Building a structure of knowledge in design and communicating through visual properties

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ABSTRACT

Software and technology are just tools that offer services, and it is the users' responsibility to employ these tools to serve a significant purpose. Colors, materials, and forms are also tools, like software, that a designer employs into serving a purpose, communicating a message or into the making of a functional object. As a user, I am always faced with questions of how I am utilizing these tools. How am I pushing the boundaries of what has already been done? And what am I offering to the world? Through the combination of experience with these tools and understanding and practicing design, I come closer to answering these questions. All the tools offered serve no purpose to a designer without the knowledge of how, where and when to resort to them.

In my design practice, I like to challenge widespread but unspoken assumptions about specific shapes, materials, and tools. The first questions I tend to ask myself are: what is expected of me as a designer in terms of functionality? And, how can I utilize the tools and skills to solve the problem and make an object or a space that is well suited for its purpose in an expressive way? As a designer, I aspire to acquire the knowledge and skills of all aspects of design in terms of functionality, visual interest and tools used, so as to produce designs that provide my customers an unexpected and dynamic experience around the objects and spaces I create.

Since I started my studies in graduate school, I was faced with many projects and opportunities to explore and develop my style and my philosophy towards design. I believe that each project I worked on pushed me a step closer towards discovering myself, my style and what I want to achieve from being a designer. Here I am sharing a detailed account of some projects that helped my development and most relate to my thought process so far.
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Software and technology are just tools that offer services, and it is the users' responsibility to employ these tools to serve a significant purpose. Colors, materials, and forms are also tools, like software, that a designer employs into serving a purpose, communicating a message or into the making of a functional object. As a user, I am always faced with questions of how I am utilizing these tools. How am I pushing the boundaries of what has already been done? And what am I offering to the world? Through the combination of experience with these tools and understanding and practicing design, I come closer to answering these questions. All the tools offered serve no purpose to a designer without the knowledge of how, where and when to resort to them.

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INTRODUCTION

Advancement in software and technology has long been a fascination of mine, and it was my door into the design world. Upon my first introduction to the world of three-dimensional modeling, I felt like not even the sky was the limit with what I can do in this imaginary world. Modeling using software offered freedom, quality, preciseness, speed, and “ctrl + z,” which is what I thought of as everything a person needs in this world. It was a world where one can dream without any rules or guidelines to follow; it was a world of exploration. Little did I know back then that these dreams can come to life.

As I began to participate in the design field and learn the fundamentals of design, I was faced with various opportunities to explore design within different dimensions and mediums. When faced with any design problem, utilizing the freedom, preciseness and speed of the modeling software was my way to challenge what is already out there and push the boundaries. It offered me the opportunity to find balance through geometrical relations, repeat and deform shapes, create movement and drama, explore organic forms and explore combining curved and straight edges. I realized that I could do with software what I cannot do with my hands, and combining that fact with knowledge in the fundamentals of design, I started to create expressive fluid forms. That is when my style as a designer began to evolve.

Software and technology are just tools that offer services, and it is the users' responsibility to employ these tools to serve a significant purpose. Colors, materials, and forms are also tools, like software, that a designer employs into serving a purpose, communicating a message or into the making of a functional object. As a user, I am always faced with questions of how I am utilizing these tools. How am I pushing the boundaries of what has already been done? And what am I offering to the world? Through the combination of experience with these tools and understanding
and practicing design, I come closer to answering these questions. All the tools offered serve no purpose to a designer without the knowledge of how, where and when to resort to them. A big part of this understanding comes from the fundamental understanding of efficiency in the process of the making as well as the user experience and how we perceive things.

Since the 1990s, the contemporary architect Frank Gehry was adopting software to optimize his designs. Frank Gehry was using a software called CATIA not only to digitize his designs, but also to find ways to build with efficient and affordable processes. Frank Gehry’s architectural style contained irregular curves and organic shapes that were not possible to make if it were not for the software calculating the math and dimensions for materials needed. Likewise, in the early 2000’s the Architect Ron Arad became a pioneer in three-dimensional printing, or what was called back then “rapid prototyping.” Rapid prototyping was used in the making of small mechanical objects due to its preciseness and efficiency. In his “not made by hand, not made in China” exhibition, Arad showcased a series of 3D-printed vases and lights that were not touched by humans. He was fascinated by the speed, quality, and inexpensiveness of rapid prototyping. He grabbed an industrialized tool and utilized it to share beauty with the world. Software and technology have long served architects and designers to minimize cost and build efficiently; it was used to enhance and complement their style, and that is what I was trying to do on a smaller scale.

Looking at my design style, I would say my major approaches to form are combining soft and sharp forms, repetition of a specific form that continues in a space with systematic and dramatic changes, and creating shapes that are different and dynamic from each perspective they are viewed. My initial interest in software provided me the opportunity to explore how these forms work as products, furniture, and spaces. I was able to come up with and test designs that break out of the uniform geometric shapes into organic shapes or the mixture of both. Not only was I able to
come up with these shapes by using software but I was able to investigate the balance in these forms, scale and deform with a few clicks of a button.

Because I was producing organic, dramatic and bold forms, my style was often associated by my mentor and peers with the contemporary Architect Zaha Hadid. Zaha created her language in design: she broke out of the norm of what buildings should look like, and she challenged the world with her Avant-Garde designs. In an interview I watched with the Zaha Hadid office, I discovered that using software and stretching it is what strengthened the Zaha Hadid identity. The primary software used at her architectural firm is Autodesk Maya because it’s a customizable tool with an open interface. An open interface means that it can connect multiple software packages to utilize various tools as needed. Algorithms were developed by her team to produce the sense of movement and explosion that Zaha is known for. She followed what Patrick Schumacher -a partner of Zaha Hadid- called the Parametricism style. In a manifesto, he defines Parametricism as ‘Systematic, adaptive variation, continuous differentiation (rather than mere variety), and dynamic, parametric figuration.’\(^1\) Although I was not using software to create algorithms for my designs, I was using the same process of algorithmic thinking when creating movement in my designs. It appeared that I was already following the parametric style without realizing and that I had much more in common with Zaha than I thought. My fascination towards her only grew larger, and she became an icon to me.

As compelling as a unique and a well-thought form can be, its communication to the world continues to grow through materials and colors. Softness, rigidness, naturalness, texture; efficiency and cost are all elements of materials that affect a designer’s choice. With the consideration of how these elements affect the user experience and expectations from a particular object, a designer can

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\(^1\) (Schumacher, 2008)
deliver a more effective product. Color is another language created by the designer to communicate with their audience. The power of color has been utilized as a significant element of communicating a message for ages, and it continues to be effective through different eras, mediums, and cultures. Through color, we express feelings, moods, boldness, attention to certain elements, and so many other messages. Antoni Gaudi was an architect who utilized color in his designs to bring his unique forms to life and to create atmospheres that take his audience out of the building and into nature. He was fearless when it came to the use of colors in his architecture. Gaudi drew from nature, mythology, and religion, and incorporated these influences into his architecture through the colored tiles. Upon the study and understanding of color and materials and their effects, I gained extra tools and communication methods to my audience.

In my design practice, I like to challenge widespread but unspoken assumptions about specific shapes, materials, and tools. The first questions I tend to ask myself are: what is expected of me as a designer in terms of functionality? And, how can I utilize the tools and skills to solve the problem and make an object or a space that is well suited for its purpose in an expressive way? My goal as a designer is to acquire the knowledge and skills of all aspects of design in terms of functionality, visual interest and tools used, so as to produce designs that provide my customers an unexpected and dynamic experience around the objects and spaces I design. That is what my style of rhythmic torsion, fluid swooping, drama and boldness evolves around; it is for people to interact with uniquely. I believe in a world of freedom of taste, uniqueness and respected differences, so I am offering the world a taste of my perspective on things. I don’t intend for my designs to be industrialized; my designs are a piece of my identity that I place on someone's body, in their home, in a store or as a commercial space.
Since I started my studies in graduate school, I was faced with many projects and opportunities to explore and develop my style and my philosophy towards design. I believe each project I worked on pushed me a step closer towards discovering myself, my style and what I want to achieve from being a designer. Here I am sharing a detailed account of some projects that helped my development and most relate to my thought process so far.
STOOL AND COAT RACK

One of the earliest works in my graduate studies was my furniture set of a coat rack and stacking stools. I implemented my design style by breaking flat surfaces into a rounded overall form, which I achieved by using a sewn fabric-folding mechanism that sandwiches the CNC-cut wooden surfaces.

My folding coat rack and stool came from my first Furniture Design II class in grad school. The assignment was to design a coat rack and a set of stacking stools that pack flat and use CNC technology. I initially came in with a paper model sketch of the coat rack, not fully understanding what material I would use or how I would be able to assemble/disassemble the furniture. The paper model (Figure 1) had a dodecagon base shape wrapped with the folded paper surface around it, with a diagonal cut that resulted in a consistent decrease in height from one side to the other. That sketch of breaking a curved surface into smaller surfaces and wrapping them around a form became my inspiration for the whole set. The form followed my style of combining curved and straight lines by creating a curve out of straight lines. It also allowed me to unwrap the pieces to pack flat for travel purposes.
After having a clear concept of what form I am following in my set, I started developing my coat rack to achieve functionality. I needed to address multiple issues simultaneously, as each aspect affects the other. First was the overall form and dimensions of the coat rack. The second was the choice of materials and assembly method of the pieces. Finally, I had to consider my hanging mechanism for articles to be hung on the coat rack. I was going back and forth between form, dimensions, mechanism, and materials as these four issues influenced each other along the way. I was also going back and forth between my stool and my coat rack: the problems I was faced with were similar, but I had to come up with some different solutions for each piece.
COAT RACK

For my coat rack, based on human ergonomics, I made the highest point on the vertically wrapped surface to be 68” and the lowest to be 18”. These measurements were to change slightly based on how steep my diagonal cut on the vertically wrapped surface was going to be, also based on how many horizontal surfaces I will have in the bottom to achieve stability. To utilize the maximum amount of space around and inside the vertically wrapped form for hanging, I investigated multiple sizes and shapes for the base of my form (Figure 2). I found out that to utilize the maximum amount of space and minimize the area of my base I needed to disregard the oval shape base (Figure 2) and stick with a regular nonagon (Figure 1). I also decided to have two horizontal surfaces on the bottom to act like beams for stability and to connect all the pieces of the vertically wrapped surface.
Going along with figuring dimensions, I was trying to figure out materials that would serve my initial concept of wrapping and folding the vertical surface to pack flat, as well as provide an easy and quick assembly method for my users. I knew I needed a rigid material that is stable enough to hold itself, but I also needed to have flexibility between the broken surfaces to wrap and fold the vertical surface. That is when I decided to combine the use of wood and fabric. The wood would offer rigidity and stability; the fabric provides the ability to wrap and fold the vertical surface. Slotting the wood into the fabric also provided my users the advantage of easy assembly and not having to worry about what wood piece goes where. For aesthetics and functionality of the coat rack, I decided not to cover the whole piece of wood with fabric, but instead to leave parts of it exposed. I also decided to close off the fabric from the bottom to carry the coat rack so as to avoid worrying about my wood pieces sliding out.
To connect the pieces using the fabric, I had to use a single sheet of fabric and sew vertical lines to create tight slots for the wood to fit inside. It was my first time using a sewing machine on a project this big; I needed to consider the order of operations and sew with precise dimensions for each piece of wood to fit in perfectly. That is when I went to AutoCAD, unwrapped and flattened out the vertical surface and drafted the profile. After I figured out my final profile, I needed to add to the dimensions of my fabric for sewing purposes. In my AutoCAD drawing, I considered the wood thickness, seam allowance on the sides of each piece and seam allowance to sew the bottom. Since I had fitted dimensions and non-standard angles, and I already had CAD drawings, I decided to utilize the laser machine to cut my fabric precisely. When I cut my two profiles for a front and a back, I had to sew around the three edges (two sides and bottom) to connect them. I started with the edges to flip my fabric and hide all my sewing seams. Once I combined the two fabric pieces, I measured the width of each wooden panel and sewed the inner vertical lines based on the measurements (Figure 3).
One of the main issues I had to deal with was my locking mechanism between the horizontal and vertical surfaces. In the process of trying to figure this out, I was faced with multiple questions: Do I have a hidden mechanism, or do I make a statement out of it and make it visible? Do I attach and lock each vertical surface to a side of the nonagon or try to minimize the points of
locking? Do I use hardware or use CNC technology to design fitted joints that could assemble and disassemble easily? All these questions I faced were applicable in both my stool and in my coat rack, and I dealt with them differently on each piece. I tested out multiple solutions for both of my furniture pieces. To provide aesthetics and stability, I decided to have a hidden mechanism for my coat rack that only attached to three of the vertical surfaces and to use hardware. My contact points were the two vertical panels on the edge and the middle one. I had tightly fitted horizontal pieces with holes in them that stick out of each contact point. The holes would then align with the ones on the horizontal nonagon to fit metal rods into them. After sliding the rods in, I would lock them into place using nuts on each side of the surface. After assembling everything, I decided to remove the whole horizontal surface because it was constraining a form that would rather be free (Figure 4 and 5).
Figure 4: Coat Rack with Locking Surface
Figure 5: Coat Rack Free Form
The last functionality issue I had to address which is the primary purpose, was how to hang the coats on the coat rack. I cut a shape out of each panel that was an offset of the outline. I then designed pieces that bite into the wood inside the negative space I created. The CNC cut hooks allow the user to switch between hanging inside and outside the vertical surface (Figure 6).

Other decisions that I made along the way involved the type of fabric I used for both pieces. I tested out different types of fabric, and I decided to use the duck canvas for multiple reasons. One was its rigid form; I needed rigidity in my coat rack to prevent the fabric from sliding down since all that I depended on was my tight sewing. The second was it was more durable: it was thick and robust, and it could handle the pressure of pulling without the possibility of it ripping. The final reason was that it didn’t have any stretch to it; had it been stretchy it would’ve ruined all my dimensions.
Figure 6: Coat Rack with Hooks
STOOL

In the process of figuring out my coat rack, I was also developing my stacking stools. I grabbed my coat rack shape, rotated 90 degrees on the x-axis and started cutting and manipulating the form based on the limitations I had. Because of stability, the requirement of the stools being stackable and because of the ergonomics of a comfortable stool height, I ended up with a side profile of only seven edges of that first dodecagon I started with and no longer equal facets. The dimensions of the stool were based on comfortable seat height of 14-inches and width of 12-inches, as well as providing the ability to stack (Figure 7).

Figure 7: Stool Stacking Foam Model
The process of thinking and making for the two pieces was developed simultaneously, and I was faced with the same problems for both pieces. One of the problems I solved entirely differently in my stool was my locking mechanism. When faced with the previously mentioned questions regarding the mechanism, after testing multiple solutions (Figure 8) I decided to have a hidden joint on the legs of my stool that only attached on the end edges of each leg. The wrapped surface of my stool would still connect the wooden pieces using fabric. I had two hooks of wood on each side of each end piece to fit into a CNC cut pocket on the edges of the legs (Figure 9). Because of the nature of the side profile of the stool, I had to stretch the fabric surface extra to fit the hooks into the pocket and lock them back up. To do that, I added half an inch - the length of the extra stretch I needed - to the length of my fabric on each side. I still sewed around that additional allowance I made because I still needed my wood panels to fit tightly. On the inner side of my surface, I stapled an elastic ribbon connecting the end wooden panels and the main seating surface. That ribbon provided enough strength to pull back and lock my mechanism in place while still providing me the ability to stretch the whole surface when fitting the hooks in.
Figure 8: Stool Mechanism Test

Figure 9: Stool Locking Mechanism
The stool is a project that I re-visited in the spring of 2018, and I made multiple changes to it. The overall form was one of the significant changes. I knew I had a functional and stacking stool (Figure 10), but it wasn’t aesthetically pleasing to me. So, I rounded off the side profile (Figure 11), made it asymmetrical, and added more drama to the diagonals on the sides (Figure 12). I also added a half inch thick foam on the top of each wooden piece to provide comfort to my users to sit or lean on it (Figure 13). The final change was in fabric; I explored using the suede fabric which offered me the same functional aspects of duck canvas but added a smoother welcoming touch.
Figure 11: Stool Re-Visit Profile

Figure 12: Stool Re-Visit
REFLECTION

Through my experimentation in this project, I built a foundation of understanding of structure, stability, and collapsibility of furniture. While testing and experimenting with different locking mechanisms and fitted CNC joints, I developed a solid understanding of the solutions for future projects. I must acknowledge that although I spent quite some time and effort solving the coat rack’s structure, if I wish to make it functional, I would have to re-visit the decision of the thickness of my material and possibly add some support to the free-form structure. The process of design thinking, problem-solving and order of operations was challenging, but being able to utilize software and CNC technology helped everything to run with a smoother flow. Being able to cut
fabrics using CNC Laser technology provided preciseness and speed, and it opened a new door for me to play with in the future. The project also introduced me to various sewing methodologies and techniques. Overall, I believe I stayed true to my style by combining what is soft and what is hard in terms of form and terms of material. I also combined the use of CAD drafting software, CNC technology, and traditional techniques. Although at that point I did not understand the effectiveness and role of color in design, color is an essential element that I plan to revisit in the future as it could bring my project to life.
MELO CUFFLINKS

Another project that was essential in building my structure of knowledge in design was designing organic and geometric cufflink pieces specifically for women. I combined the use of 3D printing technology with basic soldering of sterling silver. It was my first time confronting the world of colors as a designer, and I ended up using bold colors.

In the spring of 2019 for an assignment for a mass production class, I had to come up with and design a particular product that solves a problem, and I had to target a well-defined demographic within a specific price. As I was researching for products to make, I noticed that cufflinks are pieces of jewelry that people only associate with males. I did some research into the history of cufflinks and found out that back in the 16th century, cufflinks were associated with higher class individuals whether male or female; only in the 19th century did they become more associated with men. Looking at the history of cufflinks and how they represented higher class individuals and looking at their current cultural manner of being worn in formal or professional events, I became interested in designing cufflinks for the modern-day women.

By then I had a clear idea of what I am doing: my product was cufflinks; my demographic was bold, professional women in their mid-30s. The goal was to design the cufflinks to be worn by women who are bold, daring and think and care about what they dress and what it says about them.

By looking at several examples and asking males who wore cufflinks, I found out that cufflinks should be heavy enough to hold down the cuff of the shirt with a tight grip. I also researched different types of cufflinks, and there are the French knot cufflinks, the double panel cufflink and the swivel bar cufflinks. For the security of the cufflinks and weight, I decided to go with the dual panel cufflink, and the plan was to make them with metal.
My initial sketches for the cufflinks were made with folded wax sheets (Figure 14), while the design was intended to be made with a folded silver sheet. After testing cutting, and folding the metal prototype (Figure 15), I realized that this process was going to take a lot of labor, which would increase the price of my product and prevent it from being mass produced.

Figure 14: Cufflinks Wax Model
I then started exploring the option of making a mold and casting metal, and that is when computer modeling came in handy. By using Autodesk Fusion 360, I was able to come up with a design and make two versions of the same shape, one with straight edges and flat surfaces, and the other being a wholly organic and soft shape. My thought process was to 3D print prototypes of the two forms, adjust dimensions based on the cuff of the shirt and what is comfortable for the user, and then make a mold to cast. After seeing the prints (Figure 16), I was faced with the question, why not just 3D print the cufflinks? I revisited my decision and decided to 3D-print my double panels with ABS plastic but attach them with a silver rod to provide more weight and value to my product. Working with Fusion 360 and the preciseness of 3D printing technology provided me the opportunity to make several tests and adjust quickly and at a small cost.
To connect the two 3D printed pieces, I had to solder a 9-gauge silver rod to 20 gauge of flat pieces of the silver sheet. My initial plan was to have the edges of the rod at a 30-degree angle to tighten the cuff on one side and give room for the wrist on the other side. After testing with the angled cut (Figure 17 and 18), I decided to keep the edge straight because it will provide more accuracy with less time and labor for cuts and solders. After I had my prints and soldered pieces of silver (Figure 19), all that I had to do was fit the flat ends of the silver into pocket cuts that were planned in the prints and glue them using epoxy resin.
Figure 17: Cufflink Angled Cut Rod

Figure 18: Cufflink Angled Soldered Rod
Now that I had my form, dimensions, production, assembly process and materials figured out, I was faced with the question of color. Since my demographic was bold, professional women, I chose to print my cufflinks in four different bold and highly saturated colors: Red, Blue, Yellow, and Violet (Figure 20). I wanted to provide my users with some sense of bravery and boldness by wearing my cufflinks, and the final touch was picking the correct colors to achieve that. In my design work, I had never explored with color as a significant element of the design. After understanding color and its effect, and especially because this project had a clear message that called for color, I ended up using my understanding of the power of color.
As much as I was satisfied with my final product (Figure 21, 22, 23 and 24), I believe I was more fulfilled with the process of the making. I combined the use of jewelry and metalwork with the use of software and rapid prototyping technology; I also explored different materials, form, and color. I came into the project with a clear purpose of creating a product that challenges the norm of the society, and to do that, I needed to make it into a statement. Cufflinks is an accessory associated with a well dressed professional man in the work place. As women start to wear them in the professional world they will be perceived as what they should be, professional and dressed sharply for the occasion. I believe that the use of the materials, form, and color made that bold and daring statement very clear.
Figure 21: Cufflinks Final Product

Figure 22: Cufflinks on Shirt
Figure 23: Cufflinks on Shirt

Figure 24: Cufflinks on Stand
SCULPTURE OBJECTS FUNCTIONAL ART AND DESIGN EXHIBITION

My biggest project in grad school was being the lead designer for a booth to represent the UI 3D Design program along with nine other group members at the SOFA Connect Exhibition in Chicago. I was offered a great opportunity by my mentor Monica Correia to design a space for the exhibition. Along with a fellow designer Sarah Margaret Gutowski and eight other designers, Joan Kim, Yiran Li, James Tran, Shana Kaska, Youtian Duan, Jixuan Zhu, Sha Liu and Xi Zhu, we were awarded the second place in the competition. Participating in this exhibition was an excellent opportunity to investigate the nature of real design experience. I experimented on a bigger scale, with the continuation of curved lines in space, and use of form, colors, materials, and light to attract my audience into a warm and welcoming experience (Figure 25).

Figure 25: SOFA Booth Render
Coming up with the initial sketches for the design, I was inspired by the semi-dome shape made from paper (Figure 26). I was interested in the simplicity but the effectiveness of the rhythmic movement of the paper strips that spoke the same language as my designs, but to make them more expressive they needed to get bigger, and they needed color. The idea was to create several light structures that would be hung from the ceiling for people to walk inside and around. The strips would be made out of fabric due to how light and durable it is. These structures would collapse onto themselves, and all the panels can wrap around the top ring that carries the semi-dome (Figure 26.1). The way it collapses was essential to travel from Iowa City to Chicago within reasonable dimensions and still be able to set it up at the exhibition with reasonable time. My initial approach to the design was to use form, color, light, and materials to communicate warmth and to invite the audience into the space.

After several meetings with some of the team members that all came in with different inputs, the design took a clearer path. We needed to relate our space to Iowa and our 3D Design program, my peer Sarah Margaret Gutowski looked into the American painter Grant Wood, he started initially from Iowa, and his old studio was the first 3D Design space at the University of Iowa. Grant wood was known for his paintings of the prairies and rolling hills of the Midwest; he depicted the lands as dynamic and organic shapes. A specific painting that my peer was attracted to was the “Young Corn” (Figure 26.2) painting of the rolling hills and farming lands of Iowa. We collaborated our ideas and borrowed the warm colors and round organic shapes of the trees in the painting and applied them to the space. The cylindrical pedestal and seating islands represent a top view of the circular illustration of trees in the Young Corn painting. The complementary color

2 https://www.flickr.com/photos/yoshinobu_miyamoto/5430119613/
scheme of the blue-green background and different shades and tints of the red-orange foreground were inspired by the painting as well.

Now that the concept and design were set in place, it was time to plan and execute based on time, budget and resources available. Budgeting was one of the most significant constraints I faced coming into this project; we were given $1500 to build up a finished 24’ by 24’ space with seating, lighting, and staging. Based on the design concept, the $1500 had to be divided between flooring, dropping a point to hang the structure, wood and veneer for the structures of pedestals, seating, top ring and bottom ring, fabric and foam for the strips and cushions, and all the other small elements like lighting, logo and hardware. Along the process, I had to find ways to let go of some items and focus on others to build a space that is as elegant and finished as the design concept intended for it to be. The most significant elements that were dropped or re-evaluated because of cost were the multiple domes, the veneer, and the colors. Dropping a single point to hang 300 lb. cost $400, so I had to get rid of the initial idea of hanging multiple dome structures and reduced to one big dome. The big dome was initially designed to be asymmetrical, but I had to optimize it into a symmetrical dome, so it ends up being balanced when hung from a single drop point. Another issue was veneer cost; since we had ten pedestals and cushions we needed a lot of veneers to cover the sides as in the initial render, and veneer is not cheap. The initial concept was to use veneer because its rigid but flexible and because of the nature, texture, and warmth of wood. With the constraint of money, I had to drop the veneer and resort to a textured fabric that was a free resource at the time and could communicate the same message and give the same feel. Additionally, I had to compromise the use of blue-green color for the background because of cost. Initially, we were planning to paint the walls of the space ourselves when we got to the exhibition while setting up. But the exhibition rules prohibit exhibitors from painting the walls themselves;
we had to pay per linear foot, it was extremely overpriced that I had to let that go to focus on other essential elements in the booth.

While building the structures of the booth, the use of modeling software and CNC technology played a huge role in the initial planning, the making of the elements and minimizing of material waste. Since the initial stages, I used software to model the space with precise dimensions of everything. It provided the ability to investigate and balance the space in a matter of form, positive and negative space, and dimensions. It also provided a quick and efficient way to calculate dimensions of the strips on the structure and all the cylindrical elements. The use of CNC machinery played a significant role in optimizing the making of items in the booth with precise dimensions. For the flooring, we wanted to utilize the traditional technique of weaving to create the round rugs with a variation of tints and shades of the red-orange color (Figure 26.3). To weave the rugs into perfect circles, we needed to create round looms with equally spaced kerfs around the outside of the ring to hold the weft of the weave (Figure 26.4). We used AutoCAD to create the loom and used CNC to cut it into perfect circles to guarantee the perfection of the result. AutoCAD and CNC served well in the building of the structures for the seating, pedestals, top ring and bottom ring as well. I was able to revise the dimensions of the round pedestals and seats and nest all the CNC cut rings of the inner structures into each other to avoid wasting any material through the process. We were also able to create male and female cuts that fit into each other to build the structure for the top and bottom ring since they were bigger than our 4 by 4 bed CNC machine.
Figure 26: SOFA Inspiration Image

Figure 26.1: SOFA Top Ring

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Figure 26.2: Young Corn by Grant Wood

Figure 26.3: SOFA Weaving colors
Figure 26.4: SOFA CNC Cut Loom

Figure 27: SOFA Booth
Leading SOFA was a huge learning experience in terms of planning and budgeting, working and communicating with team members and problem-solving. Optimizing the process, re-evaluating initial concept and dimensions based on budget, resources and machine limitations, and utilizing and shaping materials that were free and available to serve the purpose of the booth were all problem-solving skills that I developed in the process of this leadership experience. Being able to work with and lead students coming from different backgrounds and levels of proficiency was also a learning experience. Although I came up with the initial design and led the group, everyone's knowledge, abilities, and problem-solving skills were essential to finishing the project at the level it was done. At the end we stayed true to the initial concept, it ended up looking a little different with the limitations and everyone’s input (Figure 27).

I had designed spaces before, made realistic renders, and walked through my spaces in Virtual Reality software, nothing compared to being able to interact with a real space that I designed. It was my first experience with creating a real-size structure and watching people interact with it. It was my first real-life experience to employ my knowledge and experience with software, CNC technology, form, color, and materials. It proved to me that the practice of design thinking and problem solving on a smaller scale builds a structure of knowledge that served me on a larger scale. It also introduced me to the joy of the process of making an environment and watching people interact with it.
WOOD BENT TABLE LAMP

Finally, my most recent experimentation was applying traditional wood-bending techniques to design. I resorted to a combination of multiple wood bending techniques to create a lamp with a three-dimensional movement of curves. Although I have always been drawn to classes that offer me an opportunity to use technology in its various forms, in the fall of 2018 I decided I need to get myself out of the technology bubble. With the intent of developing some basic understanding of wood and woodworking, I enrolled in a “Twist and Route” class offered by Hannah Givler. The class’ primary focus is teaching various techniques of wood bending. I came into the course with a plan of learning more about wood, wood bending and combining it with my knowledge in computer modeling and CNC technology to produce a designed object by the end. I ended up successfully developing and making a table lamp using a combination of a few wood-bending techniques but surprisingly no CNC technology in the initial prototyping period.

TAMBOUR

My table lamp inspiration started with the tambour project. Tambour is usually used for rolling doors in all sizes; it uses thin strips of wood mounted to a flexible material to create a flexible surface of wood (Figure 28). As a lab assignment, we were assigned to develop a small tambour surface using solid poplar wood. The process of making a regular tambour goes as follows: first, we join and plane the wood to get a square piece with a 1/4-inch thickness. Second, we round off the four long edges of the piece using the shaper tool. Third, we cut off about a 1/4-inch-thick strip from each side to end up with two strips that have one flat face and one round face. We repeat steps two and three until the original sheet is too narrow to get on the shaper tool. After having the desired number of strips, we align the pieces next to each other with the round face
down on a jig made specifically for their dimensions. Then we squeeze them on the jig using a wedge. Next, we glue a sheet of fabric on the flat surface using wood glue and clamp it for a few hours. Finally, after removing the sheet from the jig, all the pieces are joined to become one flexible surface of wood.

![Figure 28: Tambour](image)

**TAMBOUR PROTOTYPE**

Since the movement of the tambour surface still felt flat to me, I began to wonder what would happen if we would tambour bent strips of wood instead of just straight pieces to create three-dimensional movement. To generate a tambour, the strips can only bend out in one direction and would need to meet back on the same plane to glue the fabric sheet on both ends of strips. We
had already learned how to bend wood by just soaking it in water and by using the steamer. To bend the strips of wood easily without the risk of breaking, I needed thinner strips and a jig with the desired form. So, instead of cutting the strips with a 1/4-inch thickness, I cut them with a 1/8th of an inch thickness to allow them to bend. And I cut out a form with one simple curve to clamp the strips on it until they dry and hold that shape. Because of the constraint of the curve coming back into a straight line on both ends of the strips, the strips kept cracking and chipping out once clamped to the jig. Even after soaking the thinner strips in water and then steaming them, the bend was too harsh on them. Also, because of the moister in the wood, the clamps were leaving a mark on the wood strips (Figure 29). Even though I knew steam bending is not going to give me the desired result, I followed through with the first test to see what the result would be (Figure 30).

Figure 29: Tambour Prototype Cracking
Figure 30: Tambour Prototype
TABLE LAMP

After seeing my first three-dimensional tambour, I was very optimistic about what I could achieve with it. All I needed to do is to figure a more clean, reliable and efficient way to bend and finish the strips: that is when the vacuum bag came into play. The Vacuum Bag (Figure 31) is a clamping mechanism that works by sucking the air out of a sealed bag to press objects together. It provided me the opportunity to make a bigger tambour while fixing all the previous issues I had. By laminating large sheets of wood and bending them over one curved object, then cutting them down into strips, I avoided the hassle of bending each strip to match the other perfectly, I also ended up with quicker production time. Additionally, by using the bag as a clamp, I got rid of all the clamp marks on my strips.

Figure 31: Vacuum Bag
My glue-up preparation and process using the Vacuum Bag to make the primary form of my lamp goes as follows. To bend the laminated sheets of plywood, they needed to take a form of another shape. So, I cut down a long block of dense insulation foam, and I sanded the long edges to make it into a half cylinder shape (Figure 32). For my lamination, I used four layers of 2’ by 3’ sheets of wood: two outer layers of paper backed Birch veneer, and two middle layers of 3/8” bendable Lauan plywood. The bendable plywood is three layers of wood, with the outer two layers’ grain running along the long edge of the sheet and the thin middle layer with the grain running across. This way of layering gives the plywood the flexibility of bending. To adhere the layers together, I used 105 epoxy resin west system with a 205 Fast Hardener. Using resin rather than Titebond wood glue allowed my glue-up time to be stretched to 9-12 minutes rather than only 1-3 minutes. After applying the resin, I laid the sheets on top of the insulation foam. I aligned the sheets to cross the foam in the middle of the long edge (Figure 31). Finally, I turned the Vacuum Bag on with pressure between 20-25 PSI for 12 hours for the resin to cure. Because of the size and amount of the laminated sheets and the process of aligning everything together, it was difficult to stay within the 9-12-minute time constraint. This bleed in time caused gaping between my layers.
After taking the lamination out of the bag, I had my base form, but it wasn’t quite ready to cut down to strips (Figure 33). To cut straight strips off the form using the table saw, I need to have a square piece; otherwise, the strips will follow the skewed edge. Because of the nature of the imperfection of lamination, the sides were not aligned in a straight line, so my form was no longer square. I had to screw it on to a square piece of plywood with an inch of the form bleeding out of the square piece. Then I ran it on the table saw basing the cut off the squareness of the plywood and cut off the misaligned edge of the form. Once I had a square form, I was ready to cut the strips down. I locked down the rip fence on the table saw to equally cut 3/4” thick strips every time I run the form through.
When I finally had all the strips, it was time to plan the finishing of the edges of each strip and the nature of the movement between them. Making two prototypes of my lamp allowed me room for exploration with these decisions. I decided to play with these two aspects and see what different effects I could get. I rounded off the edges of each strip on one of the lamps (Figure 34) and left the other lamp with sharp edges (Figure 35). To round off the edges, I used the hand-router with a .25” diameter chamfer bit and ran it along the sides of the strips. When it came to creating movement, I was free to shift the strips up and down as I pleased. All I needed was to make sure I have at least 3 inches of room to glue the fabric on each end. I decided to create more dramatic undulation on the first prototype and a more organized and behaving movement on the second one (Figure 36 and 37). After shifting the strips, I chopped off the ends using the miter-saw to create a straight top and bottom.
Figure 34: Strips with Round Edges

Figure 35: Strips with Square Edges
Figure 36: Strips Dramatic Undulations

Figure 37: Strips Behaving Undulations
The last step was to finally create the tambour and connect the strips by gluing the piece of canvas fabric on to the back. Although it seemed like an easy step on a regular flat tambour, it was more complicated with the curves and the movement. I needed to create a jig that will hold my bent pieces facing down and have a flat surface holding the ends to squeeze the strips tight to glue the fabric on. I had to create two flat ends on the jig to carry the flat ends on the strips and raise my jig off the table to allow room for the curves in the middle to come down. While creating the jig, I made enough room on all ends for it to be adjustable in case my lamp size varies from one prototype to another. I also had to make sure all the pieces of my jig were square to end up with straight ends on my lamp. After gluing the fabric, all I had to do is wait. (Figure 38)
REFLECTION

Removing the tambour from the jig and seeing its movement was a breathtaking moment for me, it was everything I dreamt of seeing and even better (Figure 39 and 40). The systematic variation of the curves on each strip, the three-dimensional movement, the fact that it looks different from each side it is viewed and the straight chopped off edges are all aspects that satisfied my eyes. Although I did not use software to investigate the form and balance of the lamp, I was able to envision what I wanted based solely on imagination. The foundation I built in previous projects of understanding form, movement and drama all had a role to play in my vision of this lamp. By learning the technique and flexibility of wood, wood bending and combined with knowledge in software I now can take this idea back to the modeling software and refine it to make its proportions mathematically right without the hassle of prototyping based on chance.

The base of the lamp was designed temporarily to hold the form together in a perfect circle with the light bulb inside to investigate the possibility of making this tambour into a light product. I CNC cut and laminated circles to hold the light bulb and the tambour based on the circumference that I got from the width of the tambour. After putting everything together, I decided that the base needs to be invisible because it was cutting off the continuation of the vertical lines. I also need to lift the whole tambour up to create enough room for the cable to go out from the bottom.

Although I intended for the tambour form to be made into a vertical light product, I will investigate more application of the form, either as a hanging light fixture, a wall piece, a room divider or possibly seating. The rhythmic and dynamic movement in the form, as well as its flexibility between the vertical pieces opened a huge window of opportunity for exploration and applications.
Figure 39: Table Lamp
Figure 40: Table Lamp


CONCLUSION

Through experimenting, testing and investigating various methods to solve the problems I was faced with, I built the base for a structure of knowledge in design thinking. This structure will only grow stronger as I experiment more. Being able to work with projects in different scales and mediums provided me an opportunity to look at the tools I have from different perspectives and learn how and when to resort to them. When faced with any problem, I look at the tools and knowledge I built and if I can’t find the answer I find new ways of building on to the knowledge. To keep adding more layers to the structure of knowledge, it is important to keep trying new things, and asking why and why not?

I would like to note that through my past years in the University of Iowa, I did not only learn methods of making a functional object or a balanced design, I learned how to communicate through visual properties. I built stronger communication methods through forms, colors and materials based on human perception and what we expect from certain objects. I found that through design, I can say more than what I can say with words: design is a silent but strong language. My hope is to explore more mediums of communication to an audience and learn more tools to grow the knowledge at hand. Each project I worked on opened doors of exploration. My goal is to continue to open more doors and to find more ways to communicate, to challenge the norms, to wonder and to make more.
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