon and Oil
						Output	Energy spent

Component Manufacturing			Assembly & Packaging			Transport/Distribution/Purchase		
	Input/Output	Detail		Input/Output	Detail		Input/Output	Detail
Chipping	Input	energy	Machinery	Output	Forklift, handcart, loading dock/truck	Exhaust	Output	fumes
	Output	wood chips	Energy	Output	created when loading, moving, and hauling	Energy	Input	Motion, commute
	Output	saw dust	Waste	Output	bands to hold lumber together	Sales	Output	direct to customer or to
	Output	bark/knots		Output	cartons/creates/boxes			
Compression	Input	Wood Chips, Saw Dusts, Adhesive		Output	shipping tape, wrap/cushion, ties			
Drying	Output	Kiln dried causes heat, fumes, and exhaust						

Lifecycle Form

Component	Natural Environment	Raw Material Extraction			Material Processing		
	Where does it come from?	Virgin Material	Input/ Outpu	Detail	Process	Input/ Outpu	Detail
Adhesive	NA / synthetic / Lab made	methane	Input	Methane, ammonia	chemical reaction	Input	ammonia and methane gas
			Output	resin/polymer	mixing	Input	equipment, time, energy, ventilation
			Output	wax	compression	Input	Adhesive, pressure, force, mixing
			Output	offgassing			
			Output	toxins			

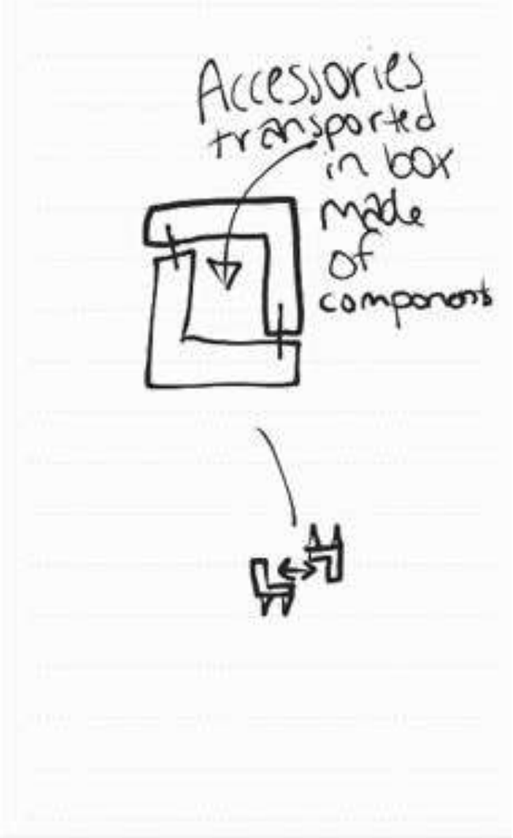
Component Manufacturing			Assembly & Packaging			Transport/Distribution/Purchase		
	Input/Output	Detail		Input/Output	Detail		Input/Output	Detail
Chemistry	Input	energy	Lab Equip	Output	Chemical Reaction	Exhaust	Output	fumes
Compression	Output	Expression of gases into air	Machinery	Output	Forklift, handcart, loading dock/truck	Energy	Input	Motion, commute
Drying	Output	Kiln dried causes heat, fumes, and exhaust	Energy	Output	created when loading, moving, and hauling	Sales	Output	direct to customer or to
			Waste	Output	Chemically safe storage bins/tubs			direct to laboratory/manufacturing
				Output	cartons/creates/boxes			
				Output	shipping tape, wrap/cushion, ties			

Lifecycle Form

Component	Natural Environment	Raw Material Extraction			Material Processing		
	Where does it come from?	Virgin Material	Input/ Output	Detail	Process	Input/ Output	Detail
Assemblage (nuts, bolts, screws, staples, and the like)	underground, ferrous metals	metal	Input	mining	mining	Input	energy, time, man hours
			Output	mining byproducts	milling	Input	equipment, time, energy, ventilation
			Output	manufacturing	casting	Input	heat, pressure, force, mixing metals
			Output	offgassing		Output	exhaust
			Output	toxins		Output	template cuts
			Output	runnoff			

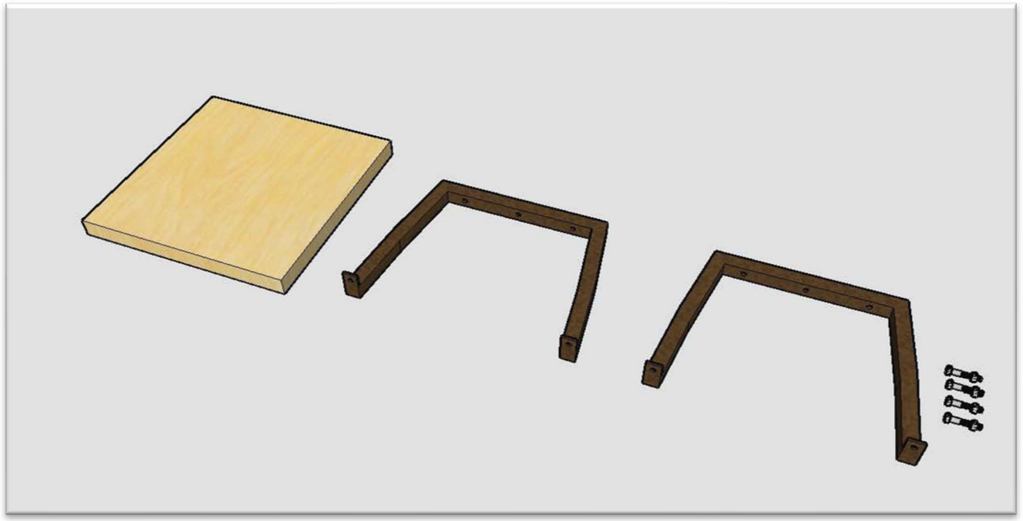
Component Manufacturing			Assembly & Packaging			Transport/Distribution/Purcha se		
	Input/Output	Detail		Input/Output	Detail		Input/Output	Detail
Chemistry	Input	energy, knowledge, metal mixing techniques	Foundary	Output	Material Re	Exhaust	Output	fumes
Heat	Output	Expression of exhaust, fumes, gases into air	Machinery	Output	Forklift, handcart, loading	Energy	Input	Motion, commute
Cooling	Output	Steam, water vapor	Energy	Output	created when loading	Sales	Output	direct to customer or to
			Waste	Output	cases/bins/ fast packs for in			direct to laboratory /manufact
				Output	cartons/creates/boxes			
				Output	shipping tape, wrap/cushi			

Preliminary Sketches



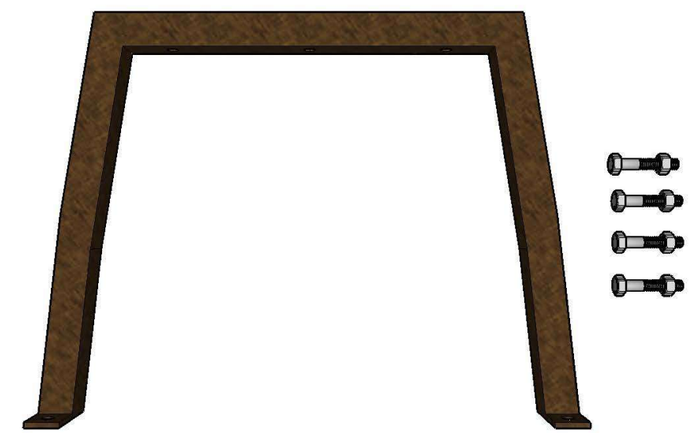
Interlink System - Lifecycle Diagram

Renderings



Assembly Methods

Focusing on simple assembly methods using reusable and durable bolts, snap-together assembly, and a modular and interchangeable component style will decrease material use through the opportunity for users to alter the assembly to fit their changing needs and reduce material strain.



Consideration 1: This design utilizes a one-support-fits-all design where the leg base of the assembly is able to be reoriented and used as the support backing for a seat back, as the base for a table, or as the supporting structures of seating. Reducing the variety or sizes and components needed to round out the system reduces the excess and miscellaneous parts that users could see as clutter and cast away.

Consideration 2: Computational Interlocking Furniture Assembly: Exploring an alternate assembly method where bolts are not needed and instead a series of slots and biscuits establish a sturdy structure is the next step in this furniture design. Could the packaging itself follow this same design ideology?

Packaging Considerations

Exploring alternatives to traditional shipping is an essential part of disrupting the furniture acquisition process.

Consideration 1: Observing the tactics of The Shipping Crate Company who has devised a system of collapsible, reusable shipping crate, can inform my product design as to how the platforms for my furniture pieces could nest together to serve as the structure for the boxes the rest of the components will be shipped in. According to The Shipping Crate Company's data sets, customers have used the crates for 50+ return cycles. Increasing the thickness of the platforms I am proposing in relation to the dimensions this shipping method currently utilizes will provide an opportunity to explore finding a happy-medium between durability and offsetting the weight of the shipping package itself.

Within the Shipping Crate Company's system, when return cycling or warehousing, "the Shipping Crate can collapse to just 9" high, a ratio of about 5:1. That's 1/5 of the truckload or warehouse space as previously used. A Shipping Crate can be set up by 1 person in less than 3 minutes. The panels are held together with steel clips that snap into machined slots. There are no special tools, screws, nails or metal banding required."

Consideration 2: Employ biodegradable and compostable cushioning materials within the product as package system. Utilizing the expertise of others such as the methods devised by experts such as World Centric and Green Cell Foam whose specialty is creating compostable and dissolvable packaging systems can provide an alternative shipping method to tradition cardboard methods.

Consideration 3: No shipping option offered to those who prefer to pick up in stores. Components will be sorted individually in bins within the store so bring your own bin to collect your components and accessories and bring a blanket and ratchet straps to get the parts home safely and packaging free.

Product Exchange Incentive Program – This system will provide:

Comprehensive Rental Program: Renting instead of owning is considered a valuable way of contributing to the mindset of sustainability. Rented furniture's reuse range rate ranges from two to six times longer than traditional furniture ownership methods allow. Implementing a rental option could provide added cost savings for participants within the system while ensuring that materials are not entering the waste stream and are instead being reclaimed by the designer. Rental Programs are a viable option for both commercial and residential applications.

Exchange and Upgrade Program: Participants in this system can benefit from discounts and promotional pricing for users who return with damaged parts or exchange components to better balance their system to fit their needs while also reducing material waste by way of integrating reclamation.

Conclusion

Creating a simplified system of furniture design and implementing an incentive program for consumers to actively participate in the furniture recycling and reclamation process is an opportunity to tangible change within the furniture industry which averages 12 million tons of waste per year and is the least recycled sector of waste exiting US homes due to the inconvenience of disassembling and relocating these materials. By providing a simple system with interchangeable parts and an easy and convenient reclamation and exchange process this material waste issue can be further addressed and the lasting effects can begin to be reversed.

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